Supplemental Waste Plan

Clarifier Materials
Silver Bow Plant

Prepared for
Solvay USA Inc.

October 2015

BARR

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Table of Contents

List of Tables

List of Figures

List of Appendices

Executive Summary

This Supplemental Waste Plan is being submitted pursuant to the Amended Administrative Order under the Resource Conservation and Recovery Act (RCRA) § 7003 (“7003 Order”)) and the Corrective Action Order on Consent under RCRA § 3008(h) (“3008(h) Order”) that were issued to Rhodia Inc. (“Rhodia” and now “Solvay”) by the Environmental Protection Agency (EPA), Region 8 on June 29, 2000 (amended December 27, 2000) and December 22, 2003, respectively, regarding the Silver Bow Plant, near Butte, Montana. This Supplemental Waste Plan documents the process that was used to develop and evaluate appropriate alternatives to manage the material in the clarifier and reports on the findings of the evaluation. The overall evaluation process is consistent with EPA guidance “RCRA Corrective Action Plan (EPA, 1994).

Technologies for the management of the clarifier materials at the Silver Bow Plant were evaluated in previous reports submitted to EPA (i.e., Waste Plan (Barr, 2001b); Focused Feasibility Study Report (EPA, 2003); and Phase 1 – Information Gathering Report (Franklin, 2007)). These evaluations identified three technologies that were developed into alternatives for evaluation in this Supplemental Waste Plan: (1) Enhanced RCRA Cap; (2) On-site Phosphorus Recovery (Mud Still Process); and (3) Off-site Incineration.

EPA established five evaluation criteria to address the RCRA requirements and to address the additional technical and policy considerations that have proven to be important for selecting among the viable alternatives. These criteria serve as a basis for evaluating the alternatives and subsequently selecting an appropriate alternative for the management of the clarifier materials at the Silver Bow Plant. According to OSWER Directive No. 9902.3-2A (May 1994), the criteria are:

- Long-term reliability and effectiveness;
- Reduction in the toxicity, mobility or volume of waste;
- Short-term effectiveness;
- Implementability; and
- Relative cost.

A comparison of alternatives follows the individual analyses. Comparative analysis considers the same five criteria used to evaluate individual alternatives. The intent of comparative analysis is to rank alternatives within each evaluation criteria and point out significant trade-offs between the different alternatives.

All of the alternatives evaluated in the Supplemental Waste Plan involve closing the clarifier, placing a cover barrier (enhanced RCRA cap or evapotranspiration cap) over the closed clarifier, and institutional controls to manage residual materials that would remain under the cover barrier. The on-site phosphorus recovery option using a mud still and the off-site incineration option, unlike the enhanced RCRA cap option, also involve removal and recovery or treatment of all of the crude phosphorus in the clarifier that can be safely and practicably removed. Because the mud still option involves replacement of the solid residues back into the clarifier that may be hazardous waste due to cadmium, EPA designation of a corrective action management unit (CAMU) is envisioned[1]. Although EPA need not designate a CAMU for the enhanced cap and incinerator options, since those two options also allow hazardous waste to remain in place under a cap, those options are functionally equivalent to a CAMU.

The Supplemental Waste Plan shows that the enhanced RCRA cap would be reliable and effective at eliminating the potential for fire and phosphine generation at harmful levels, and for protecting groundwater by a wide margin. Although the enhanced RCRA cap alternative would be considerably less costly, the alternative does not reduce the volume or toxicity of the clarifier materials.

The on-site phosphorus recovery alternative would be as reliable and effective as the enhanced RCRA cap in eliminating the long-term potential for fire and phosphine generation at harmful levels, and would also reduce the toxicity, mobility, and volume of crude phosphorus at the Silver Bow Plant. On a relative basis, this alternative ranked low regarding the short-term effectiveness criterion because of the higher relative risk of serious injury. However, this alternative would return about 80,000 to 98,000 gallons of elemental phosphorus to commercial use, which represents a commercial value of about $2 million to $2.5 million.

The Supplemental Waste Plan shows that off-site incineration is not a practicable technology for the volume of clarifier material that would be generated at the Silver Bow Plant and would take very long to complete. In addition, filling each of the estimated 12,500 drums with the clarifier material would present high short-term risks of fires and phosphine generation, and each truckload would have to be transported half-way across the United States, which represents increased risk to the general population.

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[1] In accordance with Section XII of the 3008(h) Order, the EPA designation of a CAMU is being formally requested in a separate submittal entitled “Request of Solvay USA, Inc. to Designate a Corrective Action Management Unit”.

The comparative evaluation of the alternatives is summarized in the following chart:

Alternative	**Long-term Reliability and Effectiveness**	**Reduction in Toxicity, Mobility or Volume**	**Short-term Effectiveness**	**Implementability**	**Relative Cost**[1]
Enhanced RCRA Cap	Good	Lowest Reduction	Low Risk	2 Years	$5.4 million
On-site Phosphorus Recovery (Mud Still Process)	Very Good	Large Reduction	High Risk	10+ Years	$25 million
Off-site Incineration	Very Good	Large Reduction	High Risk	20+ Years	$54 million

[1] Cost includes the cost of financial assurance.

The Supplemental Waste Plan supports the conclusion that the on-site phosphorus recovery alternative should be selected for the clarifier materials at the Silver Bow Plant.

1.0 Introduction

This Supplemental Waste Plan is being submitted pursuant to the Amended Administrative Order under the Resource Conservation and Recovery Act (RCRA) § 7003 (“7003 Order”) that was filed by the Environmental Protection Agency (EPA), Region 8 on June 29, 2000 (amended December 27, 2000), and the Corrective Action Order on Consent under RCRA § 3008(h) (“3008(h) Order”) that was filed by the EPA, Region 8 on December 22, 2003[2], regarding the Silver Bow Plant, near Butte, Montana (see Figure 1-1). A copy of the 7003 Order and 3008(h) Order is provided in Appendix A and B, respectively.

The 7003 Order required Rhodia Inc. (“Rhodia”) and now its corporate successor Solvay USA Inc. (“Solvay”) to undertake certain immediate and interim activities at the Silver Bow Plant, all of which were completed according to the specific timeline established for the respective activity. The 7003 Order required activities at the used brick and furnace liner pile, slag pile and the clarifier. The location of these areas is shown on Figure 1-2 and each is summarized below.

<u>Brick and Furnace Liner Pile</u>

The used brick and furnace liner pile was approximately 100 feet long by 30 feet wide by 5 feet high, with sizes ranging from cinder block to as large as a refrigerator. This used brick and furnace liner was a refractory lining that was removed from electric arc furnaces that were used to convert phosphate ore into elemental phosphorus. Pursuant to the 7003 Order, a security fence was installed around the pile and signs were posted on the fence stating “Danger—Unauthorized Personnel Keep Out.” In addition, the used brick and furnace liner pile was enclosed with netting to prevent wildlife contact with these materials.

The used brick and furnace liners were managed as detailed in the Completion Report, Used Carbon and Electrode Project, Silver Bow, Montana, April 9, 2009 and approved by EPA in a May 15, 2009 letter. Each carbon brick/block was tested for ignitability according to the procedures developed by Solvay and approved by EPA. The used carbon brick and the eight pieces of hazardous waste carbon

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[2] The 3008(h) Order relates to the Supplemental Waste Plan for several reasons: (1) the RFI that has been completed under the 3008(h) Order provides critical information relevant to the evaluation herein (see VIII. D. of 3008(h) Order); (2) the integration of XIII, XX, and XXIII in the 3008(h) Order are relevant to the remedy decision regarding the clarifier as provided for under VI. B. of 3008(h) Order), (3) the SWMUs 7 and 11 that have been evaluated under VI. A. of 3008(h) Order are proposed to be capped herein; and, (4) the CAMU designation under XII of 3008(h) Order that is requested herein.

block were containerized and shipped to Heritage Environmental Services in Sauget, Illinois for incineration. Approximately 818 tons of nonhazardous carbon blocks and electrodes were recycled by Pamas and Company in Elberton, Georgia. A portion of the nonhazardous carbon blocks and electrodes were too small to be recycled, or passed the crush test, but had evidence of amorphous phosphorus on the surface, remain at the site and will be managed as non-hazardous solid waste.

The Used Brick and Furnace Liner Pile was designated as solid waste management unit number three (SWMU 3), and final closure of this area will be addressed under the RCRA §3008(h) Order (EPA, 2004).

Slag Pile

The 7003 Order [Section VII. C. (3)] requires a method of ensuring that operations in the slag pile would not create conditions that could cause used brick and furnace liner to spontaneously ignite. The slag pile is nearly 100% slag, which is an inert material. As such, this interim measure requirement presumably stems from reported observations by EPA inspectors that some used brick and furnace liner was present in the slag pile at the facility. The EPA noted that slag has been moved from the slag pile to the tailing basin, a manmade impoundment, within the facility boundary. EPA stated that moving slag materials might cause currently buried used brick and furnace liner material to be exposed, and temporarily burn. Consequently, all movement of slag in the coarse slag pile was suspended throughout the period of implementation of the interim measures. The Coarse Slag Pile was designated as SWMU 12, and final closure will be addressed under the RCRA §3008(h) Order (EPA, 2004).

Clarifier

One of the few remaining process units on-site is the clarifier, which was used to store crude phosphorus prior to its secondary processing in the roaster to produce elemental phosphorus. The clarifier is a 100 foot diameter, open-topped, in-ground unit that is constructed of reinforced concrete. The clarifier is approximately 12 feet deep and contains approximately 500,000 gallons of crude phosphorus solids, often referred to as sludge, covered by several feet of water. The location of the clarifier is shown on Figure 1-2.

The 7003 Order required Solvay to conduct "immediate measures" (i.e., fencing and signage) and the following interim measures at the clarifier area:

- Installing an automatic water maintenance system and its subsequent winterization;

- Eliminating wildlife contact by placing approximately 80,000 Bird Balls™ on the water to camouflage its surface; and
- Installing a continuous phosphine monitoring system around the clarifier.

These interim measures were completed according to the specific timeline established for the respective activity.

Final closure of the clarifier (a.k.a., SWMU 2) will be addressed under the RCRA §7003 Order (EPA, 2001). Section VII.K. of the 7003 Order provides:

> *... Respondent shall submit a written work plan that evaluates alternatives for the lawful disposition of the contents of the leaking clarifier ... ("Waste Plan"). The Waste Plan shall include at least one alternative for the lawful removal and disposal of the contents of the leaking clarifier ….*

To meet this requirement, the Waste Plan (Barr, 2001b) was submitted to EPA on November 16, 2001. It addressed the requirements of the 7003 Order, as well as additional information developed in response to EPA comments on prior submittals. The prior Waste Plan identified many process options but only identified two viable alternatives for the clarifier's contents at that time:

- Capping (two options)
- Off-site Incineration

EPA has not yet selected an alternative for the management of the clarifier materials and Solvay agreed to conduct additional studies to further evaluate management options. The Clarifier Waste Treatability Study was conducted in 3 phases. Phase 1 consisted of information gathering. Information on candidate treatment processes were compiled and catalogued according to treatment technology. Based on the Phase 1 Report (Franklin, 2007), the mud still technology similar to that developed by Albright and Wilson (A&W) for evaporation and subsequent recovery of the phosphorus was selected by EPA, Montana Department of Environmental Quality (MDEQ), and Solvay for further evaluation. Phase 2 consisted of pilot-plant design, construction and initial testing of a mud still, and Phase 3 consisted of additional testing of pilot plant operations. The treatability studies demonstrated that the clarifier material could be treated at a small scale level to recover elemental phosphorus of usable quality from a variety of feed compositions found in the clarifier materials (Franklin, 2012).

For decision making purposes, Solvay agreed to supplement the original Waste Plan (Barr, 2001) with an evaluation of the on-site phosphorus recovery alternative using the mud still technology. This

Supplemental Waste Plan builds upon the original Waste Plan document and describes each alternative with sufficient detail regarding their design and operation to properly evaluate them against the relevant criteria. Solvay expects that additional design details will need to be developed for any alternative selected by EPA. Solvay will respond to specific questions EPA may have and then submit a schedule with detailed designs, plans and reports that would be developed with EPA following selection of an alternative.

1.1 Waste Plan Organization

Section 2.0 provides an overview of the evaluation process and explains the evaluation criteria and methodology. The evaluation of the alternatives for the clarifier materials appears in Section 3.0. Section 4.0 provides a set of conclusions regarding the alternatives for the clarifier materials. Section 5.0 provides a list of references that were used for development of the Supplemental Waste Plan.

1.2 Waste Plan Implementation Report

A Waste Plan Implementation Report will be prepared detailing and confirming the completion of the activities associated with the selected alternative conducted pursuant to the Supplemental Waste Plan. The report will contain the following:

- Implementation dates for construction activities.
- Photographs documenting implemented actions.
- Description of any deviation from the approved plan(s).

The draft implementation report will be mailed to the EPA within 90 days after completion of the selected alternative, or as otherwise agreed with the EPA.

1.3 Site Ownership

The amended 7003 Order was issued in 2000 to Rhodia, which owned the Silver Bow Plant at that time. Extensive work was conducted at the direction of Rhodia to comply with the 7003 Order. In September 2011, Solvay S.A. completed the acquisition of the shares of Rhodia S.A. (Rhodia Inc.'s ultimate parent) and Rhodia Inc. became a member of the Solvay Group. Effective October 1, 2013, the Solvay Group United States corporate legal entity currently known as Rhodia Inc. changed its name to Solvay USA Inc. The company will remain a Delaware corporation and an indirect but wholly-owned subsidiary of Solvay SA based in Brussels, Belgium. The company will also remain a sister company of the other Solvay Group United States legal entities that are also subsidiaries of Solvay SA. This report refers to prior work that was performed by Rhodia as having been performed by Solvay to reflect the current legal owner and operator of the Silver Bow Plant.

2.0 Process for Evaluating Alternatives

This section provides an overview of how the technologies and developed alternatives for closing the clarifier were evaluated. The process consisted of gathering a knowledgeable team, identifying viable technologies and developing alternatives, an evaluation of each alternative against RCRA criteria, a comparative evaluation of the alternatives against the RCRA criteria, and a recommendation therefrom.

2.1 Gathering a Knowledgeable Team

This Supplemental Waste Plan represents the collective thinking of a team of professionals who together have over 200 years of directly relevant experience to the evaluation that is presented herein. The experience of the team members includes:

1. The team consists of four professionals from Solvay. These individuals have spent most of their professional life with responsibilities that involve the production of elemental phosphorus, the management of associated production residues, environmental compliance, and the decommissioning of elemental phosphorus plants.

2. Solvay has used five consulting firms in the development of the Waste Plan (Barr Engineering Company (Barr), Franklin Engineering Group, Inc. (Franklin), KPRyan Consultancy, JJDS Environmental, and ENSR). These consulting firms have direct experience in the potential risks associated with elemental phosphorus residues. They also are very familiar with the treatment, disposal, and decommissioning options that have been evaluated and are being implemented at the other elemental phosphorus (P4) production facilities. Barr has worked with Solvay on decommissioning issues relating to the Silver Bow facility since the plant ceased production in 1997 and has been heavily involved in the concurrent RCRA Corrective Action evaluations for the Silver Bow Plant. Franklin has extensive experience with designing, constructing, and operating elemental phosphorus recovery processes. Franklin assisted with the technology evaluation and treatability studies for the crude phosphorus.

3. The team also consists of a principal scientist of a major national consulting firm’s risk assessment group and his supporting professionals. They have been involved in evaluating risks associated with various remedial/closure/decommissioning alternatives for over two dozen projects.

4. The team also includes three lawyers who are intimately familiar with regulations that pertain to elemental phosphorus residues as well as evaluating decommissioning/closure/remedial options under RCRA and Montana State law.

This team was selected to ensure that each option was fully evaluated from a technical, legal and health and safety standpoint. Team members are listed in Appendix C.

2.2 Identification of Alternatives

Alternatives for managing the phosphorus-containing materials were identified by the project team based on their knowledge about the phosphorus industry, decommissioning of phosphorus plants, and the character of the phosphorus-containing materials at Silver Bow throughout the waste plan development process. The alternatives identified include on-site and off-site options for treatment, recovery and disposal of the clarifier contents.

The previous Waste Plan (Barr, 2001b), the Focused Feasibility Study Report (EPA, 2003), and the Phase 1 – Information Gathering Report (Franklin, 2007) evaluated all potentially feasible technologies regardless of their cost or how much time they would take to implement. These previous evaluations[3] were reviewed, and were found to still be applicable and relevant. The results of these previous evaluations were compiled, and the conclusions are summarized in Table 2-1.

Three viable technologies were identified through initial screening of technologies:

1. Capping
2. On-site Phosphorus Recovery (Mud Still Process)
3. Off-site Incineration

These viable technologies were incorporated into alternatives that could abate the characteristics that are the focus of the 7003 Order with respect to the clarifier material: (1) spontaneous and uncontrolled fires; and (2) generation of phosphine gas at potentially harmful levels.

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[3] The technologies were screened on an initial basis considering: (1) Site Characteristics (i.e., identify conditions that may limit or promote the use of different technologies); (2) Material Characteristics (i.e., will material characteristics inhibit the effectiveness of a technology); and (3) Technology Limitations (i.e., has the technology been used successfully in the phosphorus industry). Technologies were eliminated if they were not appropriate for site characteristics, are not effective at abating the hazardous characteristic, have not been demonstrated in the phosphorus industry, or if no off-site facilities are permitted to receive the phosphorus-containing material.

2.3 Alternative Evaluation Criteria

The alternatives were evaluated against five criteria identified in EPA guidance document "RCRA Corrective Action Plan", OSWER Directive No. 9902.3-2A (May 1994), and defined therein at pages 54-56 as follows:

a. ***Long-term Reliability and Effectiveness***

Demonstrated and expected reliability is a way of assessing the risk and effect of failure. The respondent may consider whether the technology or a combination of technologies have been used effectively under analogous site conditions, whether failure of any one technology in the alternative would have an immediate impact on receptors, and whether the alternative would have the flexibility to deal with uncontrollable changes at the site (e.g., heavy rain storms, earthquakes, etc.).

Most corrective measure technologies, with the exception of destruction, deteriorate with time. Often, deterioration can be slowed through proper system operation and maintenance, but the technology eventually may require replacement. Each corrective measure alternative should be evaluated in terms of the projected useful life of the overall alternative and of its component technologies. Useful life is defined as the length of time the level of effectiveness can be maintained.

b. ***Reduction in the Toxicity, Mobility or Volume***

As a general goal, remedies will be preferred that employ techniques, such as treatment technologies, that are capable of eliminating or substantially reducing the inherent potential for the materials at the facility to cause future environmental releases or other risks to human health and the environment. There may be some situations where achieving substantial reductions in toxicity, mobility or volume may not be practical or even desirable. Examples might include large, municipal-type landfills, or facilities with unexploded munitions that would be extremely dangerous to handle, and for which the short-term risks of treatment outweigh potential long-term benefits.

Estimates of how much the corrective measures alternatives will reduce the waste toxicity, volume, and/or mobility may be helpful in applying this factor. This may be done through a comparison of initial site conditions to expected post-corrective measure conditions.

c. ***Short-term Effectiveness***

Short-term effectiveness may be particularly relevant when remedial activities will be conducted in densely populated areas, or where material characteristics are such that risks to workers or to the environment are high and special protective measures are needed. Possible factors to consider include fire, explosion, exposure to hazardous substances and potential threats associated with treatment, excavation, transportation, and redisposal or containment of the material.

d. Implementability

Implementability will often be a determining variable in shaping remedies. Some technologies will require state or local approvals prior to construction, which may increase the time necessary to implement the remedy. In some cases, state or local restrictions or concerns may necessitate eliminating or deferring certain technologies or remedial approaches from consideration in remedy selection. Information to consider when assessing Implementability may include:

1. *The administrative activities needed to implement the corrective measure alternative (e.g., permits, rights of way, off-site approvals, etc.) and the length of time these activities will take.*

2. *The constructability, time for implementation, and time for beneficial results.*

3. *The availability of adequate off-site treatment, storage capacity, disposal services, needed technical services and materials.*

4. *The availability of prospective technologies for each corrective measure alternative.*

e. Relative Cost

The relative cost of a remedy may be an appropriate consideration, especially in those situations where several different technical alternatives to remediation will offer equivalent protection of human health and the environment, but may vary widely in cost. However, in those situations where only one remedy is being proposed, the issue of cost would not need to be considered. Cost estimates could include costs for: engineering, site preparation, construction, materials, labor, sampling/analysis, material management/disposal, permitting, health and safety measures, training, operation and maintenance, etc.

At page 21 of the "Guidance on the Use of 7003 of RCRA," EPA/OECA (Oct. 20, 1997), the EPA states that "EPA may also order … long-term cleanup, including the design, construction and implementation of any measures necessary to abate the conditions that may present an endangerment." Since the order issued to Solvay is a RCRA 7003 Order and its genesis was EPA's concern that the clarifier material presents an imminent and substantial endangerment for the generation of fire and phosphine gas, the Waste Plan was focused on abating the generation of fire and phosphine gas at harmful levels with respect to the clarifier materials.

The five evaluation criteria have been chosen because they are the criteria EPA normally uses in the RCRA program when evaluating remediation, closure and decommissioning options. For example, in the RCRA corrective action plan, EPA uses these five factors to evaluate various remedies that will reduce the contamination at a RCRA corrective action site to health based standards. These five factors evaluate the relative advantages and disadvantages of each alternative in terms of their long-term and short-term effectiveness; their reduction of toxicity, mobility and volume; their implementability; and cost. These factors were therefore deemed appropriate for an evaluation of Waste Plan activities under a RCRA 7003 Order that similarly involves decommissioning of units and areas with residual materials.

2.4 Evaluation Methodology

This section describes how each alternative was evaluated against the five evaluation criteria. This evaluation consisted of a mix of qualitative and quantitative analysis. For example, the evaluation of the cost of an alternative, and its short-term effectiveness, which includes potential risk of injury or fatality, are criteria that are very amenable to some level of quantitative analysis. The methodology for evaluating each of the criteria is described more below.

- **Long-term Reliability and Effectiveness.**
  This criterion considered whether the proposed technology has historically been demonstrated to be effective in controlling or removing the threat of fire and phosphine gas generation at harmful levels over the long-term. For example, factors that might impact the long-term reliability, such as erosion and earthquakes, were considered in the evaluation of these criteria.

- **Reduction in Toxicity, Mobility or Volume.**
  With respect to reduction of toxicity, this criterion considered the inherent toxicity of the clarifier material. Distinctions were made between alternatives that remove the toxicity through recovery or destruction or otherwise reduce the concentration of the toxic constituents, versus options that control the toxicity by preventing pathways of exposure.

  With regard to reduction of mobility, Solvay has made similar distinctions between alternatives that reduce or immobilize the clarifier material itself versus options that reduce the mobility through creating barriers or other controls to the clarifier material.

  With regard to reduction in volume, Solvay has distinguished between options that recover or destroy the clarifier material versus options that do not change its volume.

  With respect to all three criteria--reduction in toxicity, mobility and volume--Solvay also considered how long it would take for an alternative to achieve the reduction. Options that take a long time to implement, while ultimately achieving a reduction in toxicity, mobility and/or volume, could allow existing potential hazards in the material to persist for several years before implementation of the alternative is completed.

An attempt was made to quantify these reductions where possible through modeling, data from similar sites, and/or experience.

- **Short-term Effectiveness.**
  The short-term effectiveness of each alternative was evaluated by considering the risks associated with implementing the alternative. As described in EPA's explanation of this criterion, as quoted above from EPA's "RCRA Corrective Action Plan," the risks include not only those to workers and contractors on-site, but also to off-site workers or others that might result from the transportation of the material to the incinerator or elemental phosphorus production facility and its management at that facility. The risk methodology employed for this analysis is based on a study entitled "Methodology for Assessing Worker Risks during Remediation at the United States Department of Energy's Hazardous Waste Sites" (Datskou & Sutherland, 1995) and a closely related study entitled "U.S. Department of Energy Worker Health Risk Evaluation Methodology for Assessing Risks Associated with Environmental Restoration and Waste Management" (Blaylock, *et al* 1995). The risk methodology is discussed in greater detail in Appendix D.

- **Implementability.**
  All of the alternatives are implementable, but some alternatives can be implemented more quickly and with greater certainty than others. Accordingly, for this criterion, factors such as how long it would take to design, construct, test and operate the decommissioning option were considered. Also considered, were whether various federal, state or local approvals would be required, and if so, how long those approvals may take. Finally, the evaluation considered whether it would have to rely upon external vendors and consultants for expertise and supplies to implement a particular option, and if so, the availability of such external services and supplies.

- **Relative Cost.**
  A quantitative analysis of the cost of each alternative was undertaken by considering the significant cost factors from design through construction, operation and maintenance, and completion. Certain assumptions, such as EPA or MDEQ designating an on-site corrective action management unit, also were made for costing each alternative. Order-of-magnitude cost estimates are prepared. This evaluation considers the capital and general operation and maintenance costs associated with the alternative. The cost of financial assurance was also estimated based on the order-of-magnitude cost estimates. Because very little of the detailed design is typically completed at this time, order of magnitude estimates are provided and are

expected to provide an accuracy of plus 50 to minus 30 percent for the described scope of the alternative. A fuller description of the cost methodology appears in Appendix E.

2.5 Comparative Evaluation

A comparative analysis of the alternatives is provided after the individual analyses of the clarifier material alternatives. In that section, each alternative is compared against each evaluation criteria. The comparison notes whether a particular option is better or worse than others, and also characterizes the option as to how well it meets the objectives of each criterion. This comparison helps to point out significant trade-offs between the different alternatives, and aids in the selection of an appropriate alternative.

2.6 Preferred Alternative

After the comparative evaluation of the alternatives, a preferred alternative is identified for evaluation and remedy selection by EPA. The comparisons are reviewed and trade-offs are highlighted.

3.0 Clarifier Materials

This section evaluates the alternatives for management of the crude phosphorus contained in the clarifier (i.e., clarifier materials) and provides the following information:

- Description of the clarifier materials and its assumed characteristics and regulatory status;
- Description of each alternative that was considered for the clarifier materials; and
- Evaluation of each alternative against the RCRA criteria.

3.1 Material Description and Regulatory Status

The Silver Bow Plant was constructed in the early 1950s to produce elemental phosphorus using an electric arc furnace method developed by the Tennessee Valley Authority. The letter from the Plant Manager, D. Bersanti, and the Process Flow Diagram attached to his letter, both of which are in Appendix F, explain this method. First, raw ore was beneficiated by passing it through two nodulizing kilns. The beneficiation process operated at very high temperatures using rotary kilns that caused the metals in the ore to sublime and the ore to agglomerate into nodules to make it suitable furnace feed. The nodules were mixed with coke and silica and charged into an electric arc furnace. Slag (primarily calcium silicate) was drawn off the furnace, cooled and stockpiled on site. From 1990 until the end of operations in 1997, approximately 50 percent of the slag was granulated to a sand size and stockpiled separately.

The electric furnace drove off the P4 as a gas, which was condensed to a liquid. The liquefied phosphorus was filtered. The liquid filtrate became the elemental phosphorus product. What was left was a sludge-like material that had substantial P4. This material, referred to as the crude phosphorus, was secondarily processed in a roaster to recover the remaining phosphorus. The clarifier was used to hold the crude phosphorus awaiting roasting. In March 1997, the roaster process was shut down, since the crude phosphorus could no longer be removed from the clarifier and fed into the roaster. The feed stream could not be maintained in a uniform slurry. The piping continuously plugged, and steady state feed conditions, which were critical to maintenance of operating temperature and pressure, could not be maintained. These difficulties are described in greater detail in D. Bersanti's letter in Appendix F.

The crude phosphorus contains approximately 20% [v/v] elemental phosphorus based on the roaster production record in Appendix F that reflects conditions just before the roaster ceased operations. The record shows that about 18.3% [v/v] of the crude phosphorus that was fed into the roaster from the clarifier in February 1997 was recovered as elemental phosphorus. The treatability study (Franklin,

2012) also showed that the average P4 content in eleven samples of crude phosphorus was 23% [v/v], which is consistent with the previous estimates.

The clarifier was constructed as a 100-foot diameter, open-topped, in-ground unit with reinforced concrete walls and base. Photos of clarifier construction showing the use of rebar are included in Appendix G. The clarifier walls extend above the ground approximately 0.5 feet on the south side and approximately 4.5 feet on the north, northeast and northwest sides, where the ground is somewhat lower. A metal railing approximately 3.5 feet tall is mounted on top of the west and southwest clarifier wall. The clarifier is approximately 12-feet deep, including the aboveground portion of the walls, and contains 8 to 9 feet of crude phosphorus, covered by more than 2 feet of water (the water cap). The crude phosphorus consists of elemental phosphorus, water and solids, such as phosphate dust, coke dust, and silica dust.

The clarifier contains an estimated 500,000 gallons of crude phosphorus. The crude phosphorus was not blended with other waste streams (i.e., high pH) that may be affecting the potential to generate phosphine that may have occurred at other elemental phosphorus production facilities.

The crude phosphorus is covered by the water cap. The water cap prevents the atmosphere from contacting and reacting with the elemental phosphorus. Water losses occur as a result of leaks in the clarifier and evaporation. The water cap is maintained by an automatic water addition system installed as an interim measure. The automatic water addition system adds water when the level falls below the low set point and shuts off when the water level rises above the high set point. The trigger is set to maintain the water level at more than 2 feet above the level of crude phosphorus in the clarifier. The water cap maintenance system has been winterized to provide for year-round operation. A fence was installed around the clarifier area during the interim actions. Figure 3-1 shows the general configuration of the clarifier and fence.

3.1.1 Regulatory Status of Clarifier Material

During an investigation in early May 2000, an EPA team removed several samples of the material from the water-covered clarifier, dried the samples in the atmosphere, and caused some of the samples to ignite after periods of about one-half to four hours. EPA considered this to satisfy the D001 ignitability characteristic and Solvay and EPA agreed to classify the clarifier material as D001 hazardous waste in the Plea Agreement Solvay entered into in 2003. Also, after agitating the water and crude phosphorus in the clarifier, the EPA team measured an instantaneous phosphine concentration of 1.08 ppm. Although this and subsequent readings did not exceed any worker protection standard in this Supplemental Waste Plan evaluation, Solvay will evaluate the potential for each alternative to minimize phosphine generation.

The EPA did not classify the clarifier material as a D002 corrosive hazardous waste and the water cap has a near neutral pH.

Two samples of crude phosphorus were collected and analyzed for RCRA metals in March 1997 by Energy Laboratories using Method 1311. These samples were taken in accordance with the procedures described in the *100-Foot Clarifier Sampling and Analysis Plan for February 1997*, which is included in Appendix G. The regulatory limits and corresponding leachate concentrations are summarized in the following chart:

Parameters	Leachate Concentrations (Method 1311)		
	Regulatory Limits [mg/L]	Crude Phosphorus Sample 01 [mg/L]	Crude Phosphorus Sample 02 [mg/L]
Arsenic	5.0	< 0.5	< 0.5
Barium	100.0	< 10	<10
Cadmium	1.0	< 0.1	<0.1
Chromium	5.0	< 0.5	< 0.5
Lead	5.0	< 0.5	< 0.5
Mercury	0.2	< 0.02	< 0.02
Selenium	1.0	< 0.1	< 0.1
Silver	5.0	< 0.5	< 0.5

All metals were below the respective TCLP regulatory limit. Copies of the analytical reports for these samples are included in Appendix G. The reports from Energy Laboratories are dated 3/03/97, and refer to “Sludge #01” and “Sludge #02.” Analysis of a blank sample is also included. Since representative samples of the crude phosphorus did not leach metals at concentrations above the regulatory limit, the crude phosphorus was not considered a hazardous waste based on metals.

3.1.2 Clarifier Conceptual Model

The clarifier was constructed as a 100-foot diameter, open-topped, in-ground unit with reinforced concrete walls and base. The clarifier walls extend above the ground approximately 0.5 feet on the south side and approximately 4.5 feet on the north, northeast and northwest sides, where the ground is somewhat lower. Based on soil borings installed near the clarifier, the soils are generally sand to silty sand in the upper 10 to 20 feet with silty sand to sandy silt with clay and some coarse lenses to 45 to

50 feet. Groundwater is approximately 20 feet below the bottom of the clarifier as shown on a cross section through the clarifier (Figure 3-2).

3.1.2.1 Hydrogeology

The general direction of groundwater flow in the vicinity of the clarifier is to the north-northwest (Figure 3-3) towards Silver Bow Creek. In the plant vicinity, the bedrock is igneous rock of the Boulder Batholith. The depth to bedrock is greater than 400 feet in places at the site, as demonstrated by well logs for the plant production wells. The unconsolidated material overlying the bedrock consists primarily of clays with lesser amounts of sands, silts, and loosely consolidated shale, silty shale, and silty sandstone. Coarse-grained deposits that produce significant yields of water were found below 185 to 230 feet deep when drilling the plant production wells. The upper 100 to 150 feet is sand, silt, and clay that produce less water than the deeper zones. The hydraulic conductivity of the upper groundwater unit is approximately 1 foot per day (ft/day) based on the geometric mean of the slug test results for the monitoring wells at the clarifier. A hydraulic gradient based on water levels measured in September 2013 in nearby monitoring wells is approximately 0.006 ft/ft.

3.1.2.2 Groundwater Quality

EPA required Solvay to conduct pre-closure groundwater monitoring of the area near the clarifier under the 7003 Order. A Field Sampling Plan and Quality Assurance Project Plan (Sampling Plan) (Barr, 2001a) for pre-closure groundwater monitoring at the clarifier was approved by EPA in a letter dated September 6, 2001. Three water table monitoring wells were installed at the clarifier in accordance with the Sampling Plan. MW-01-2 was installed upgradient (i.e., south) of SWMU 2, and MW-01-3 and MW-01-6 were installed downgradient of SWMU 2. Two additional wells (MW-02-1 and MW-02-2) were installed further downgradient of the clarifier to evaluate the potential transport of elemental phosphorus via groundwater. The monitoring well locations are shown on Figure 3-3.

Three rounds of groundwater samples were collected during the pre-closure groundwater monitoring program and analyzed for general and site-specific parameters, metals, VOCs, SVOCs, and radionuclides. The results were summarized in the Final Pre-Closure Groundwater Monitoring Report (Barr, 2002).

The clarifier monitoring wells were included in the site-wide groundwater quality monitoring program included in the RFI Work Plan (Barr, 2009). Investigation activities conducted at the clarifier (i.e., SWMU 2) were presented in Section 5.5.2 of the RFI Report (Barr, 2013), which is provided in Appendix H. The analytical results for the groundwater samples from the clarifier monitoring wells are detailed in Section 5.5.2.4. The main conclusion of the RFI Report related to groundwater quality at the clarifier is stated below:

> *Although it is clear that process water has leaked from the clarifier, no distinct trends in groundwater parameter concentrations are observed at this site over time. Only fluoride concentrations appear to be increasing over time. Alternatively, total phosphorus, sulfate, total and dissolved barium, total cobalt, total and dissolved manganese, and total nickel exhibit decreasing trends over time.*

Continued monitoring of groundwater quality trends associated with releases from the clarifier was recommended in the Draft Long-term Groundwater Monitoring Plan (Barr, 2014) that was submitted to EPA in May 2014. This monitoring plan would be reviewed and modified, if needed, to meet regulatory requirements of the closed clarifier.

3.2 Enhanced RCRA Cap

3.2.1 Description of Alternative

This alternative for the clarifier material would include closure of the clarifier in place with an Enhanced RCRA cap, and followed by post-closure maintenance of the cap, monitoring of groundwater quality and subsurface phosphine concentrations. The enhanced RCRA cap would include systems to capture and treat, as needed, phosphine gas, if any were generated at harmful levels.

This Enhanced RCRA cap alternative would close the clarifier with a multi-layer, multi-material cover (including a penetration-resistant layer and a synthetic flexible membrane liner (FML), also referred to as a geomembrane) that meets the RCRA standards at 40 CFR 265.310(a). RCRA caps have been selected for closure of phosphorus-containing wastes by the regulators in other EPA regions and states.

The proposed Enhanced RCRA cap system would: (1) provide long-term minimization of the migration of liquids through the clarifier material; (2) function with minimum maintenance; (3) promote drainage and minimize erosion or abrasion of the cover; (4) accommodate settling and subsidence so that the cover's integrity is maintained; and (5) have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

A schematic cross-section of the Enhanced RCRA cap is shown on Figure 3-4, and is the same cap design presented in the July 31, 2003 letter to J. Wardell from D. Bersanti, which is provided in Appendix I.

The first construction phase would involve:

- Placement of a geofabric filter over the clarifier material and placement of approximately four feet of a granulated slag subgrade with intermixed geoweb layers;

- Recession of the water;

- Filling the clarifier with an additional one to four feet (depending on location) of granulated slag subgrade;

- Placement of additional slag to surcharge and consolidate the underlying crude phosphorus and granulated slag; and

- Consolidation monitoring, as needed.

The crude phosphorus would be covered by water or slag at all times, thus minimizing the potential for fire. Specifically, the water cap would be maintained until the granulated slag layer covers the crude phosphorus to a depth of at least two feet. The water cap maintenance would then be suspended and the remaining water would be allowed to recede. As a backup, in the unlikely event that the crude phosphorus was to ignite during dewatering activities, the area of ignition would be covered immediately by additional granulated slag that would be stockpiled nearby.

The second phase of the Enhanced RCRA Cap construction would consist of:

- Removing the excess slag (i.e., surcharge layer) and installing the phosphine monitoring/collection piping;

- Adding a 6-inch sand and 6-inch liner foundation layer

- Equivalent Low Hydraulic Conductivity Layer – Geosynthetic Clay Liner (GCL) [Hydraulic conductivity on the order of 10^{-9} cm/s];

- Flexible Membrane Liner (FML) – 60-mil High Density Polyethylene FML;

- Drainage Layer – synthetic polyethylene drainage material (e.g., Geonet); and

- Filter Layer – synthetic filter fabric.

Protective Layer – The overall thickness of this protective layer was designed to place the flexible membrane liner below the normal frost penetration depth (i.e., 42 inches [Harrington, 2000; personal communication]), and provide adequate soil to support growth of the vegetation. This protective layer would consist of, from bottom to top, a(n):

- 1-foot (30 cm) of sand as a filter

- 1-foot (30 cm) granulated slag (sand) layer to protect the underlying flexible membrane and geosynthetic clay layers during construction
- 2.5-foot (75 cm) (minimum) biotic protection layer of coarse slag placed in lifts to minimize settling
- 1-foot (30 cm) granulated slag filter layer
- Additional geofabric layer
- A 2.5-foot (75 cm) topsoil layer
- 1-foot (30 cm) topsoil with 15% pea gravel, and vegetation

The areal extent of the enhanced RCRA cap is shown on Figure 3-5. Due to the overall thickness of the enhanced RCRA cap and allowable slope, the enhanced RCRA cap would extend over a large portion of the adjacent crude phosphorus burial area (SWMU 11). The conceptual cap was expanded over the entire crude phosphorus burial area for constructability concerns.

When the cap was complete, a perimeter fence would be installed around the cap area to restrict access and discourage animal presence close to the cap.

Safety procedures during construction would include continuous phosphine monitoring in accordance with a plan to be developed for the specific construction sequence. Personal phosphine monitoring would be conducted during construction activities. Personal protective equipment would also be used, as described in Appendix D for the protected worker.

The Enhanced RCRA cap would meet the standards in 40 CFR § 265.310(a)(1)-(5). Specifically, the design cap would:

40 CFR § 265.310(a)	Cap Design
(1) provide long-term minimization of the migration of liquids through the used carbon brick and furnace liner pile;	As discussed in Section 3.2.1, the cap would minimize migration of rainwater through the barrier layer.
(2) function with minimum maintenance;	Minimal maintenance would be necessary given the consolidated contents, arid conditions and minimum slopes.
(3) promote drainage and minimize erosion or abrasion of the cover;	Positive drainage would be maintained by a final surface slope of 3 to 5 percent from the center of the cap to the edges.
(4) accommodate settling and subsidence so that the cover's integrity is maintained; and	The materials would be consolidated before the cap would be constructed. Therefore, minimal settling and subsidence would be expected.
(5) have a permeability less than or equal to the permeability of the natural soils present.	The cap would meet this requirement as described in the next paragraph.

The cover design exceeds EPA's design recommendations in its Final Covers Guidance in three beneficial respects. First, the barrier layer, which consists of a geosynthetic clay liner (GCL), would exceed the specified 10^{-7} cm/s hydraulic conductivity by approximately two orders of magnitude. Second, a 60 mil FML would be used instead of the thinner 20 mil FML. Finally, instead of two feet of material above the drainage layer, the design would entail a minimum of 9 feet of cover material to protect the synthetic liners from frost penetration and burrowing animals. This layer is nearly three times greater than the 3.5 foot average of frost penetration in the Butte, Montana area. In addition, there would be nearly 7 feet of subgrade, which would result in a total cap of nearly 16 feet of material above the clarifier material.

The capped area would be designated in the land records as a no excavation zone. The substantive requirements of 40 CFR §§ 265.116, .119 and .309 would also be met, including designating the restricted area on the survey plat, providing required notices of waste disposal, and maintaining records of waste disposal.

The no excavation restriction would be placed on the land records so that any future purchaser would take the property subject to this restriction. By so restricting the use of the property, any future purchaser would be unable to convey the property again if it were to violate this restriction.

In addition, this alternative would restrict the use of the clarifier area by applying Mont. Code Ann. § 75-10-727 to restrict the property without a conveyance. The statute allows restrictions on property to run with the land and successors in interest to be bound by the restrictions. This option requires approval by the MDEQ. The statute provides:

> *"(2) The institutional control restricting present and future real property rights is placed on a property by filing a written instrument evidencing the restrictions to be placed on the use of the property with the county clerk in the county where the real property is located.*
>
> *(3) An institutional control that restricts real property runs with the land and is binding on all successors in interest to real property until the institutional control is removed."*

A restriction could only be removed if approved by MDEQ. Restricting the use of property where materials have been landfilled is a common and widely used practice. For example, following closure of Class II landfills in Montana, a notation must be recorded in the deed or other instrument subject to a title search that the land has been used as a landfill and that its use is restricted. ARM 17.50.530(1)(i). When notice of a restriction is given, it is enforceable by the local governmental authorities. *See* Hampton v. Lewis and Clark Co. Commission, 2001 WL 46317 (Mont. 2001). Selection of appropriate institutional controls would be resolved at closure.

A Post-Closure Plan consistent with 40 CFR § 265.118 would be developed for the Enhanced RCRA cap. The post-closure plan would identify the routine activities that would be conducted after the enhanced RCRA cap is constructed.

Maintenance of the cap would include inspection, assuring vegetation establishment, and correcting any critical erosion within a specified time period. Such inspections would occur in the spring after snow melt, in the fall before significant snowfall, and after any precipitation event that exceeds the 25-year, 24-hour storm. During these inspections, the fence would also be inspected, and repaired if necessary.

Monitoring of vapors beneath the cap would be specified in a phosphine monitoring program. Intitially, phosphine monitoring might be conducted on a quarterly basis, but the frequency would be modified based on findings of the initial program. If actionable levels of phosphine are found, a phosphine treatment system (e.g., vapor-phase carbon) would be connected to the phosphine monitoring/collection system for capturing and destroying the phosphine gas.

A groundwater monitoring system would be installed at upgradient and downgradient locations to continue to monitor the groundwater quality near the closed clarifier. For cost estimating purposes, the groundwater monitoring network consists of 5 monitoring wells with annual sample collection and analysis for the 30-year post-closure monitoring period[4]. This data would be used to continue to evaluate groundwater quality trends associated with releases from the clarifier. If the groundwater monitoring program identifies an ongoing trend of increasing contamination related to releases from the closed clarifier then corrective measures would be evaluated at that time.

Operation, maintenance, and monitoring activities would be evaluated on a periodic basis to improve efficiency, effectiveness, and reliability, and to reflect knowledge gained from the program. Adjustments to the program would be recommended for EPA approval on the basis of these evaluations.

3.2.2 Evaluation of Alternative

This Section evaluates the enhanced RCRA cap alternative against the five evaluation criteria described in Section 2.3.

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[4] Groundwater monitoring beyond the 30-year post-closure period specified in 40 CFR 265.117 may be necessary, but the costs for extended monitoring period are not reflected in the cost estimate for this alternative.

3.2.2.1 Long-term Reliability and Effectiveness

Flexible membranes and other similar membrane-containing caps have been successfully used at phosphorus production facilities to provide effective containment of residual phosphorus-bearing materials. These caps are designed to last for many hundreds of years and their reliability to control ignition and phosphine generation can be assured early on. High density polyethylene (HDPE) liners, as proposed for this option, can be expected to last for a very long time. "*…HDPE geomembranes should last well beyond the 30-year closure period required in many environmental regulations without any measurable degradation mechanical properties. Clearly, lifetime of hundreds of years appear to be achievable.*" (Hsuan, 1995).

Monitoring and maintenance activities designed into the management strategy for the enhanced RCRA cap, would reinforce the effectiveness of the cap over time and address specific concerns about the generation and release of phosphine and groundwater contaminants.

As noted above, multi-layer caps have been in place at the Silver Bow Plant since the late 1970s, and five were in place and evaluated in the 1993 Albright & Wilson study (AWA, 1993). Although enhanced caps have been used for less than three decades, their use in situations similar to the Silver Bow Plant, have shown no problems that would raise questions about their long-term effectiveness.

Phosphine monitoring at the Silver Bow Plant found non-consequential concentrations of phosphine in the soil gas in the immediate vicinity of SWMU 11. SWMU 11contains crude phosphorus that was occasionally excavated from the clarifier and immediately placed in trenches and covered with soil or slag. This burial area was closed in the late 1970s with a multi-layer cap. The phosphine concentrations detected in the soil gas were at least two orders of magnitude below the Immediately Dangerous to Life or Health (IDLH) level of 50 ppm_v, and the maximum phosphine concentration detected in the soil gas was below the occupational short-term exposure level (STEL) of 1.0 ppm_v. The results from the screening level phosphine monitoring program demonstrate that phosphine is not being released to the atmosphere at consequential concentrations. Low concentrations of phosphine are present in the soil gas in the immediate area below ground, with no detected concentrations above ground (Barr, 2013).

Hazardous levels of phosphine were generated at certain capped waste ponds at the FMC Plant. These ponds contain elemental phosphorus waste streams and alkaline conditions ($pH > 8$). These alkaline conditions provide the ingredients to increase the rate of phosphine generation. Capped ponds at the FMC Plant that contain elemental phosphorus waste and acidic conditions (i.e., Phase IV Ponds) have not generated actionable levels of phosphine (Feldman, 2014).

Moreover, the history of soil caps over the last several decades demonstrates that soil caps are very effective in eliminating the hazards of fire and phosphine generation at harmful levels. Since the Enhanced RCRA cap contains nine feet of additional synthetic and natural liner on top of the traditional soil cap, one would expect the Enhanced RCRA cap to be every bit as reliable in the long term as soil caps have been.

The Enhanced RCRA cap at the clarifier would not be susceptible to failure due to erosion or flooding. The clarifier is not a drainage way, so neither flooding nor nearby runoff would induce erosion of the clarifier cap. Only water falling on the cap would contact it. The 100-year, 24-hour rainfall for this area is 3.2 inches and the 25-year, 24-hour rainfall is 2.6 inches (National Oceanic and Atmospheric Administration, 1973). The runoff during 24 hours from this little rain is not adequate to cut through the cap material, much less any burrowing animal protection zone, synthetic membranes, or the concrete clarifier walls. Animal activity would also be impeded from affecting the synthetic liner by the burrowing-animal barrier and a fence. This form of cap is extremely effective at minimizing infiltration. The range of infiltration estimated by the HELP model for this conceptual Enhanced RCRA cap (Appendix J), based on a sensitivity analysis of relevant parameters, would be from 3E-6 inches/year to 6E-6 inches/year. The corresponding range of annual percolation values would be 0.002 ft^3/yr to 0.004 ft^3/yr. Thus, the Enhanced RCRA Cap would achieve its purpose of greatly minimizing infiltration over the full range of conditions. Flooding would be unlikely at this location, as Silver Bow Creek is 3,000 feet away from the clarifier and 50 feet lower in elevation. The clarifier is not located in the 100-year flood plain of Silver Bow Creek (DHES, 1989). The cap would be flexible enough to accommodate differential settlement. Deed restrictions would define this area as a no excavation zone, so that the integrity of the cap would not be compromised by human activity.

This site is located in Earthquake Hazard Zone 3, which is not expected to suffer the severe earthquakes expected in areas like San Francisco along the San Andreas Fault. The cap would be designed to resist damage from reasonably anticipated earthquake forces, such as earth-shaking or horizontal acceleration forces. Uncontrollable changes at the site such as those caused by earthquake could conceivably affect the cap, but the cap is flexible, and the cover soil could easily be repaired if needed.

The cap could accommodate a wide range of native vegetation cover types, including shallow-rooted trees, because of the thickness of the cover soil. After the cover vegetation has been established, and monitoring has demonstrated no on-going environmental issues, this form of cap could function effectively without further maintenance. Nonetheless, the cap would be inspected before and after the snow season and after each 25-year storm event, and it would be maintained whenever necessary.

3.2.2.2 Reduction in the Toxicity, Mobility or Volume

The potential for exposure to the inherent toxicity of the material would be essentially eliminated. The cap would provide a barrier to the air that is essential to cause ignition. Phosphine generation would be minimized by several mechanisms. Contact with water, necessary to generate hazardous levels of phosphine, would be greatly minimized by the infiltration-reducing effect of the Enhanced RCRA Cap. The pH of the precipitation would be buffered by the soil so that the water would not be highly alkaline, again reducing the potential for phosphine production. Additionally, a phosphine monitoring system would be in-place to detect hazardous levels of phosphine and, if found, a phosphine treatment system would be designed and operated to prevent exposure to harmful levels of phosphine. Note: Phosphine monitoring in soil gas at the Silver Bow Plant has not shown harmful levels being generated at the capped SWMUs that contain elemental phosphorus-containing materials (Barr, 2013).

Regarding the mobility of the clarifier material, the Enhanced RCRA cap provides a very low permeability cover that serves to minimize the mobility of substances that might otherwise leach from the clarifier materials and be transported in dissolved form in the water. After cap construction, estimated infiltration would be reduced to less than 0.03 gallons per year over the clarifier area, thus reducing the potential for leaching to insignificant levels. In addition, the monitoring for potential groundwater impacts provides a safety net.

The enhanced RCRA cap quickly ends the need to maintain the water cap and the future percolation through the clarifier contents would be reduced to the water infiltrating through the cap, which is estimated to be from 3E-6 inches/year to 6E-6 inches/year (Appendix J). This future condition has been modeled to estimate the potential impacts of the capped clarifier on groundwater quality. Three approaches were used to evaluate the potential impacted on groundwater quality: (1) Partition Model; (2) Leachate Model; and (3) Solids Model (see Appendix K). These evaluations shows that no impacts to groundwater would be expected above drinking water quality standards if the enhanced RCRA cap were placed on the clarifier. This finding holds true, using the consciously conservative SSL model, for all three different approaches to evaluating protectiveness for groundwater. In addition, the sensitivity analysis of infiltration (see HELP model, Appendix J), found less than an order of magnitude increase in infiltration under the full range of sensitivity conditions evaluated. These sensitivity results mean that, for the expected range of infiltration conditions, the cap remains protective of groundwater.

The Enhanced RCRA cap option does not reduce the volume of material that would be left in place, other than removal of the water cap. Nonetheless, for the reasons noted above, the Enhanced RCRA cap would ensure that the remaining clarifier material would not be a source of groundwater contamination or of fire or phosphine generation at harmful levels.

3.2.2.3 Short-term Effectiveness

The short-term effectiveness of the Enhanced RCRA cap option would largely be a function of the risks resulting from the activities that would be necessary to construct the Enhanced RCRA cap. These risks would primarily be from mechanical hazards, like digging borrow soil, and from the potential for fire and phosphine gas generation during the first phase of cap construction. Once the first phase granulated slag cap is in place, there would be relatively little potential for fire or phosphine exposure for the workers engaged in the second phase construction work.

The list of steps that were evaluated for risk for this option included the following:

- Site preparation
- Subgrade placement (moving fill materials to and then into the clarifier)
- Surcharge placement/removal (placing and grading the coarse cover material)
- Consolidation monitoring (dewatering and stabilization of the covered material)
- Gas collection system installation
- Subgrade grading
- Synthetic liner placement
- Cover soil placement/grading(final layer)
- Restoration/revegetation
- Maintenance of the cap and groundwater monitoring system

The estimated crew size and task duration for this work area are shown in Appendix L. There would be some potential for incidental exposure to phosphorus-bearing materials during the “placing of the initial coarse cover” and thus the workers were assumed to operate under a site-specific health and safety plan, as explained in Appendix D. However, the potential for fire and phosphine generation after that initial construction would not be significantly different from ordinary construction risk rates. The exception is that the revegetation task would have a bit lower rate, since such activity would mimic landscaping and grounds keeping activities, and the monitoring and maintenance risk rate would also be lower since this activity would be akin to typical professional consultant work.

Table 3-1 presents the probability of a fatality for this option. The risk calculations are provided in Appendix M. The probability of a fatality to the unprotected worker would be “low” 0.0007%.The probability of serious injury to the unprotected worker would be somewhat higher (0.02%), but the value shown in Table 3-2 is at a “medium” risk level. The protected worker would face a probability of about 0.0006% of fatality, and 0.02% of serious injury. These relative risks are considered “low” and “medium.”

3.2.2.4 Implementability

A preliminary implementation schedule was developed based in the review team’s professional judgment and experience with similar capping projects. The preliminary implementation schedule represents a best estimate at the duration of this alternative.

Preliminary Implementation Schedule

Timeline	Description
4Q 2015	Supplemental Waste Plan.
1Q 2016	EPA approves the Supplemental Waste Plan.
1Q 2016	EPA conducts a public hearing on the Supplemental Waste Plan remedy and selects this capping remedy.
2Q 2016	EPA prepares the Corrective Measures Decision Document.
2016-2017	Phase 1 Cap Design and Construction - Subgrade and surcharge placed, and design for Phase 2 cap construction.
2018	Phase 2 Cap Construction – Remove surcharge and construct cap layers and grade/seed.
2019	Construction of enhanced RCRA cap complete and vegetated surface established. The Draft Waste Plan Implementation Report would be submitted to the EPA within 90 days after completion of the cap construction.

This alternative would likely take two construction seasons to consolidate the clarifier materials and build the multi-layer cover systems. Implementation of the enhanced cap option could begin promptly after EPA approval, weather conditions permitting. No permits would be necessary. The Enhanced RCRA cap would be constructed using standard construction techniques and equipment that are readily available on-site or from commercial sources, as necessary. No off-site treatment, storage capacity, or disposal services would be required to implement this alternative. Contractors could quickly be trained to undertake the construction activities.

The construction time is estimated at a few months during the first construction season to place the subgrade and any necessary surcharge. The surcharge would remain until the second construction season, which is estimated at a few months to construct the Enhanced RCRA cap and establish the vegetated surface. Vegetation may require more than one growing season after cap construction to fully establish a vegetated surface. Design work, contractor procurement, and approval of the necessary air monitoring and other plans for construction may be assumed to require several months prior to construction. This alternative offers the following benefits from its quick implementation:

- The short duration of construction would result in any mechanical, fire and phosphine risks from construction being short-term;
- Potential for fire and phosphine generation would be removed quickly; and
- Beneficial effects for the environment would commence upon completion of the cap subgrade, because any potential percolation of leachate from the clarifier area into the groundwater would begin declining as soon as the water addition to the clarifier is terminated.

In a letter dated June 27, 2003 to Rhodia, EPA Region 8 made a preliminary decision that a capping alternative would not be the best option for the short and long-term management of the clarifier wastes[5]. MDEQ concurred with EPA's preliminary decision in a letter to the Director of EPA Region 8 dated June 26, 2005, and questioned whether this alternative could be approved by the regulators.

3.2.2.5 Relative Cost

The representative cost of this alternative is estimated at $5.0 million and the cost of financial assurance is estimated at $0.43 million for a total estimated cost of $5.4 million. This order of magnitude estimate is expected to provide an accuracy of plus 50 to minus 30 percent for the described scope of the alternative. The details of the cost estimate are in Appendix N and the cost estimate methodology is in Appendix E.

3.3 On-site Phosphorus Recovery (Mud Still Process)

3.3.1 Description of Alternative

The on-site phosphorus recovery alternative involves recovery of the elemental phosphorus as a usable product. The mud still technology was developed by Albright and Wilson (A&W) in the early 1970s and patented in 1978. Nine individual mud still treatment trains were constructed at five separate elemental phosphorus production plants (two in the United Kingdom, two in Canada, and one in the United States of America). These treatment trains were safely and successfully operated for a period of approximately 20 years. These elemental phosphorus plants including the mud still treatment trains were decommissioned during the early 1990. A more detailed history of operation of mud still treatment systems is provide in Appendix O. Solvay has retained knowledgeable staff that helped develop and operate this patented treatment process.

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[5] The preliminary decision was based on the alternatives presented in the Waste Plan (Barr 2001a) and the Focused Feasibility Study Report (EPA, 2003).

As was done at other elemental phosphorus plants, a mud still treatment train would be constructed at the Silver Bow Plant that would vaporize P4 from the crude phosphorus and condense the phosphorus vapor into a usable product. The mud still would likely be located near the clarifier for logistical purposes, as shown on Figure 3-6. The on-site phosphorus recovery would involve three distinct operations, as depicted on the process flow diagram (Figures 3-7 and 3-8). The operations include:

- Crude Phosphorus Excavation and Handling;
- Mud Still Operations; and
- Residue Management.

Each of the operations is described in the following subsections. The mud still technology was identified and evaluated as part of a three-phase treatability study, which culminated with the construction and operation of a pilot-scale mud still. Much of the information included in the following subsections is derived from the results of the treatability study (Franklin, 2007; 2011; 2012). A conceptual layout of the mud still is depicted on Figure 3-9.

3.3.1.1 Crude Phosphorus Excavation and Handling

The first process involves excavation and handling of the crude phosphorus sludge, as depicted on Figure 3-7. The crude phosphorus sludge would be removed from the clarifier using an excavator with bucket attachment. The material would be transferred from the excavator bucket to a metal skip that would be located within a spill pan (i.e., secondary containment) adjacent to the clarifier. Approximately 590 gallons of crude phosphorus sludge would be placed in the skip (10-foot diameter by 1 foot deep). The bucket could be continuously sprayed with water to minimize fires that could occur if the crude phosphorus were exposed to air. Any material that spills during transfer would be captured by the spill pan and flushed back into the clarifier.

The water cap would be maintained at least one foot above the layer of crude phosphorus in the clarifier. If necessary, production well water would be added to increase the water level to extinguish crude phosphorus fires. The water cap would be maintained at a pH between 5.0 and 6.0 standard units to minimize the potential for phosphine generation. This pH adjustment, which was standard practice to minimize phosphine generation during plant operations, would be accomplished by adding concentrated acid to the water cap.

As the water level recedes during the removal of crude phosphorus, crude phosphorus would likely cling to the walls of the clarifier and could ignite. To minimize this situation, exposed crude phosphorus on the interior clarifier walls would be washed (i.e., high pressure hot water) into the clarifier in an attempt to dislodge the material and minimize fires. Some P4 would likely remain entrained in the crevices of the clarifier walls, which is one reason why after the crude phosphorus removal occurs, the clarifier would be filled and covered as part of the designated CAMU.

During removal, excess water would be decanted from the skip back to the clarifier, leaving about a few inches of water over the crude phosphorus in the skip. A lid would then be secured over the skip compartment and the covered skip would be transported to the skip staging area near the mud still furnace.

Despite the procedures that would be followed to attempt to maintain the water cap throughout the process, removal and transfer activities might result in situations where some amount of the crude phosphorus might be exposed to air. As a result, phosphorus fires could occur during the excavation and transfer operations. Fires outside the clarifier could be smothered with granulated slag or water. If exposed materials in the clarifier ignite, additional water could be pumped into the clarifier until the burning materials were covered and extinguished. Procedures for safe operations would be addressed through the process safety management of highly hazardous chemicals program, and development of a health and safety plan, and contingency plan.

Crude phosphorus would be removed from the clarifier until it could no longer be safely and practicably removed by the excavation equipment (estimated between 80% to 98% removal). The concrete surface would be scraped with the smooth-edge bucket to remove as much crude phosphorus as practicable. The excavator encountered the concrete bottom of the clarifier during the excavation of crude phosphorus for the pilot plant tests. If in some areas, the concrete bottom has deteriorated, the excavation would terminate at the bottom of the clarifier. As noted earlier, high pressure hot water jets would also be used to dislodge crude phosphorus from the walls and enable its removal. For safety reasons, workers would be instructed to not go into the clarifier to remove crude phosphorus. At the point when removal of the crude phosphorus sludge would no longer be safe and practicable, EPA would be consulted to confirm that the removal activities may be terminated. A water layer would be maintained over the sludge that cannot be safety and practicably removed from the clarifier to prevent fires until the CAMU construction begins.

The literature indicates that EPA has acknowledged that all environmental dredging projects leave behind some residual contamination in sediment due to resuspension in the water column, dislodged material that is left behind, slope failure, etc. and material that cannot be removed because of site conditions and equipment constraints (EPA, 2005). Studies conducted by the Army Corp of Engineers (ACE) suggest that approximately two to nine percent of the mass of materials during the last production cut typically remain as residuals (ACE, 2008). For example, if the last production cut were one foot, then about an inch of sediment would likely remain in the excavated area. The crude phosphorus may behave differently than the sediments evaluated by the ACE, but the principles remain the same and suggest that some mass of crude phosphorus would remain in the clarifier even under the most optimal excavation conditions. EPA and ACE acknowledge that contaminated residuals are a factor that needs to be considered and managed. Therefore, the material that cannot be removed from the clarifier would be covered with granulated slag or soil as described in Section 3.3.1.4.1.

3.3.1.2 Mud Still Operations to Recover Elemental Phosphorus

The second process is operation of the mud still. The mud still operation involves a series of connected tanks and process equipment, as depicted on Figure 3-7.

The skip would be placed in the mud still furnace compartment. The lid would be removed from the skip and the furnace compartment would be closed. The electric furnace would heat molten lead, which acts as the heat transfer medium and provides a seal for the skip. As the temperature of the still rises, water would be vaporized (at approximately 202 ºF), followed by vaporization of white phosphorus (approximately 503 ºF) and conversion of some white phosphorus to red phosphorus. As the temperature continues to rise, the red phosphorus would be vaporized at approximately 730 ºF. The furnace would be continuously purged with nitrogen to maintain the necessary reducing atmosphere and to drive the water and phosphorus vapors through the process.

The water and phosphorus vapors would be conveyed to a stainless steel condenser where the vapors would be condensed to liquid water and phosphorus. The liquid phosphorus would accumulate in the bottom of the condenser since it is denser than water. The liquid phosphorus would be removed from the condenser at the end of each batch and transferred to a product phosphorus collection tank. When sufficient volume of product phosphorus has accumulated in the collection tank, the contents of the collection tank would be transferred to an International Standards Organization (ISO) specification container that would meet the U.S. Department of Transportation (DOT) requirements for transporting elemental phosphorus.

The filled ISO container would be hauled via truck to a Solvay P4 facility. The Solvay facility in Charleston, South Carolina was used for risk evaluation and cost estimating purposes. Approximately 38 shipments (20 tons per truck shipment) would be necessary to transport the phosphorus product to the P4 facility. The distance between Silver Bow, Montana and Charleston, South Carolina is estimated at 2,350 miles, for a total loaded travel distance of about 89,000 miles.

Process water would be sprayed through nozzles throughout the condenser. The water would collect at the bottom of the condenser above the phosphorus layer. The water level would be maintained by an overflow pipe that would convey the water to the water collection/recirculation system. Water from the collection tank would be recirculated to the condenser and to a wet scrubber (see below). If excess water were present in the collection tank, it would be piped back to the clarifier.

Small amounts of phosphorus may collect in the water collection/recirculation tanks. Phosphorus that accumulates in these water tanks would be transferred to the phosphorus collection tank, when needed.

The gas stream that exits the condenser would likely contain low concentrations of phosphorus vapor and possibly phosphine. Therefore, the exit gas stream would be directed to a vapor combustor where the reduced phosphorus compounds would be oxidized to phosphorus oxides and water. The off gas from the vapor combustor would be directed to a wet scrubber to remove the oxidation products. Exhaust from the wet scrubber would be vented to the atmosphere and water that accumulates would be sent to the water collection/recirculation system.

Water would be reused to the maximum possible extent. However, some water might need to be removed from the water recirculation system on a periodic basis (e.g., blow down) or would remain at the end of the operations. This excess water could be returned to the clarifier if needed, or discharged to an evaporation basin constructed for that purpose. The excess water would contain low quantities of elemental phosphorus, phosphate, fluoride and metals.

The mud still would be operated on a batch basis. If the mud still were to process five batches over seven days with round-the-clock operations (i.e., 24 hours per day; 7 days per week), the length of time necessary to process the 500,000 gallons of the crude phosphorus would be on the order of 170 weeks of continuous operation. In reality, the mud still would require a regular turn around period for equipment inspection and maintenance, which would likely result in at least five, and likely more, years of total operation and maintenance.

The treatability study helped to identify operational parameters that need to be monitored to help evaluate when to terminate the heating portion of the operations. During one of the trial runs, the heating portion was not run long enough to vaporize all of the elemental phosphorus from the skip. This elemental phosphorus ignited when the lid was removed from the vessel. To reduce the likelihood of this happening during production-scale operations, monitoring of the temperature and pressure of the mud still system and the characteristics of the still vapor would be a critical part of the operation. Operation of the mud still and monitoring of the operational parameters would require specific training.

3.3.1.3 Residue Management

The third part of the on-site mud still phosphorus recovery process would be management of the mud still solid residues. The solid residues from the mud still's recovery of P4 would remain in the skip.

After completion of each batch, the skip would be removed from the furnace compartment and placed in the residue management area (see Figure 3-8).

A vacuum system would be used to remove the solids from the skip and transfer the residue to the residue silo. These dry solid residues would be fed into a residue silo through a cyclone separator. Air from the cyclone separator would travel through a bag house before it would be emitted to the atmosphere. The solid residues would collect in the silo, and then transferred (via gravity) to super sacks for storage until disposal back into the clarifier after crude phosphorus removal is completed and the CAMU has been designated. The solid residues consist of phosphate ore, coke, silica, and other inert materials that were in the crude phosphorus sludge.

Results of solid residue samples tested during the treatability studies are summarized in Appendix P. The solid residue would not be a hazardous waste for ignitability since the elemental phosphorus would have been vaporized from the solid material by the mud still operation. For the pilot test runs that went to completion, there was no smoke or fire, or phosphine emission when the still was opened[6]. In addition, the solid residue does not have an aqueous or liquid layer, and as such, could not be a hazardous waste for corrosivity.

Eight of eleven solid residue samples analyzed during the treatability study failed the TCLP test for cadmium but no other metal (see Appendix P). As such, much of the solid residue would exhibit the D006 hazardous waste toxicity characteristic for cadmium.

3.3.1.4 Corrective Action Management Unit (CAMU)

As part of this mud still remedy, the clarifier (which is SWMU 2) would be designated as a CAMU and closed with an evapotranspiration cap. This CAMU would be the long-term disposal unit for the mud still solid residue, which would be placed back into the clarifier, as well as for the crude phosphorus sludge that cannot be safely and practicably removed from the clarifier.

A CAMU designation permits disposal of hazardous waste residues without first treating the solid residues to meet land disposal restriction (LDR) standards. See 40 CFR §264.552(a)(4). Further, the CAMU would not be required to meet the minimum technological requirements of a double liner and leachate collection system. See 40 CFR §264.552(a)(5). As such, the solid residue from the mud still

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[6] In the unlikely event that there is a flame observed from any solid residue, the material would be extinguished, and then reprocessed in the mud still after confirming that the mud still is operating properly

operations could be placed into the clarifier and the crude phosphorus sludge that cannot be safely or practicably removed would remain in place in the clarifier for long-term disposal.

3.3.1.4.1 Design and Operation of CAMU

After all of the crude phosphorus sludge that can be safely and practicably removed from the clarifier is removed and processed in the mud still, Solvay would begin constructing the CAMU. First, if there were any excess cover water (an amount beyond what would be needed to prevent the remaining crude phosphorus from igniting), Solvay would remove the excess water and manage it on-site in an evaporation pond.

A solid waste management system license might be needed to construct and operate an evaporation pond for this nonhazardous wastewater. Solvay met with MDEQ on March 7, 2014 to discuss such license. At that time, MDEQ indicated that there was insufficient information to make a final determination as to whether a license would be required. Solvay will continue discussions with MDEQ to determine whether a license is required, and if so, Solvay would work with MDEQ to obtain the necessary license.

Next, the remaining crude phosphorus that cannot be safely or practicably removed would be covered with about 2 feet of granulated slag. The slag is a fine grained (particle size of about 0.1 to 1.5 mm diameter) calcium silica material that would act as an absorbent for any remaining liquid, and would serve to prevent oxygen from contacting any remaining elemental phosphorus, and thereby minimize fire. The super sacks of mud still solid residue would then be returned to the clarifier. Voids between the super sacks would be filled with additional granulated slag, and then the sacks would be covered with additional granulated slag.

As a precautionary measure, a system of interconnected perforated pipes would be installed within the clarifier to collect and capture phosphine gas in the unlikely event that actionable levels of phosphine gas were generated in the closed clarifier. The piping would extend above ground, but there it would not be perforated, but rather solid and valved/capped off to prevent emissions. In the unlikely event, significant phosphine generation occurs, a phosphine gas treatment unit would be added to the end of the pipe to eliminate the phosphine gas. We do not expect phosphine gas generation in the closed/capped clarifier at actionable levels for several reasons.

First, phosphine monitoring at the Silver Bow Plant found non-consequential concentrations of phosphine in the soil gas in the immediate vicinity of SWMU 11 (Barr, 2013). SWMU 11 contains crude phosphorus that was occasionally excavated from the clarifier and immediately placed in trenches and covered with soil or slag. This burial area was closed in the late 1970s with a multi-layer cap. The SWMU contains elemental phosphorus-containing waste that is not subjected to alkaline conditions. The phosphine concentrations detected in the soil gas at SWMU 11 were at least two orders of magnitude below the Immediately Dangerous to Life or Health (IDLH) level of 50 ppm_v, and the maximum phosphine concentration detected in the soil gas was below the occupational short-term exposure level (STEL) of 1.0 ppm_v.

Second, the environmental conditions within the closed unit act to minimize phosphine generation as discussed below. Elemental phosphorus has the potential to generate phosphine gas when in contact with water (Spanggord et al., 1983). ATSDR states that in water with low oxygen, elemental phosphorus may degrade to phosphine.[7] Higher temperature and higher pH increase the generation of phosphine as they promote the reaction of elemental phosphorus (P_4) to form hypophosphite and phosphine. Reaction kinetics are favored under alkaline conditions[8]. The redox reactions and standard electrode potentials (E°) are as follows (Jolly, 1966):

Oxidation: $3P_4 + 24OH^- \rightarrow 12H_2PO_2 + 12\ e^-$ $E^\circ_{ox} = 2.05\ V$

Reduction: $P_4 + 12H_2O + 12\ e^- \rightarrow 4PH_3 + 12OH^-$ $E^\circ_{red} = 0.111\ V$

Net: $P_4 + 3OH^- + 3H_2O \leftrightarrow 3H_2PO_2 + PH_3$ $E^\circ_{cell} = 1.94\ V$

Since the E°_{cell} is positive, the reaction would occur spontaneously.

At temperatures less than 60ºC and water at pH <8, the rate of phosphine generation by hydrolysis of aqueous elemental phosphorus is very slow. These are the current conditions at the capped area (SWMU 11), and would be the conditions at the closed CAMU. These conditions should virtually eliminate the potential for phosphine gas to be generated at actionable levels.

Third, actual monitoring for phosphine gas generation from and around the clarifier over the last 14 years while conditions have existed that might result in phosphine gas generation has found no consequential detections of phosphine gas, except during disturbance of the clarifier for sampling purposes.

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[7] ToxFAQs for White Phosphorus, CAS #7723-14-0. http://www.atsdr.cdc.gov/tfacts103.html.

[8] Hazardous levels of phosphine were generated at certain capped waste ponds at the FMC Plant. These ponds contain elemental phosphorus waste streams and alkaline conditions (pH > 8). These alkaline conditions provide the ingredients to increase the rate of phosphine generation. Capped ponds at the FMC Plant that contain elemental phosphorus waste and acidic conditions (i.e., Phase IV Ponds) have not generated actionable levels of phosphine (Feldman 2014).

Nonetheless, solely as a precautionary measure, a long-term phosphine monitoring/collection system would be installed beneath the CAMU cap.

After installation of the phosphine gas collection piping, the above-grade portion of the clarifier walls would be demolished and pushed into the clarifier. This is necessary to enable proper cap construction. The area would be brought to grade by filling it with additional granulated slag and shaped as needed to establish the subgrade for the final cover.

3.3.1.4.2 Evapotranspiration Cap

The CAMU could be closed with an evapotranspiration cap. The evapotranspiration cap would be constructed over a subgrade of granulated slag, and would consist of at least 1.5 feet of borrow soil and an additional 0.5 feet of topsoil seeded with a vegetated cover. The 1.5 feet of borrow soil would be obtained from an on-site borrow source of clay-rich material. Testing of a sample from the upper 6 feet of a potential on-site borrow area classified the soil as a clayey sand (silty clay loam by Department of Agricultural categorization). The 0.5 feet of topsoil might be obtained from an on-site borrow area, amended as appropriate to enhance plant growth, or might be obtained from an off-site source. The evapotranspiration cap would be seeded with vegetation appropriate to the climate. Figure 3-11 shows the cross-section of the conceptual evapotranspiration cap.

An evapotranspiration cap functions by returning infiltrated precipitation to the atmosphere via evaporation from the soil and plants, and transpiration from plants. In the Silver Bow region of Montana, about 60 percent of the approximately 13 inches annual precipitation occurs during the five-month May to September growing season, which is favorable for evapotranspiration caps. HELP modeling of the conceptual evapotranspiration cap shows that very little infiltration would penetrate the cap (Appendix Q). The annual average runoff estimated by the HELP model for this cap is about 0.5 inches, and the average annual evapotranspiration is about 12.0 inches. The average annual infiltration estimated by the HELP (Hydrologic Evaluation of Landfill Performance) model for the proposed evapotranspiration cap is 0.013 inches per year. This is equivalent to less than 10 ft^3 per year (less than 70 gallons per year), or 0.00012 gallons per minute over the 100-foot clarifier area. The modeling shows that this level of effectiveness is achieved for site borrow soil placed at 90 percent of maximum standard proctor density and moisture content typical of natural conditions. This means that the borrow source material is capable of producing a very effective evapotranspiration cap with relatively little control on moisture and compaction conditions during cap construction.

An evapotranspiration cap has the advantage over traditional synthetic membrane or compacted clay caps in that a variety of cover vegetation types are acceptable. Deep-rooted grasses, shrubs, and trees would be compatible with evapotranspiration caps, although they might be problematic for caps with a synthetic liner that is placed near the surface. Deep-rooted grasses, shrubs and trees would generally be as effective as shallow-rooted plants for providing the evapotranspiration function of the cap. Deep-rooted plants would primarily be a concern for synthetic liners, where decay of old roots can leave passages for infiltration through the liner. For evapotranspiration caps in arid climates, deep-rooted plants offer the advantage of hardiness and the ability to draw moisture from greater depths. In effect, they retrieve the water that may have percolated deeper into the soil. The potential evapotranspiration for these plants would be much greater than the total average annual rainfall for the Silver Bow area. Thus, on balance, deep-rooted plants would be effective in an evapotranspiration cap.

The evapotranspiration cap would meet the standards in 40 CFR § 264.552(e)(6)(iv). Specifically, the design cap would:

40 CFR § 264.552(e)(6)(iv)	Evapotranspiration Cap Design
(1) provide long-term minimization of the migration of liquids through the closed unit;	The cap would minimize migration of rainwater through the closed clarifier at an extremely slow infiltration rate of approximately 10 ft^3/yr.
(2) function with minimum maintenance;	Minimum maintenance would be necessary given the consolidated contents, arid conditions and minimum slopes.
(3) promote drainage and minimize erosion or abrasion of the cover;	Positive drainage would be maintained by a final surface slope of 3 to 5 percent from the center of the cap to the edges.
(4) accommodate settling and subsidence so that the cover's integrity is maintained; and	The materials would be consolidated before the cap would be constructed. Therefore, minimal settling and subsidence would be expected.
(5) have a permeability less than or equal to the permeability of any bottom liner or natural subsoils present.	The cap would meet this requirement as described in the next paragraph.

The evapotranspiration cap would have a permeability less than or equal to the permeability of the natural soils present, and therefore would meet the standards in 40 CFR § 265.552(e)(6)(iv)(5). Specifically, the vertical permeability of the natural soils is estimated to be in the range of 1.8 to 4.6 ft/day. This range is based on measurements of hydraulic conductivity ranging from 14 to 37 ft/day in site wells, reduced to account for anisotropy, consistent with the groundwater flow model (anisotropy of 8 to 1) developed for this site. The vertical hydraulic conductivity of the evapotranspiration cap is estimated at 0.12 ft/day, based on laboratory measurements using a site borrow soil sample compacted to 90% standard proctor density. (The soil testing report is in Appendix R). Consequently, the evapotranspiration cap has a vertical hydraulic conductivity less than the range of natural soil hydraulic conductivities measured and estimated at the site (and adjusted down by a factor of eight to account for anisotropy).

Final design of the cover system would be resolved at closure. However, the details presented here demonstrate that an evapotranspiration cap could meet the regulatory requirements.

3.3.1.4.3 Post Closure Care

A chain link fence that is at least six feet above grade with a locked gate would be installed around the entire perimeter of the cap. This would prevent unauthorized foot and vehicular traffic from damaging the cap, and would minimize animal crossings onto the cap and burrowing into the cap. The fence would also reinforce "no dig" restrictive covenants that would be designated in the land records. The substantive requirements of 40 CFR §§ 264.116, .119 and .309 would also be met, including designating the restricted area as a no excavation zone on the survey plat, providing required notices of waste disposal, and maintaining records of waste disposal. By placing the no excavation restriction in the land records, any future purchaser would take the property subject to this restriction. By so restricting the use of the property, any future purchaser would jeopardize its mortgage and be unable to convey the property again if it were to violate this restriction.

Pursuant to 40 CFR §264.552(e)(5), a post-closure care groundwater monitoring program would be established following closure of the CAMU. The post-closure care groundwater monitoring program may incorporate the pre-closure groundwater monitoring wells that were installed at the request of the EPA under the 7003 Order. Five water table monitoring wells were installed at the clarifier. The primary objective of the groundwater monitoring network would be to continue to monitor groundwater quality related to the CAMU during the post-closure care period. The second objective of the groundwater monitoring program would be to establish a procedure for notifying the EPA Regional Administrator if the results of groundwater monitoring indicate that groundwater concentrations are statistically increasing, and corrective action may be warranted If the groundwater monitoring program identifies an ongoing trend of increasing contamination related to releases from the closed clarifier then corrective measures would be evaluated at that time. For cost estimating purposes, the groundwater monitoring network consists of five monitoring wells with annual sample collection and analysis for the 30-year post-closure monitoring period.

Maintenance of the cap as part of 30-year post-closure care would include inspection, assuring vegetation establishment, and correcting any erosion. Such inspections would occur in the spring after snow melt, in the fall before significant snowfall, and after any precipitation event that exceeds the 25-year, 24-hour storm. During these inspections, the fence would also be inspected, and repaired if necessary. Operation, maintenance, and monitoring would be evaluated on a periodic basis to improve efficiency, effectiveness, and reliability, and to reflect knowledge gained from the program.

3.3.1.4.4 CAMU Designation

Critical to the viability of the mud still option is a CAMU being designated on the Silver Bow Plant property. Specifically, it is expected that EPA would designate the clarifier (SWMU 2) as a CAMU. The location and area for the designated CAMU are shown on Figure 3-10 as the general cap area. The CAMU would allow the clarifier material that cannot safely and practicably be removed from the clarifier to remain in place and be disposed therein. The large volume of solid residues from the mud still operation, which could be hazardous for cadmium, would also be placed into the clarifier and disposed there. The CAMU would be appropriately closed, capped and monitored and maintained under post-closure care as described above.

Section XII of the 3008(h) order expressly envisions the designation of an area at the Silver Bow facility as a CAMU. The designation of a CAMU at the Silver Bow Plant for the purposes described above would meet the 40 CFR § 264.552 regulatory requirements for designation of a CAMU, as discussed in the “Request of Solvay USA, Inc. to Designate a Corrective Action Management Unit”, which will be submitted to EPA for consideration.

3.3.2 Evaluation of Alternative

This section evaluates the on-site phosphorus recovery alternative against the evaluation criteria described in Section 2.3.

3.3.2.1 Long-term Reliability and Effectiveness

The mud still alternative would remove a large volume of ignitable material from the clarifier and render it non-ignitable. The pilot-scale plant successfully recovered about 0.5 tons of elemental phosphorus from about 1.5 tons of crude phosphorus, and a similar yield should result from full scale operation. Thus a valuable and diminishing resource would have been recovered. The mud still solid residue would not generate phosphine or fire, but may exhibit the toxicity characteristic for cadmium. As discussed in Section 3.3.1.1, some small amount of clarifier material that cannot be practicably and safely removed would remain in the clarifier. This material that cannot be safely removed, as well as the mud still solid residue, would be disposed of in the clarifier and capped and closed.

The CAMU, closed with an evapotranspiration cap, would be even more reliable and effective than the enhanced RCRA cap alternative described in Section 3.2 for minimizing fire and phosphine generation because this alternative would remove almost all of the P4 from the clarifier, thereby removing the source material from the clarifier that could ignite or generate phosphine gas.

The evapotranspiration cap would not be susceptible to failure due to erosion or flooding. The CAMU is not a drainage way, so neither flooding nor nearby runoff would induce erosion of the CAMU cap as detailed in Section 3.2.2.1. Deed restrictions would define this area as a no excavation zone, so that the integrity of the cap would not be compromised by human activity.

This site is located in Earthquake Hazard Zone 3, which is not expected to suffer the severe earthquakes expected in areas like San Francisco along the San Andreas Fault. The cap would be designed to resist damage from reasonably anticipated earthquake forces, such as earth-shaking or horizontal acceleration forces. Uncontrollable changes at the site such as those caused by earthquake could conceivably affect the cap, but the cap is flexible, and the cover soil could easily be repaired if needed.

The useful life of this alternative would potentially be unlimited. The cap could accommodate all types of native vegetation cover, including shrubs and trees, without unacceptable loss of function. After the cover vegetation has been established, and monitoring has demonstrated no on-going environmental issues, it is expected that this form of cap could function effectively with little or no further maintenance. Nonetheless, the cap would continue to be inspected before and after the snow season and after each 25-year storm event, and it would be maintained whenever necessary.

3.3.2.2 Reduction in the Toxicity, Mobility, or Volume

In the long term, the toxicity, volume and mobility of the clarifier material would be reduced by virtue of removal and recovery of the P4 from the material. The small amount of clarifier material that cannot be safely or practicably removed and the solid residues that are placed into the clarifier and capped would have greatly reduced toxicity for the generation of fire and phosphine. The toxicity of the recovered elemental phosphorus would also be greatly reduced when it is used in the phosphorus industry. The recovered elemental phosphorus would likely be used in an industrial process that converts P4 to phosphorus oxides and/or phosphoric acid, which are less toxic than elemental phosphorus. On the other hand, the mud still process would concentrate the cadmium in the solid residue as several residue samples failed the TCLP test for cadmium while the crude phosphorus samples did not fail the TCLP test for metals.

The water cap would need to be maintained throughout the excavation period (about another eight years). The water cap maintenance system would be terminated after the bulk of the crude phosphorus has been removed from the clarifier and the remaining crude phosphorus that cannot be safely or practicably removed would be covered with granulated slag. The future percolation through the clarifier contents would be reduced to the water infiltrating through the evapotranspiration cap, which is estimated at about 0.013 inches per year inches/year (Appendix Q).

The solid residue would be managed in a CAMU. After closure, the evapotranspiration cap would minimize leachate and mobility of hazardous constituents. This future condition has been modeled to estimate the potential impacts of the capped clarifier on groundwater quality. Three approaches were used to evaluate the potential impact on groundwater quality: (1) Partition Model; (2) Leachate Model; and (3) Solids Model (see Appendix K). This evaluation shows that no impacts to groundwater would be expected above drinking water quality standards if the evapotranspiration cap were placed on the clarifier containing the remaining crude phosphorus and the mud still residue. This finding holds true, using the consciously conservative SSL model, for all three different approaches to evaluating protectiveness for groundwater. In addition, the sensitivity analysis of infiltration (see HELP model, Appendix Q), found less than an order of magnitude increase in infiltration under the full range of sensitivity conditions evaluated. These sensitivity results mean that, for the expected range of infiltration conditions, the evapotranspiration cap remains protective of groundwater. In any event, the groundwater would continue to be monitored.

The alternative has the potential to increase the toxicity in the short term due to potential ignition of the P4 and emission of phosphine during the excavation and processing operations. The alarm on the continuous phosphine monitors was activated during excavation of some crude phosphorus for the pilot-scale test. Excavation immediately stopped and the workers proceeded to evacuate the area. The phosphine concentrations dissipated immediately. The production-scale plant includes an oxidation chamber in which elemental phosphorus and phosphine emission from the condenser would be converted to phosphorus pentoxide. The continuous phosphine monitoring system would be operated and workers near the clarifier would wear personal phosphine monitors to notify the workers of potentially hazardous conditions.

Situations might arise where some amount of the crude phosphorus would be exposed to air. As a result, smoke and possibly fires could occur during the excavation and transfer operations. Fires outside the clarifier could be smothered with granulated slag or water. If exposed materials in the clarifier ignite, additional water could be pumped into the clarifier until the burning materials were covered and extinguished. Procedures for safe operations would be addressed through the process safety management of highly hazardous chemicals program, and development of a health and safety plan, and contingency plan. Solvay has extensive expertise in design and operation of processes involving elemental phosphorus.

3.3.2.3 Short-term Effectiveness

The following sequence of activities would be necessary to complete the mud still process for the clarifier materials:

- **Removal and Material Handling Operations**
  - Site preparation.
  - Mud still construction and trial runs.
  - Water cap control (partial dewatering of clarifier).
  - Removal of clarifier material (mechanical removal using excavator with bucket attachment).
  - Material handling (transfer of material from clarifier to skip).
- **Mud Still Operations**
  - Loading the skip that contains crude phosphorus into mud still.
  - Operating and monitoring mud still.
  - Unloading and cleaning out mud still.
- **Closure Operations**
  - Shut-down and clean out (i.e., triple rinse) the process equipment.
  - Place layer of granulated slag in the clarifier to cover the remaining crude phosphorus.
  - Remove (or drain) water above the granulated slag layer.
  - Place the mud still residue in the clarifier and cover the residue with another layer of granulated slag.
  - Demolish the above grade portion of the clarifier walls.
  - Backfill and compaction of cover material at clarifier.
  - Extending cover/cap beyond clarifier over the crude phosphorus burial area and P4 production area.
  - Final grading of cap.
  - Restoration/revegetation of cap.
  - Maintenance and monitoring of cap.
- **Recovered P4 Handling, Transportation and Use**
  - Moving liquid P4 between collection vessel(s) and transport container.
  - Transport container via truck to Solvay P4 facility.
  - Liquefy (i.e., reheat) P4 in transport container and move liquid P4 to the facility’s P4 raw material storage vessel.
  - Return transport container (via truck) to Silver Bow Plant.

The anticipated person hours and associated rates of relative risk for this entire list of activities has been evaluated on a preliminary basis. Appendix L contains the task list and estimated time and crew size for each task for this alternative. There are several general points to note with respect to that evaluation. First, it would take approximately two years to design, fabricate and install the production-scale mud still. Second, based on the volume of the clarifier material and the length of time required to process each batch, it would require at least five, and likely more, years to process the material in the clarifier. Third, it is possible that some of the crude phosphorus would ignite during the extended removal and handling operations. Clarifier removal and handling operations could be difficult to manage and that difficulty increases with the quantity and extended duration of the operations. The risk rates assigned to each of these activities reflect these potential, relative risks. Fourth, for safety reasons of confined space, structural integrity, and P4 hazards, this alternative does not require placing workmen into the clarifier to manually remove the sludge. What can be removed would be removed by mechanical means with workmen outside of the clarifier.

Two risk levels were developed for this option--one for the unprotected worker and one for the protected worker. In assigning risk factors for each activity, consideration was made as to whether a particular activity would be reasonably described as an “ordinary construction risk,” or is inherently more dangerous. In particular, as outlined in Appendix D, the proximity of the workers to the phosphorus-bearing materials, and the relative amount of personal handling of materials, was carefully considered in selecting relative risk rates for each step of the process.

Table 3-1 presents the probability of a fatality for this option. The risk calculations are provided in Appendix M and are presented in regards to construction risk and operational risk. The probability of a fatality to the unprotected worker is “medium” at 0.005%. The probability of a serious injury to the unprotected worker in Table 3-2 is “high” at 0.3%. The protected worker would face a probability of 0.003% of fatality and 0.2% of serious injury. These relative risks are considered “medium” and “high”, respectively, even when appropriate worker protections are followed.

3.3.2.4 Implementability

A preliminary implementation schedule was developed based in the review team’s professional judgment and experience with similar industrial and/or environmental projects. The preliminary implementation schedule represents a best estimate at the duration of this alternative.

Preliminary Implementation Schedule	
Timeline	**Description**
4Q 2015	Supplemental Waste Plan and request to designate CAMU for the clarifier.
1Q 2016	EPA approves the Supplemental Waste Plan and agrees to designate a CAMU.
1Q 2016	EPA conducts a public hearing on the Supplemental Waste Plan remedy and the CAMU designation request and selects the On-site Phosphorus Recovery Alternative (Mud Still Process) and designates a CAMU.
2Q 2016	EPA prepares the Corrective Measures Decision Document.
2016-2017	Mud still system design and off-site fabrication of process equipment.
2Q 2018	On-site construction of clarifier excavation and mud still facilities begins.
4Q 2018	Construction of excavation and mud still facilities complete. Start-up testing begins.
1Q to 2Q 2019	Mud still operations begin. This is likely the earliest the operations would begin, and they may not begin for possibly two more years.
2024 +??	Mud still operations complete and mud still residue would be returned to the clarifier. Construction of evapotranspiration cap begins.
2026 +??	Construction of evapotranspiration cap complete and vegetated surface established. The Draft Waste Plan Implementation Report would be submitted to the EPA within 90 days after completion of the cap construction.

This alternative would likely take at least 10 and possibly more years for completion, given all the technological uncertainties.

A thorough evaluation of state and federal administrative requirements for this alternative was completed by Solvay, and a Required Permit and Rationale Document and a follow-up July 3, 2013 letter from Dan Bersanti to Larry Kimmel (Appendix S) were submitted to the EPA for review. EPA indicated general concurrence with the conclusions in an email dated September 17, 2013.

Solvay met with MDEQ on March 7, 2014 to discuss Solvay's evaluation in the Required Permit and Rationale Document. The key points in that Document are:

- Operation of Mud Still – The mud still would be operated pursuant to the RCRA Section 7003 Order. Pursuant to Section XX of the 3008(h) Order and the waiver authority of a 7003 Order (see Appendix S), Solvay would operate the mud still without obtaining a RCRA permit and without other RCRA hazardous waste management requirements. Despite this, Solvay would operate the mud still in an environmentally responsible manner.

- Solids Residuals – As previously documented, most of the solid residuals generated during the pilot-scale operation contained cadmium at concentrations above the toxicity characteristic level. If all RCRA rules applied: (1) treatment of the residuals would be required to meet land disposal restriction (LDR) standards before such hazardous waste residues could be land disposed; (2) the disposal in a landfill would necessitate that the landfill meet minimum technological requirements (MTR) for liners and a leachate collection system; and (3) the disposal unit would require a RCRA permit. However, disposal of the residual solids in the clarifier and leaving some sludge in the clarifier that cannot be practicably or safely removed can occur without meeting LDR, MTR or permit requirements under the 7003 Order and related 3008(h) Order if, among other options, the clarifier and its immediate surrounding phosphorus burial area are designated by EPA as a CAMU. See 40 CFR §264.552(a)(4). Our evaluation of this alternative assumes that the proposed CAMU would be approved and that the mud still residue and sludge that cannot be safely and practicably removed from the clarifier can be disposed in the CAMU. If the proposed CAMU is not designated, the mud still option would have additional disadvantages and be much more costly.

- Water Residuals – Although water that would be generated during the process may contain some phosphorus particles, because it would not flame or exhibit any other hazardous waste characteristic, it would be considered a nonhazardous wastewater. Any wastewater that remains after the mud still operations would be pH adjusted with lime in one or more units meeting the RCRA definition of a “tank” at 40 CFR § 260.10, and then conveyed to an earthen evaporation pond. Per Montana regulations, a solid waste management system license would be needed to construct and operate an evaporation pond for this nonhazardous wastewater, and Solvay would obtain this license if any wastewater needs to be evaporated in a pond.

- Air Permits – Operation of the mud still would not constitute a “major” source of air pollution and there are no applicable New Source Performance Standards or National Emissions Standards of Hazardous Air Pollutions. Further, no permit is required under Montana law because the mud still is not subject to the federal Clean Air Act and the process is not an “incinerator.” Nevertheless, Solvay would control the emissions through the controlled flare combustion unit and the wet scrubber. An analysis of air quality permitting requirements for this alternative is provided in Appendix T.

- Future Commercial Operations – This facility could serve as a viable commercial P4 recovery facility for managing similar materials from other elemental phosphorus facilities. If Solvay decides to pursue commercial operations, then RCRA permitting pertaining to storage of hazardous waste might be required, and Solvay would obtain any required permit.

The administrative requirements needed to implement the alternative include:

- Working with EPA to designate the clarifier and surrounding crude phosphorus burial and P4 production areas as a CAMU
- Obtaining a solid waste disposal permit for the evaporation pond
- Recruiting, hiring, and training a labor force

Solvay is continuing discussions with MDEQ to see if MDEQ agrees with Solvay's analysis of the administrative and permit requirements.

3.3.2.5 Relative Cost

The representative cost of this alternative, assuming the CAMU is approved, is estimated at $24 million, and the cost of financial assurance is estimated at $1.4 million for a total cost of $25 million. This alternative could return about 80,000 to 98,000 gallons of elemental phosphorus to commercial use, which represents a commercial value of about $2 million to $2.5 million. This order of magnitude estimate is expected to provide an accuracy of plus 50 to minus 30 percent for the described scope of the alternative. The details of the cost estimate are in Appendix N and the cost estimate methodology is in Appendix E.

3.4 Off-Site Incineration

3.4.1 Description of Alternative

Off-site incineration may be feasible, but it has not been demonstrated for the volume of clarifier material. Incineration of only small volumes of elemental phosphorus-bearing materials at commercial facilities has been done to date, not the estimated 11,500 drums that would be generated at the Silver Bow Plant. Nonetheless, because the off-site incineration option is theoretically possible, this section describes the alternative and the results of this evaluation.

Incineration involves the controlled oxidation (through combustion) of the phosphorus. Elemental phosphorus oxidizes to form phosphorus pentoxide, which is a dense fume. Consequently, high efficiency particulate removal equipment would be necessary to control particulate emissions. In addition, the incinerator facilities indicate that they must have a relatively slow feed rate to maintain compliance with their permit conditions.

The off-site incineration option arises from the survey in which 47 commercial TSD facilities were contacted to evaluate their ability to receive, treat and dispose of the clarifier materials. The survey work plan and responses from the TSD facilities in 2001 are provided in Appendix U. Based on the survey responses, two commercial incinerators were identified as potentially capable of treating and disposing of the clarifier material at that time:

- Waste Technologies, Inc. (WTI) [OHD980613541], East Liverpool, Ohio – now operated by Heritage Environmental Services, Inc.
- Trade Waste Incinerator, Inc. (TWI) [ILD098642424], Sauget, Illinois – now operated by Veolia.

Three projects involving the packaging and incineration of elemental phosphorus-containing materials have been conducted at the Silver Bow Plant since this information was compiled for the prior Waste Plan.

Project Name	Year	Number of Drums	Commercial Facility
SWMU 17: Removed Precipitator Dust Pans	2002	534 (30-gallon)	Trade Waste Incinerator [ILD098642424] Sauget, Illinois
SWMU 24: Discharge Pipeline	2004/2005	21 (30-gallon) 98 (30-gallon)	Onyx Environmental SVCS [ILD098642424] Sauget, Illinois
SWMU 3: Used Carbon and Electrode Project	2008/2009	108 (30-gallon)	Heritage Environmental Services [ILD098642424] Sauget, Illinois

The two waste management companies that operate the incineration facilities listed above were recently contacted to reevaluate their potential capability to treat the clarifier material.

Heritage Environmental Services stated that the incinerator would only process two 55-gallon drums of elemental phosphorus-containing materials per day due to uneven heating in the kiln (i.e., hotspots) and excessive wear of the refractory brick lining. At this processing rate, one truck load consisting of eighty 55-gallon[9] drums would take forty days to incinerate, or about nine truckloads (80 drums each) per year factoring in down time at the incineration facility. It was assumed that each 55-gallon drum would have at least a 2-inch air space and 6-inch water cover[10] over the crude phosphorus. As such,

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[9] The crude phosphorus would be packaged according to DOT-SP 13552 (fifth revision). This special permit authorizes the transportation in commerce of … Phosphorus, white, under water … in alternate packaging. The prescribed packaging is a 55-gallon UN 1A2 steel drum certified to the PG I performance level for solids and the PG II performance level for liquids and dual marked to a minimum of UN1A2 A/400/S and UN1A2 Y/1.2/150. In addition, sufficient water must be present in each drum to ensure that the waste phosphorus is covered during transportation, in any orientation of the drum.

[10] The 6-inch water cover was necessary for the previous elemental phosphorus-containing waste packaging operations conducted at the Silver Bow Plant.

approximately 12,500 (55-gallon) steel drums would be needed to implement this alternative. This alternative would take about 20 years to incinerate the crude phosphorus from the clarifier at the incineration facility in East Liverpool, Ohio.

Veolia confirmed that the elemental phosphorus-containing clarifier materials acceptability and treatment assumptions from 2001 are still valid for the Sauget, Illinois incinerator. Veolia would only accept elemental phosphorus-containing materials in 30-gallon drums. It was assumed that each 30-gallon drum would have at least a 2-inch air space and 6-inch water cover over the crude phosphorus. As such approximately 25,000 (30-gallon) steel drums would be needed to implement this alternative. The 30-gallon drums would be accepted by the truckload drums, at a rate of four (100 drum) truckloads accepted every three months. As such, about five drums per day could be incinerated. This alternative would take about 16 years to incinerate the crude phosphorus from the clarifier at the incineration facility in Sauget, Illinois.

In addition to this feed-rate constraint, other factors described in this Supplemental Waste Plan limit the manner in which this incineration alternative may be conducted. These factors result in a conceptual approach whereby the clarifier material must be:

- Removed from the clarifier and placed into open-top drums at an on-site packaging facility;
- Stored on-site, and transported off-site;
- Transported in drums via truck to the TSD facility;
- Unloaded at the TSD by TSD personnel;
- Incinerated at the TSD facility;
- The ash must be collected, stabilized and disposed in accordance with regulatory requirements; and
- Closure of the clarifier and surrounding SWMUs with an evapotranspiration cap.

This conceptual approach would in large part be dictated by the necessity of both incinerator facilities to receive the clarifier material in open-top drums. They do not have the facilities to receive and handle the clarifier materials from a bulk transport vessel. The drums would need to be open top drums (i.e., the entire top can be removed during filling and emptying and secured during storage and shipment), as opposed to drums with a fill port and screw or bung closure. Each major activity that would have to be undertaken for this off-site incineration option is discussed in the following sections.

3.4.1.1 Removal and Packaging

The crude phosphorus would be removed from the clarifier using an excavator with bucket attachment. The material would be transferred from the excavator bucket to a metal drum-filling funnel that would be located within a spill pan (i.e., secondary containment) adjacent to the clarifier. The funnel would direct the crude phosphorus into DOT specification containers (e.g., 30-gallon, open-top drums (49 CFR § 173.188(a)(2)) or 55-gallon, open-top drums (DOT-SP 13552 (Appendix V))). Approximately, 10 gallons of water would be placed in the drum before the crude phosphorus would be added. Excess water would be decanted from the drum back to the clarifier, leaving a minimum of 6 inches (or more) of water over the crude phosphorus in each drum. A cover would then be secured over the drum and the drum would be transported to the nearby drum staging area. The drums would be vented and monitored at the staging area to evaluate whether phosphine was being generated in the drum. If phosphine was being generated, the pH of the overlying water would be adjusted to minimize the continued phosphine generation, as was done during the precipitator dust pan removal action in 2002. The drums would be closed after its contents no longer generate excess phosphine and would be moved to the storage area.

The bucket could be continuously sprayed with water to minimize fires that might occur if the crude phosphorus would be exposed to air. Any material that spills during transfer would be captured by the spill pan and flushed back into the clarifier. The water cap would be maintained in the clarifier. If necessary, production well water would be added to maintain the water cap over the crude phosphorus. The water cap would be maintained at a pH between 5.0 and 6.0 standard units to minimize the potential for phosphine generation. This pH adjustment, which was standard practice to minimize phosphine generation during plant operations, would be accomplished by adding sulfuric or other concentrated acid to the water cap.

Despite the procedures that would be followed to attempt to maintain the water cap throughout the process, removal and transfer activities might result in situations where some amount of the crude phosphorus might be exposed to air. Filling drums with phosphorus-bearing material would almost certainly involve events or accidents in which the material would be exposed to air for a sufficient period of time to cause fire. Such fires would be in close proximity to workers involved in the filling and drum handling operations, and splashes and spills of material on workers are possible. Procedures for control and worker protection would be identified in a health and safety plan and contingency plan. Fires may be difficult to control, in some cases, as the entire drum contents may be on fire. In other cases, released phosphorus that is on the top or sides of equipment or drums could ignite. Water would have to be used to extinguish fires in these situations, as it would be difficult to smother such material that would be above ground level with slag.

The same amount of crude phosphorus would remain in the clarifier as discussed in Section 3.3.1.1 since the same removal technique would be used in this alternative.

3.4.1.2 Storage

The commercial TSD facilities are unable or unwilling to store large volumes of the phosphorus-containing materials at their facilities. Consequently, one truckload could be received every forty days, or so. The schedule on which individual shipments could arrive at the processing facility would be subject to the requirements, permit conditions, and limitations of the processing facility. Coordination of packaging and transportation activities to approximate the 80 drum per 40 days processing capacity would be anticipated. Filled drums would be stored in a heated building during the cold weather period and might need to be stored longer than 90 days due to the incinerator's slow processing capacity.

3.4.1.3 Transportation

Approximately 200 shipments (100 drums (30-gallon) per truck shipment) would be necessary to transport the crude phosphorus to the incineration facility in Sauget, Illinois (about 1,500 miles) for a total loaded travel distance of about 300,000 miles. As an alternate, approximately 160 shipments (80 drums (55-gallon) per truck) would be necessary to transport the crude phosphorus to the incineration facility in West Liverpool, Ohio (about 1,900 miles) for a total loaded travel distance of about 300,000 miles.

3.4.1.4 Activities at the Incineration Facility

Based on discussions with facility personnel, activities at the incineration facility would need to follow specific drum unloading procedures from the truck trailers. The drums would be unloaded at the incinerator area. The drums would be placed on a conveyor feed system into the incinerator. After placement there, the ring that secures the lid on the drum would be removed so that when the drum is conveyed into the incinerator, the material would spread out and be combusted evenly. The drums would be combusted with their contents. Special precautions would need to be taken for all of these activities, particularly when the drum lids are opened and there would be a potential for release of phosphorus-bearing materials and phosphine.

3.4.1.5 Stabilization and Disposal of Ash

The ash that results from the incineration of D001 hazardous waste must meet universal treatment standards for underlying hazardous constituents. The ash is assumed to contain metal constituents that would need to be treated to meet their universal treatment standards under the LDR program. Such treatment was assumed to require stabilization of the metal constituents. As such, the incinerator facilities would stabilize the ash prior to disposal. After stabilization occurs, the ash would be sent off-site for disposal at a Subtitle D landfill (or Subtitle C landfill). It is assumed at that point that the solidified ash would not exhibit any hazardous waste characteristic. As discussed earlier, the clarifier material is not expected to contain organics as underlying hazardous constituents that must meet LDR treatment standards, since such organics would have been destroyed in the nodule kilns and electric arc furnaces. But even if we assume that the clarifier material has organics, the incinerator would destroy them and satisfy the theoretical LDR treatment requirements for organics.

3.4.1.6 Closure

After the bulk of the crude phosphorus has been removed from the clarifier and packaged for off-site incineration, the remaining crude phosphorus that cannot be safely or practicably removed would be covered with granulated slag and the water cap maintenance system would be terminated. Additional granulated slag would be added to absorb the water cap and fill the clarifier to just below ground surface. The above-grade portion of the clarifier walls would be demolished and clarifier area would be filled with additional granulated slag and shaped, as needed, to establish the subgrade for the final cover. The clarifier area would be closed with the same evapotranspiration cap (Figure 3-11) as detailed in Section 3.3.1.4, except there would be no mud still residue to place in the clarifier. The conceptual extent of the cap is shown on Figure 3-10. The actual extent of the cap would be more precisely defined during the cap design phase.

3.4.1.7 Post Closure Requirements

The post closure requirements for the capped clarifier would be the same as those identified in Section 3.3.1.4.3 for the CAMU in the mud still option.

3.4.2 Evaluation of Alternative

This section evaluates the off-site incineration alternative against the evaluation criteria described in Section 2.3.

3.4.2.1 Long-term Reliability and Effectiveness

The off-site incineration alternative would remove a large volume of ignitable material from the clarifier and render it non-ignitable. The off-site incineration process would result in an ash residue that would not ignite or generate phosphine gas. It is possible that the ash would have to be further stabilized to meet land disposal restriction treatment standards.

As discussed in Section 3.3.1.1, some small amount of clarifier material that cannot be practicably and safely removed would remain in the clarifier. This material that cannot be removed would remain in the clarifier and capped and closed. The clarifier, closed with an evapotranspiration cap, would be even more reliable and effective than the enhanced RCRA cap alternative described in Section 3.2 for minimizing fire and phosphine generation because this alternative would remove almost all of the P4 from the clarifier, thereby removing the source material that could ignite or generate phosphine gas. Deed restrictions would define this area as a no excavation zone, so that the integrity of the cap would not be compromised by human activity.

The evapotranspiration cap would not be susceptible to failure due to erosion or flooding as detailed in Section 3.2.2.1, and the cap would be designed to resist damage from reasonably anticipated earthquake forces, such as earth-shaking or horizontal acceleration forces. Uncontrollable changes at the site such as those caused by earthquake could conceivably affect the cap, but the cap is flexible, and the cover soil could easily be repaired if needed.

The useful life of this alternative would potentially be unlimited. The cap could accommodate all types of native vegetation cover, including shrubs and trees, without unacceptable loss of function. After the cover vegetation has been established, and monitoring has demonstrated no on-going environmental issues, it is expected that this form of cap could function effectively with little or no further maintenance. Nonetheless, the cap would continue to be inspected before and after the snow season and after each 25-year storm event, and it would be maintained whenever necessary.

3.4.2.2 Reduction in the Toxicity, Mobility or Volume

After incineration, the toxicity, mobility and volume of the clarifier sludge would be reduced by virtue of most of it being removed from the clarifier and its elemental phosphorus being combusted in the incinerator. The elemental phosphorus would be converted to phosphorus oxides and/or phosphoric acid, which are less toxic than elemental phosphorus. The residual ash would not generate phosphine or fire. The stabilized ash would be placed in a landfill (after stabilization if needed to meet LDR requirements) where it would be immobile.

The water cap would need to be maintained throughout the excavation period (about another 17 years). The water cap maintenance system would be terminated after the bulk of the crude phosphorus has been removed from the clarifier and the remaining crude phosphorus that cannot be safely or practicably removed would be covered with granulated slag. The future percolation through the clarifier contents would be reduced to the water infiltrating through the evapotranspiration cap, which is estimated at about 0.013 inches per year inches/year (Appendix Q).

After closure, the evapotranspiration cap would minimize leachate and mobility of hazardous constituents. This future condition has been modeled to estimate the potential impacts of the capped clarifier on groundwater quality. Three approaches were used to evaluate the potential impacted on groundwater quality: (1) Partition Model; (2) Leachate Model; and (3) Solids Model (see Appendix K).

This evaluation shows that no impacts to groundwater would be expected above drinking water quality standards if the evapotranspiration cap were placed on the clarifier containing the remaining crude phosphorus. This finding holds true, using the consciously conservative SSL model, for all three different approaches to evaluating protectiveness for groundwater. In addition, the sensitivity analysis of infiltration (see HELP model, Appendix Q), found less than an order of magnitude increase in infiltration under the full range of sensitivity conditions evaluated. These sensitivity results mean that, for the expected range of infiltration conditions, the evapotranspiration cap remains protective of groundwater. In any event, the groundwater would continue to be monitored.

Prior to incineration, however, this alternative increases the mobility of the clarifier material due to the significant physical disturbance that would be required to remove, package, and transport this material. During all of these activities, potential for fire and phosphine generation would be increased. Thus, the question of whether there would be a reduction in mobility depends on what timeframe is considered. Over several years, prior to incineration, the mobility would actually be increased, while after incineration, it would be substantially decreased.

The alternative has the potential to increase the toxicity in the short term due to potential ignition of the P4 and emission of phosphine during the excavation and packaging operations. The alarm on the continuous phosphine monitors was activated during prior excavation of some crude phosphorus for the testing purposes. Excavation immediately stopped and the workers proceeded to evacuate the area. The phosphine concentrations dissipated immediately. The continuous phosphine monitoring system would be operated and workers near the clarifier would wear personal phosphine monitors to notify the workers of potentially hazardous conditions.

Phosphine might be generated in the closed drums that would be stored at the Silver Bow Plant before they could be transported to the off-site incinerator, during transport, and at the incinerator awaiting combustion. If excess phosphine were being generated (i.e., bulging drum), the drum would need to be opened to vent any excess gas. The drums would need to be inspected on a daily basis to prevent over-pressurization of any drum. Although these inspections could be undertaken while the drums were stored on-site, inspections would be much more difficult after the drums were loaded into a trailer for transportation and during transportation.

Situations might arise where some amount of the crude phosphorus would be exposed to air. As a result, phosphorus fires would be expected to occur during the excavation and packaging operations. Fires outside the clarifier could be smothered with granulated slag or water. If exposed materials in the clarifier ignite, additional water could be pumped into the clarifier until the burning materials were covered and extinguished. Procedures for safe operations would be addressed in the health and safety plan, and contingency plan at both the Silver Bow plant and at the incinerator facility.

3.4.2.3 Short-term Effectiveness

The sequence of activities that are necessary to complete the incineration option for the clarifier materials includes the following:

- **Removal Operations**
    - Site preparation
    - Water cap control (partial dewatering of clarifier)
    - Removal of clarifier material
    - Transfer and drum-filling operations (open-top drums at an on-site packaging facility)
    - Drum transfer to storage (as needed)
- **Transportation Operations**
    - Drum transfer (loading drums onto truck)
    - Transport drums via truck to TSD facility (assumed to be in Illinois)
    - Return transport (via unloaded truck) to facility site
- **Incineration Operations**
    - Receive/unload drums at TSD facility
    - Transfer into incinerator unit
    - Stabilize ash and waste residue from air cleaning system for final landfill disposal
- **Closure Operations**
    - Decontaminate removal and packaging equipment
    - Backfill and compaction of cover material at clarifier and phosphorus burial area
    - Final grading of cover/cap
    - Restoration/revegetation of cover/cap
    - Maintenance and monitoring of cover/cap

The anticipated person hours and associated rates of relative risk for this entire list of activities were evaluated. Appendix L contains the task list and estimated time and crew size for each task. There are several general points to note with respect to that evaluation. First, the sheer volume of the clarifier material and the stated incineration rate would require an estimated 16 years to complete, as explained in Section 3.4.2.4 below. Second, the fact that the proposed operations would involve water could result in phosphine generation. For example, crude phosphorus would be transferred into drums that contain water. This process would provide an opportunity for the phosphorus and water to contact and react. The EPA team measured an instantaneous phosphine concentration of 1.08 ppm after agitating the water and crude phosphorus in the clarifier. Third, it would be likely that some of the crude phosphorus would ignite during these extended removal and handling operations. Clarifier removal and drum-filling operations could be difficult to manage and that difficulty increases with the quantity and extended duration of the operations. The risk rates assigned to each of these activities reflect these potential risks.

Two risk levels were developed for this option—one for the unprotected worker and one for the protected worker. In assigning risk factors for each activity, consideration was made as to whether a particular activity would be reasonably described as an "ordinary construction risk," or is inherently more dangerous. In particular, as outlined in Appendix D, the proximity of the workers to the phosphorus-bearing materials, and the relative amount of personal handling of materials, was carefully considered in selecting relative risk rates for each step of the process.

Table 3-1 presents the probability of a fatality for this option. The risk calculations are provided in Appendix M and are presented in regards to construction risk and operational risk. The probability of a fatality to the unprotected worker is "medium" at 0.02%. The probability of a serious injury to the unprotected worker in Table 3-2 is also at a "high" at 1%. The protected worker would face a probability of 0.007% of fatality and 0.4% of serious injury. These relative risks are considered "medium" and "high", respectively, even when appropriate worker protections are followed.

3.4.2.4 Implementability

A preliminary implementation schedule was developed based in the review team's professional judgment and experience with similar industrial and/or environmental projects. The preliminary implementation schedule represents a best estimate at the duration of this alternative.

Preliminary Implementation Schedule	
Timeline	**Description**
4Q 2015	Supplemental Waste Plan.
1Q 2016	EPA approves the Supplemental Waste Plan.
1Q 2016	EPA conducts a public hearing on the Supplemental Waste Plan remedy and selects this off-site incineration remedy.
2Q 2016	EPA prepares the Corrective Measures Decision Document.
2016-2017	Excavation and packaging/storage system design and construction.
2Q 2018	On-site excavation and packaging of clarifier materials begins. Eighty drums are transported to the off-site incineration facility every 40 days, or so.
2034 +??	Removal and off-site incineration complete, and construction of evapotranspiration cap begins.
2036 +??	Construction of evapotranspiration cap complete and vegetated surface established. The Draft Waste Plan Implementation Report would be submitted to the EPA within 90 days after completion of the cap construction.

This alternative would likely take at least 20 and possibly more years for completion, given the very low incineration rate specified by the experienced facility.

Material removal, handling and packaging processes must be designed, constructed and operated before this alternative could be implemented. It is estimated that the design, construction, testing and start-up of such systems would take a minimum of one year.

The administrative requirements needed to implement the commercial TSD facility alternative include:

- Confirmation that the off-site TSDs have all necessary permits to receive and treat the clarifier material.
- Completing a Waste Stream Profile and obtaining acceptance from the TSD facility.
- Manifesting of drums.
- Use of hazardous waste transporters.
- Meeting DOT requirements.
- Meeting LDR requirements.

3.4.2.5 Relative Cost

The representative cost of this alternative is estimated at $49 million and the cost of financial assurance is estimated at $5.3 million for a total cost of $54 million. This order of magnitude estimate is expected to provide an accuracy of plus 50 to minus 30 percent for the described scope of the alternative. The details of the cost estimate are in Appendix N and the cost estimate methodology is in Appendix E.

3.5 Comparative Evaluation

This section provides the comparative analysis of the three alternatives for the clarifier material that were evaluated against the RCRA criteria. Comparative analysis considers the same criteria used during the individual alternatives evaluation. This comparative evaluation is summarized in Table 3-3.

3.5.1 Long-term Reliability and Effectiveness

Each alternative developed for the clarifier materials would require that the clarifier and surrounding P4 production area and crude phosphorus burial area be closed with a cap to enhance the long-term reliability and effectiveness of the alternative. Each alternative would require maintenance and groundwater monitoring activities during the post-closure period to ensure that the caps have long-term reliability and effectiveness.

The on-site phosphorus recovery and off-site incineration alternatives would remove the bulk of the crude phosphorus from the clarifier, thus assuring that once the removal was complete, it would provide a long-term reliable and effective solution for the material that could be removed from the clarifier. Under the enhanced cap option, all of the sludge would be entombed in place. Under the recovery and incineration options, some crude phosphorus would remain in the bottom of the clarifier and be capped on-site. Under the on-site phosphorus recovery option, the mud still residue with levels of cadmium that would likely exceed hazardous waste levels would also be left on-site and capped in the designated CAMU.

3.5.2 Reduction in the Toxicity, Mobility or Volume

The on-site phosphorus recovery and off-site incineration alternatives equally reduce the toxicity of the clarifier material by removing the elemental phosphorus, and thereby eliminating the possibility that the removed clarifier material would burn or generate phosphine at harmful levels. The on-site phosphorus recovery alternative would transform the crude phosphorus into a product that would be used in the phosphorus industry. The off-site incineration alternative would convert the elemental phosphorus to less toxic phosphorus oxides that would be landfilled with the other incinerator ash. Metal constituents in the ash would be stabilized prior to final disposal.

With regard to the enhanced RCRA cap, it would not reduce the inherent toxicity of the crude phosphorus in the clarifier, but would essentially minimize its mobility and exposure potential by creating a thick barrier between the elemental phosphorus and air and by removing the water, thus greatly minimizing the potential for fire and phosphine generation. Although phosphine monitoring in soil gas at the Silver Bow Plant has not shown harmful levels being generated at the capped SWMUs that contain elemental phosphorus-containing materials (Barr, 2013), the cap would have a phosphine detection and management system to further address potential phosphine generation at harmful levels.

The enhanced RCRA cap alternative quickly ends the need for the water cap and its potential to leach hazardous constituents to the groundwater. The water cap could be terminated by year 2015, as compared to year 2022 for the on-site phosphorus recovery alternative and year 2032 for the off-site incineration alternative. The enhanced RCRA cap is more protective than the evapotranspiration cap in that it reduces the amount of precipitation that could infiltrate through the cap and clarifier contents.

The on-site phosphorus recovery and off-site incineration alternatives increase the exposure of workers to phosphine at potentially harmful levels since the crude phosphorus would be agitated with water during the removal and material handling activities. The potential phosphine exposure would exist whenever crude phosphorus was being processed. The on-site phosphorus recovery alternative also increases the mobility of cadmium since several samples of the mud still residue failed the TCLP test for cadmium. This increased leachability would be controlled by the evapotranspiration cap that would minimize infiltration of rainwater through the mud still residue.

The enhanced RCRA cap would reduce mobility by substantially eliminating infiltration. The cap would not reduce the volume of the material, but what remains would not be a source of leachable toxic metals that result in unsafe levels for drinking water. Table K-3 of Appendix K shows that the cap would not allow leaching of metals at levels that would result in exceedance of Montana’s or EPA’s drinking water standards. In fact, the enhanced RCRA cap would provide a margin of safety of more than five orders of magnitude beyond the MDEQ and EPA water quality standards.

The on-site phosphorus recovery and off-site incineration alternatives equally reduce the volume of crude phosphorus remaining in the clarifier prior to final closure. The same excavation techniques would be employed to remove the bulk of the crude phosphorus. The enhanced RCRA cap alternative does not reduce the volume of crude phosphorus remaining in the clarifier.

3.5.3 Short-term Effectiveness

The short-term effectiveness of the alternatives is reflected in their relative potential to result in fatalities and serious injuries during their implementation. These comparative short-term risks are reflected in the following table:

Alternative	Probability of Serious Injury to Protected Worker	Probability of Fatality to Protected Worker
Enhanced RCRA Cap	Medium (0.02%)	Low (0.0006%)
On-site Phosphorus Recovery (Mud Still Technology)	High (0.2%)	Medium (0.003%)
Off-site Incineration	High (0.4%)	Medium (0.007%)

With regards to the enhanced RCRA cap alternative, once the first layer of granulated slag were placed on the crude phosphorus, there would be limited potential for fire or phosphine generation. The enhanced RCRA cap alternative provides the lowest probability of serious injury and the lowest probability of a fatality during the implementation of this alternative. These probabilities are considered medium at 0.02% and low at 0.0006%, respectively. These relative risks are considerably lower than the probabilities posed by the on-site phosphorus recovery alternative.

The off-site incineration and the on-site phosphorus recovery alternatives result in higher probability of serious injury due to the workers potential exposure to crude phosphorus and phosphine for longer time periods. The probabilities of a fatality are lower for the enhanced RCRA cap alterative compared to the on-site phosphorus recovery and off-site incineration alternatives.

3.5.4 Implementability

Off-site incineration may not be implementable, since it has not been demonstrated for the volume of clarifier material. Incineration of only small volumes of elemental phosphorus-bearing materials at commercial facilities has been done to date, not the estimated 12,500 drums that would be generated at the Silver Bow Plant. The time to implement this alternative would likely take twenty and possibly more years for completion, given the very slow processing rate specified by the experienced facility.

Although the pilot-scale mud still plant successfully recovered about 0.5 tons of elemental phosphorus from about 1.5 tons of crude phosphorus, a production-scale mud still process must be designed, permitted, fabricated and installed, and tested before this alternative could be implemented. It is estimated that the design, permitting, fabrication, installation, testing, and start-up of such systems would take a minimum of two years, if everything goes well, and possibly more given all the technological uncertainties. The time to operate the mud still would be at least five years. The time to implement this alternative would take at least 10 years and possibly more for completion, given all the technological uncertainties.

In contrast, the enhanced RCRA capping alternative could be implemented within a relatively short period using demonstrated and available construction materials and techniques. This alternative would likely take two construction seasons to consolidate the clarifier materials and build the multi-layer cover systems plus additional time to establish the vegetated surface. This alternative offers the following benefits from its quick implementation:

- The short duration of construction would result in any mechanical, fire and phosphine risks from construction being short-term;
- Potential for fire and phosphine generation would be removed quickly; and
- Beneficial effects for the environment would commence upon completion of the cap subgrade, because any potential percolation of leachate from the clarifier area into the groundwater would begin declining as soon as the water addition to the clarifier is terminated.

3.5.5 Relative Cost

The enhanced RCRA cap alternative would be considerably less expensive than the other alternatives. The on-site phosphorus recovery alternative costs are estimated to be about one-half the cost of the off-site incineration alternative. The costs shown below include the cost of financial assurance.

Alternative	Relative Cost (Million)
Enhanced RCRA Cap	$5.4
On-site Phosphorus Recovery	$25
Off-Site Incineration	$54

4.0 Preferred Alternative

The comparative evaluation of the alternatives is summarized in the following chart:

Alternative	Long-term Reliability and Effectiveness	Reduction in Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Relative Cost
Enhanced RCRA Cap	Good	Lowest Reduction	Low Risk	2 Years	$5.4 million
On-site Phosphorus Recovery (Mud Still Process)	Very Good	Large Reduction	High Risk	10+ Years	$25 million
Off-site Incineration	Very Good	Large Reduction	High Risk	20+ Years	$54 million

The Supplemental Waste Plan supports the conclusion that the on-site phosphorus recovery alternative should be selected for the clarifier materials at the Silver Bow Plant. The on-site phosphorus recovery alternative would be as reliable and effective as the enhanced RCRA cap, and would also reduce the toxicity, mobility, and volume of crude phosphorus at the Silver Bow Plant. On a relative basis, this alternative ranked low regarding short-term effectiveness criterion because of the higher relative risks of serious injury and fatality. The risk estimates are based on generalized incident rates and estimated duration of work tasks. The risk estimates are not specific to any single operation. These risks would be considered while developing the chemical safety program (i.e., industry experience, mud still design, and process control), health and safety plan, and contingency plan. Solvay has extensive expertise in design and operation of processes involving elemental phosphorus.

A production-scale mud still process must be designed, fabricated, installed, and tested before this alternative could be implemented. The viability of the phosphorus recovery option also depends on a CAMU being designated for disposal of the solid residues and the small amount of clarifier material that cannot be safely or practicably removed from the clarifier.

This alternative could recover approximately 80,000 to 98,000 gallons of elemental phosphorus from the clarifier for use in commercial operations. This volume of elemental phosphorus is currently valued at about $2 million to $2.5 million.

The mud still operations could be commercialized to process elemental phosphorus-containing waste streams from other facilities if agreeable to EPA and MDEQ. Although commercial incinerators are capable of treating smaller volumes of elemental phosphorus-containing materials, they do not desire to treat large volumes over a short time period. The mud still operation could fill this market niche.

5.0 References

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Tables

Table 2-1

Screening of Technologies
Clarifier Materials

Technology	Process(es)	Description	Preliminary Screening	Retained for Alternative Evaluation
			Viability/Technology Status	
Horizontal Barrier	Soil Cap; Enhanced Cap	Construction of an engineered barrier over the materials to minimize airflow and rainfall percolation through the covered materials.	**Potentially viable**. Demonstrated in Phosphorus Industry.	Yes
	Underlying Barrier; Grout Injection	Injection of grout to create a less permeable zone beneath the subject materials. Used in conjunction with cap and vertical barrier.	**Not viable**. Not appropriate for site characteristics. Would not significantly reduce percolation of leachate because cap restricts flow more than underlying barrier layer.	No
Vertical Barrier	Slurry Wall; Sheetpile Wall; Waterloo Barrier	Construct a low permeable barrier around the subject materials to prevent groundwater from contacting the contained materials.	**Not viable**. Not appropriate for site characteristics. Materials do not extend to groundwater unit (approx. 40-ft bgs). There is no subsurface confining layer.	No
Chemical Extraction	Water Washing/Flooding	Application of water sprays or water baths of sufficient temperature, pressure, residence time, agitation, surfactants, acids, bases, detergents to transfer the hazardous contaminants into the liquid and recover/treatment of the liquid.	**Not viable**. Not appropriate for site characteristics. Crude phosphorus is already flooded with water. Water is not an effective solvent for elemental phosphorus.	No
	Liquid Phase Solvent Extraction	Removal of hazardous contaminants from the solids by applying nonaqueous liquid or liquid solution which causes the hazardous contaminants to enter the liquid phase and be flushed away from the solids along with the liquid or liquid solution while using appropriate agitation, temperature, and residence time.	**Not viable**. Not appropriate for site characteristics and not demonstrated in the phosphorus industry. Phosphorus is soluble in organic solvents (i.e., Benzene, Toluene, Xylene, Ethyl Benzene, Carbon Disulfide, etc). A solvent heavier than water would be necessary to contact the crude phosphorus. Remaining solids would retain organic solvent. Solvent would likely be released to the subsurface soils during this process and possibly migrate to groundwater.	No
Chemical Extraction	Vapor Phase Solvent Extraction	Application of an organic vapor using sufficient residence time, and temperature to cause hazardous contaminants in the solids to enter the vapor phase and be flushed away with the organic vapor.	**Not viable**. Not appropriate for site characteristics. Assuming that phosphorus could be transferred to the organic vapor, phosphorus would likely ignite when the organic vapor is emitted to the air space above the clarifier water cover.	No
Thermal Extraction	Vitrification	Electrical heating of materials to convert the solids to glass matrix at very high temperatures.	**Not viable**. Not appropriate for site characteristics. Phosphorus materials must remain covered by water and this process cannot be implemented below water.	No

Table 2-1

Screening of Technologies
Clarifier Materials

Technology	Process(es)	Description	Preliminary Screening Viability/Technology Status	Retained for Alternative Evaluation
Immobilization Technologies	Microencapsulation	Stabilization/solidification with the following reagents or combinations of reagents: (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust)--this does not preclude the addition of reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength, or to overall reduce the leachability of the metal or inorganic.	**Not viable**. Not appropriate for site characteristics. Mixing required to distribute the reagents could emit excessive phosphine levels. Addition of lime-based materials would further increase phosphine generation. Research level testing has not demonstrated viability.	No
	Sealing	Application of an appropriate material which adheres tightly to solids surface to avoid exposure of the surface to potential leaching media. Sealing materials include epoxy, silicone, and urethane compounds, but paint may not be used as a sealant.	**Not viable**. Not appropriate for site characteristics. Sealing not practical for this material, which must be molten to be accessible for sealing.	No
Destruction Technologies	Biological Destruction (Biodegradation)	Removal of hazardous contaminants from solids in an aqueous solution and biodegration of organic or nonmetallic inorganic (i.e., inorganics that contain phosphorus, nitrogen, or sulfur) in units operated under either aerobic or anaerobic conditions.	**Not viable**. Not appropriate for site characteristics. It has not been demonstrated at a laboratory scale, or in the environment that elemental phosphorus can be used as a nutrient, or in biologically mediated red-ox reactions as either electron acceptor or an electron donor.	No
Destruction Technologies	Chemical Oxidation	Chemical or electrolytic oxidation via injection of the following oxidation reagents (or waste reagents) or combinations of reagents: (1) Hypochlorite (e.g., bleach); (2) chlorine; (3) chlorine dioxide; (4) ozone or UV (ultraviolet light) assisted ozone; (5) peroxides; (6) persulfates; (7) perchlorates; (8) permangantes; and/or (9) other oxidizing of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals.	**Not viable**. Not demonstrated in phosphorus industry. Transfer of oxygen is limited by its aqueous solubility. Mixing required to distribute oxygen throughout the solid matrix could emit excessive phosphine levels. Oxidation of phosphorus under water would generate forms of phosphoric(ous) acid, which could increase the leachabiliy of the metals contained in the crude phosphorus. Laboratory-scale testing has not demonstrated viability.	No
	Chemical Reduction	Chemical reduction via injection of the following reducing reagents (or waste reagents) or combination of reagents: (1) sulfur dioxide; (2) sodium, potassium, or alkali salts of sulfites, bisulfites, and metabisulfites, and polyethylene glycols (e.g., NaPEG and KPEG); (3) sodium hydrosulfide; (4) ferrous salts; and/or (5) other reducing reagents of equivalent efficiency.	**Not viable**. Not appropriate for site characteristics. Elemental phosphorus is a highly reduced chemical. Further reduction would generate excessive concentrations of phosphine gas.	No

Table 2-1

Screening of Technologies
Clarifier Materials

Technology	Process(es)	Description	Preliminary Screening	Retained for Alternative Evaluation
			Viability/Technology Status	
Phosphorus Industry Processes	Mud Still	Recovery of phosphorus from the crude phosphorus via vaporization and condensation.	**Potentially viable**. Successfully implemented on pilot scale at Silver Bow Plant. Process equipment not available. Production-scale facility would need to be designed, and constructed.	Yes
	Roasting (On-site)	Recovery of phosphorus from the crude phosphorus under oxygen-starved conditions in an externally fired rotary kiln system.	**Not viable**. Demonstrated in phosphorus industry, but process equipment is no longer available. (former Silver Bow Process)	No
Phosphorus Industry Processes	Distillation (Off-site)	Volatilization of phosphorus from the crude phosphorus under oxygen-starved conditions in an externally heated, batch distillation pot.	**Not viable**. Demonstrated in phosphorus industry, but process equipment is no longer available. (Solutia Process)	No
	Conversion to Phosphoric Acid	Oxidation and hydration process to produce phosphoric acid from phosphorus-containing material.	**Not viable**. Demonstrated in phosphorus industry for more concentrated phosphorus-containing materials. Not appropriate for clarifier materials (Samancor and Rhodia Morrisville Processes)	No
	Proprietary process to recover phosphorus.	Unknown	**Not viable**. Information not accessible for technology evaluation. (Glen Springs Holding Company Process)	No
Immobilization Technologies	Microencapsulation (Stabilizaton/ Solidification)	Removal followed by stabilization/ solidification with the following reagents or combinations of reagents: (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust)--this does not preclude the addition of reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength, or to overall reduce the leachability of the metal or inorganic.	**Not viable**. Not appropriate for site characteristics. Mixing required to distribute the reagents could emit excessive phosphine levels. Addition of lime-based materials would further increase phosphjne generation. Research level testing has not demonstrated viability.	No
Chemical Extraction	Liquid Phase Solvent Extraction	Removal followed by physical separation process that removes contaminants to the extract phase with organic solvents.	**Not viable**. Not appropriate for site characteristics. Phosphorus is soluble in organic solvents (i.e., Benzene, Toluene, Xylene, Ethyl benzene, carbon disulfide, etc). Ignition of phosphorus during processing would create an inferno. Remaining solids would retain the organic solvent and phosphorus.	No
Combustion (CMBST)	Onsite or Offsite Incineration at RCRA Facility	Removal followed by high temperature organic destruction technologies, such as combustion in incinerators, boilers, or industrial furnaces operated in accordance with the applicable requirements of 40 CFR part 264, subpart O, or 40 CFR part 265, subpart O, or 40 CFR part 266, subpart H.	**Potentially viable**. Onsite – research & development needed to apply this technology. Off-site – demonstrated on small quantities.	Yes

Table 2-1

Screening of Technologies
Clarifier Materials

Technology	Process(es)	Description	Preliminary Screening Viability/Technology Status	Retained for Alternative Evaluation
Deactivation (DEACT)	Chemical Oxidation	Removal followed by chemical or electrolytic oxidation utilizing the following oxidation reagents (or waste reagents) or combinations of reagents: (1) Hypochlorite (e.g., bleach); (2) chlorine; (3) chlorine dioxide; (4) ozone or UV (ultraviolet light) assisted ozone; (5) peroxides; (6) persulfates; (7) perchlorates; (8) permangantes; and/or (9) other oxidizing of equivalent efficiency.	**Not viable**. Not demonstrated in phosphorus industry. Transfer of oxygen is limited by its aqueous solubility. Mixing required to distribute oxygen throughout the solid matrix could emit excessive phosphine levels. Oxidation of phosphorus under water would generate forms of phosphoric(ous) acid, which would increase the leachabiliy of the metals contained in the crude phosphorus. Not demonstrated to be viable.	No
	Chemical Reduction	Removal followed by chemical reduction via injection of the following reducing reagents (or waste reagents) or combination of reagents: (1) sulfur dioxide; (2) sodium, potassium, or alkali salts of sulfites, bisulfites, and metabisulfites, and polyethylene glycols (e.g., NaPEG and KPEG); (3) sodium hydrosulfide; (4) ferrous salts; and/or (5) other reducing reagents of equivalent efficiency.	**Not viable**. Not appropriate for site characteristics. Reduction process would generate excessive levels of phosphine gas that would require significant offgas processing.	No
	Biological Destruction (Biodegradation)	Removal followed by biodegration of organic or nonmetallic inorganic (i.e., inorganics that contain phosphorus, nitrogen, or sulfur) in units operated under either aerobic or anaerobic conditions.	**Not viable**. Not appropriate for site characteristics. It has not been demonstrated at a laboratory scale, or in the environment that elemental phosphorus can be used as a nutrient, or in biologically mediated red-ox reactions as either electron acceptor or an electron donor.	No
Water Reaction (WTTRX)	Zimpro - Anoxic	Removal followed by controlled reaction with water for highly reactive inorganic or organic chemicals with precautionary controls for protection of workers from potential violent reactions as well as precautionary controls for potential emissions of toxic/ignitable levels of gases released during the reaction.	**Not viable.** Phosphorus-containing materials will react to form highly toxic phoshine gas under aqueous and alkaline conditions. Upon generation, the phosphine can be thermally oxidized to form P_2O_5 that can be recovered as a product. This technology system is no longer being constructed at the FMC facility to treat its wastewater streams.	No
Wet Air Oxidation (WETOX)	Wet Air Oxidation	Removal followed by Wet Air Oxidation. The Zimpro® Wet Air Oxidation process is a liquid phase reaction in water using dissolved oxygen to oxidize wastewater contaminants. The oxidation reactions occur at moderate temperatures of 275°F to 600°F (150° - 315°C) and at pressures from 150 to 3000 pounds per square inch (10 to 207 Bar). The process can convert organic contaminants to carbon dioxide, water and biodegradable short chain organic acids. Inorganic constituents such as sulfides and cyanides can also be oxidized.	**Not viable**. Not appropriate for site characteristics. Not specified for treatment of D001 or D003 characteristic wastes. Extensive testing by FMC/Astatirs failed to find a satisfactory operating conditions. This technology is less attractive/acceptable than WTTRX because the WAO process requires a higher pressure than the anoxic process (500 psig vs. 200 psig.) and at approximately twice the lime rate and the off-gas from the WAO process had phosphine levels as high as 400 ppm, which would still require a combustion unit to convert it to P_2O_5 and subsequently to H_3PO_4 treatment.	No

Table 2-1

Screening of Technologies
Clarifier Materials

Technology	Process(es)	Description	Preliminary Screening	Retained for Alternative Evaluation
			Viability/Technology Status	
On-site Disposal	Landfill	Removal and transfer of phosphorus-materials for disposal in permitted landfill.	**Not viable**. Not appropriate for site characteristics. Treatment to remove the alleged ignitability and reactivity characteristics and universal treatment standards under RCRA land disposal program required prior to land disposal.	No
Off-site Disposal	Landfill	Removal and packaging of phosphorus-materials for disposal in permitted landfill.	**Not viable**. Not appropriate for site characteristics. Treatment to remove the alleged ignitability and reactivity characteristics and universal treatment standards under RCRA land disposal program required prior to land disposal.	No

Table 3-1

Summary of Short-Term Worker Risk Scenarios and Probability of Fatality, Clarifier Materials

Option	Probability of Worker Fatality			
	Baseline Worker		Protected Worker	
	Quantitative	Qualitative	Quantitative	Qualitative
Clarifier Materials				
Enhanced RCRA Cap	0.0007%	Low	0.0006%	Low
On-site Phosphorus Recovery (Mud Still)	0.005%	Medium	0.003%	Medium
Off-site Incineration	0.02%	Medium	0.007%	Medium

Probability = [Expected Fatalities / Number of Workers]

Table 3-2

Summary of Short-Term Worker Risk Scenarios and Probalility of Serious Injury, Clarifier Materials

Option	Probability of Serious Injury			
	Baseline Worker		Protected Worker	
	Quantitative	Qualitative	Quantitative	Qualitative
Clarifier Materials				
Enhanced RCRA Cap	0.02%	Medium	0.02%	Medium
On-site Phosphorus Recovery (Mud Still)	0.3%	High	0.2%	High
Off-site Incineration	1%	High	0.4%	High

Probability = [Expected Injuries / Number of Workers]

Table 3-3

Comparative Evaluation and Ranking of Alternatives
Clarifier Materials

Alternative	Description	Long-term Reliability and Effectiveness	Reduction in the Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Relative Cost
Enhanced RCRA Cap	Construction of an engineered barrier over the materials to minimize airflow and rainfall percolation through the covered materials.	**Good** Designed to last hundreds of years. Crude phosphorus would be entombed in place. Requires long-term maintenance and monitoring.	**Lowest Reduction** Exposure to toxicity essentially eliminated by cap. No change to volume. Mobility significantly reduced by low permeability cap.	**Low Risk** Serious Injury: Medium Fatality: Medium Following placement of first layer of cap, primary risks would be reduced to those associated with construction activities.	**2 Years** Construction requires standard equipment and methods Demonstrated in Phosphorus Industry Anticipated to take two construction seasons plus additional time to establish the vegetated surface.	**$5.4 million** Lowest cost of the three options
On-site Phosphorus Recovery (Mud Still Process)	Recovery of phosphorus from the crude phosphorus via vaporization and condensation, followed by construction of an evapotranspiration cap	**Very Good** Removes the bulk of the crude phosphorus from the clarifier. Limited volume of residual crude phosphorus would be entombed in place. After closure, would be at least as effective as Enhanced RCRA Cap option Requires long-term maintenance and monitoring.	**Large Reduction** Toxicity and volume of the crude phosphorus would be significantly reduced. Potential to increase toxicity related to fire and phosphine exposure during excavation, processing and transportation. Mobility significantly reduced by low permeability cap.	**High Risk** Serious Injury: High Fatality: Medium Workers exposed to potential fire and phosphine hazards for an extended duration.	**10+ Years** Successfully implemented on pilot scale. Requires design and construction of a production-scale facility. Anticipated to take at least 10 and possibly more years to complete.	**$25 million** Approximately 5 times the cost of the Enhanced RCRA Cap option
Off-site Incineration	Removal followed by high temperature organic destruction technologies, such as combustion in incinerators, boilers, or industrial furnaces operated in accordance with the applicable requirements of 40 CFR part 264, subpart O, or 40 CFR part 265, subpart O, or 40 CFR part 266, subpart H, followed by construction of an evapotranspiration cap.	**Very Good** Removes the bulk of the crude phosphorus from the clarifier. Limited volume of residual crude phosphorus would be entombed in place. After closure, would be at least as effective as Enhanced RCRA Cap option. Requires long-term maintenance and monitoring.	**Large Reduction** Toxicity and volume of the crude phosphorus would be significantly reduced. Potential to increase toxicity related to fire and phosphine exposure during excavation, packaging and transportation. Mobility significantly reduced by low permeability cap.	**High Risk** Serious Injury: High Fatality: Medium Workers exposed to potential fire and phosphine hazards for an extended duration.	**20+ Years** Low processing rate (i.e., 2 drums/day) specified by incinerator and large quantities have not been incinerated. Anticipated to take at least 20 and possibly more years to complete.	**$54 million** Approximately 2 times the cost of the On-site Phosphorus Recovery option

Figures

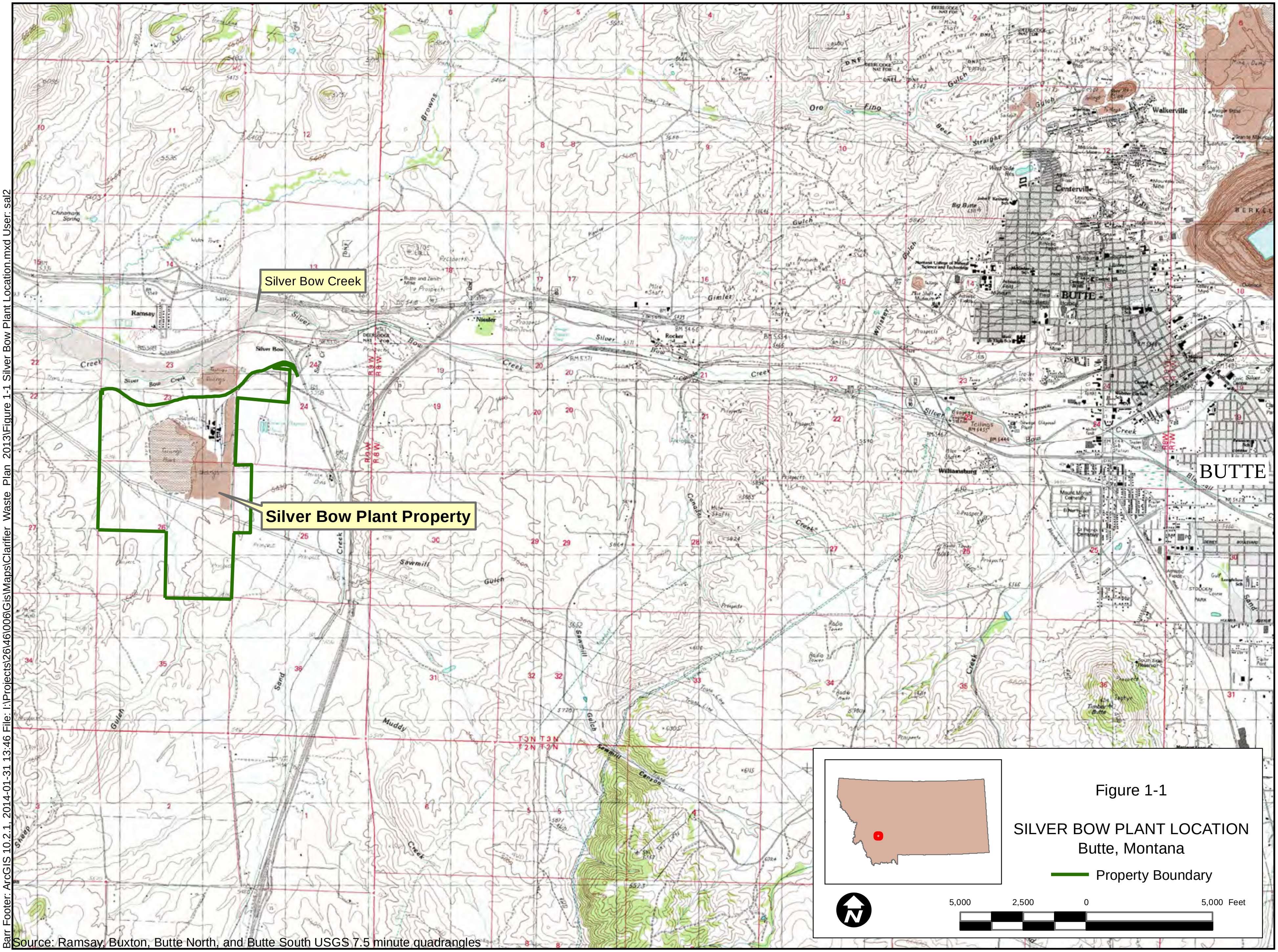


Figure 1-1

SILVER BOW PLANT LOCATION
Butte, Montana

Source: Ramsay, Buxton, Butte North, and Butte South USGS 7.5 minute quadrangles

Barr Footer: ArcGIS 10.2.1, 2014-01-31 13:46 File: I:\Projects\26\46\006\Gis\Maps\Clarifier Waste Plan 2013\Figure 1-1 Silver Bow Plant Location.mxd User: sal2

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN,

▭ SWMU 2 - Clarifier

▭ Other Areas Included in 7003 Order

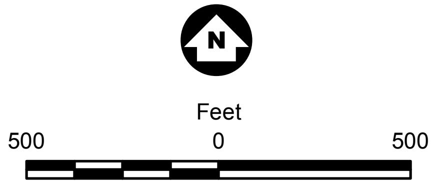


Figure 1-2

AREAS INCLUDED
IN 7003 ORDER
Silver Bow Plant
Butte, Montana

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN,

● Monitoring Well

▭ SWMU 2 - Clarifier

☒ Fence

—+— Railroad

— Road

N

Feet

100 0 100

Figure 3-1

CLARIFIER AREA
Silver Bow Plant
Butte, Montana

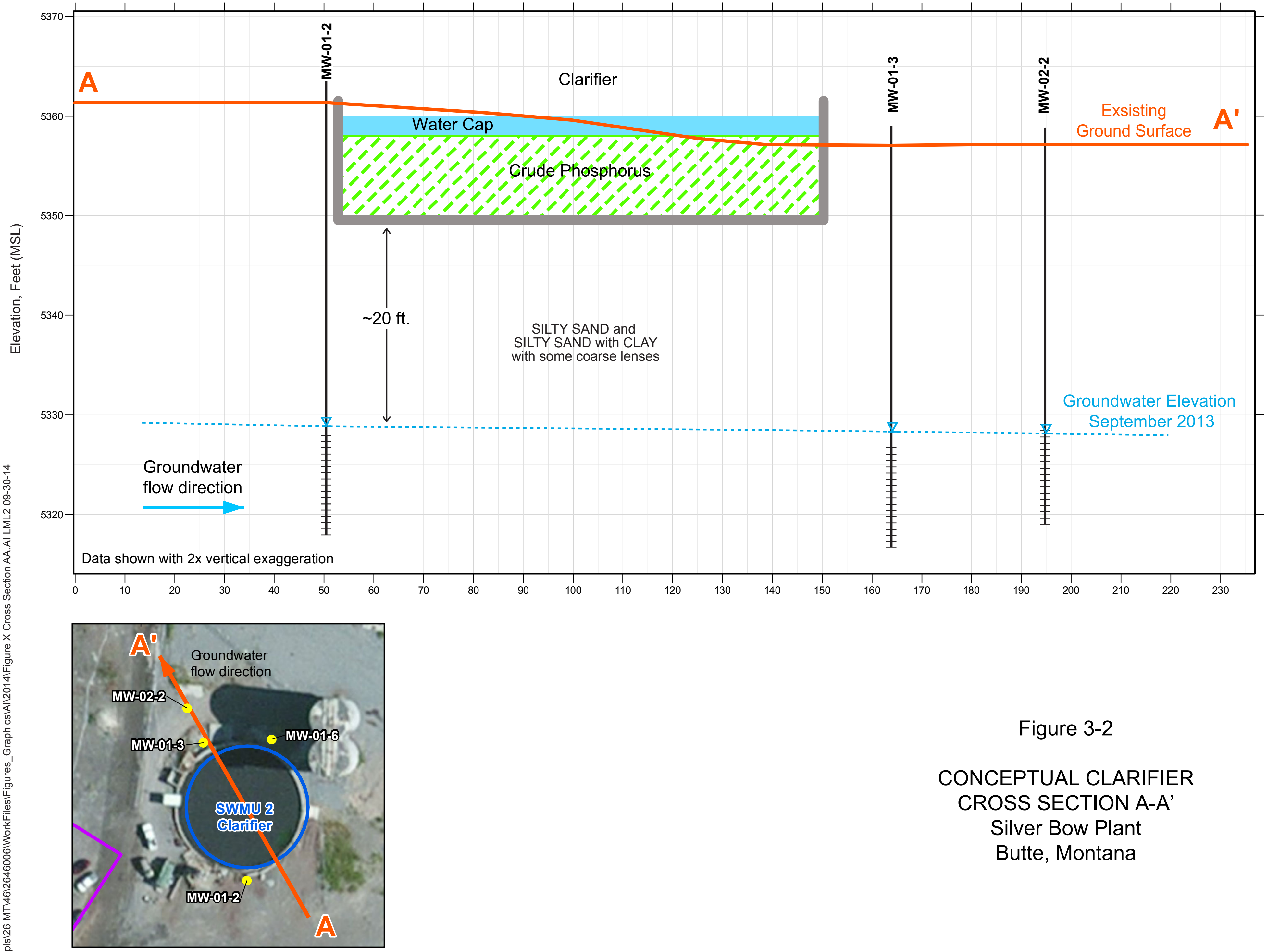


Figure 3-2

CONCEPTUAL CLARIFIER
CROSS SECTION A-A’
Silver Bow Plant
Butte, Montana

P:\Mpls\26 MT\46\2646006\WorkFiles\Figures_Graphics\AI\2014\Figure X Cross Section AA.AI LML2 09-30-14

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN,

● Monitoring Well

— September 2013 Groundwater Elevation Contours (ft MSL)

5329.35 Groundwater Elevation, ft MSL (September 2013)

Feet

200 0 200

Figure 3-3

GROUNDWATER FLOW CONTOURS (SEPTEMBER 2013)
Silver Bow Plant
Butte, Montana

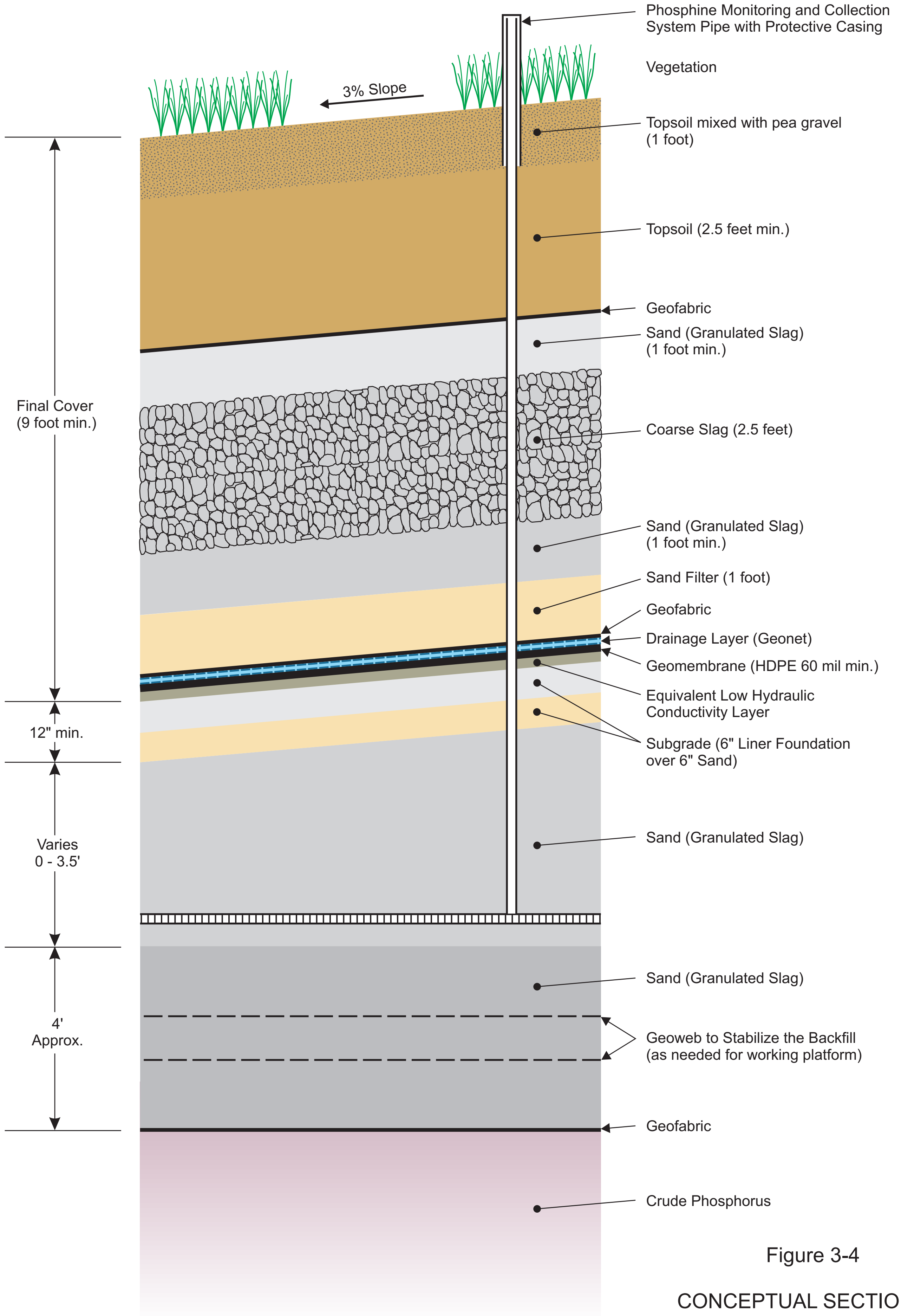


Figure 3-4

CONCEPTUAL SECTION OF ENHANCED RCRA CAP
Silver Bow Plant
Butte, Montana

P:\Mpls\26 MT\46\2646006\WorkFiles\Figures_Graphics\Typical Section of Enhanced RCRA.CDE RLG 04-16-15

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

● Monitoring Well
Enhanced RCRA Cap
SWMU 2 - Clarifier
Railroad
Road

Feet
100 0 100

Figure 3-5

CONCEPTUAL EXTENT OF
ENHANCED RCRA CAP
Silver Bow Plant
Butte, Montana

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN,

● Monitoring Well
▭ SWMU 2 - Clarifier
▭ Mud Still Crude Phosphorus Process Area
—+— Railroad
— Road

N

Feet
100 0 100

Figure 3-6

CONCEPTUAL MUD
STILL PROCESS AREA
Silver Bow Plant
Butte, Montana

CADD USER: Rick Gustner FILE: M:\ADEPTWORK\RLG\2646000630_MUD STILL PFD.DWG PLOT SCALE: 1:1 PLOT DATE: 10/2/2014 9:16 AM
Xrefs in Drawing – H:\Backho.dwg
. rlg M:\AdeptWork\RLG\2646000630_Mud Still PFD.dwg Plot at 0 10/02/2014 09:15:25

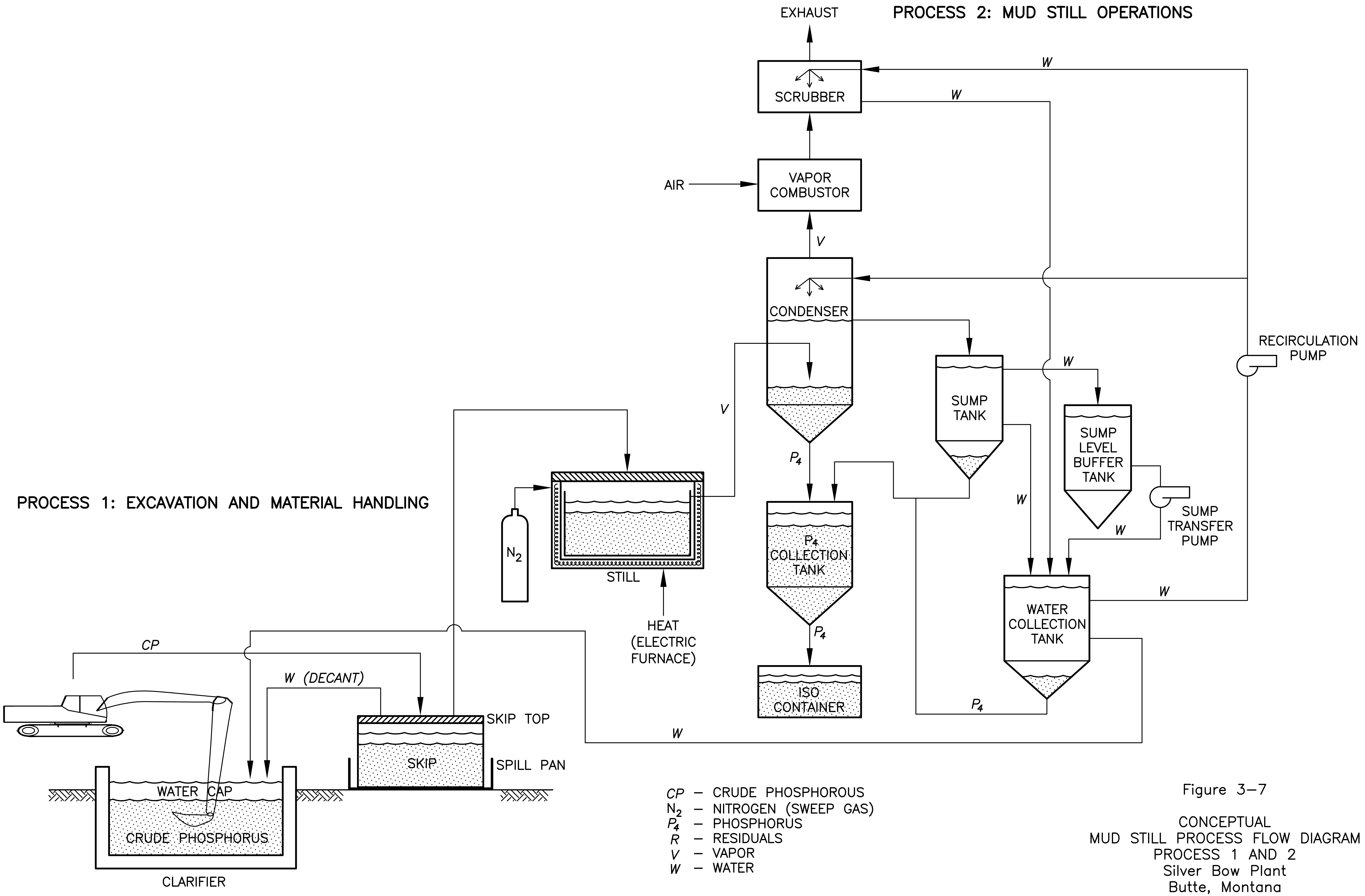
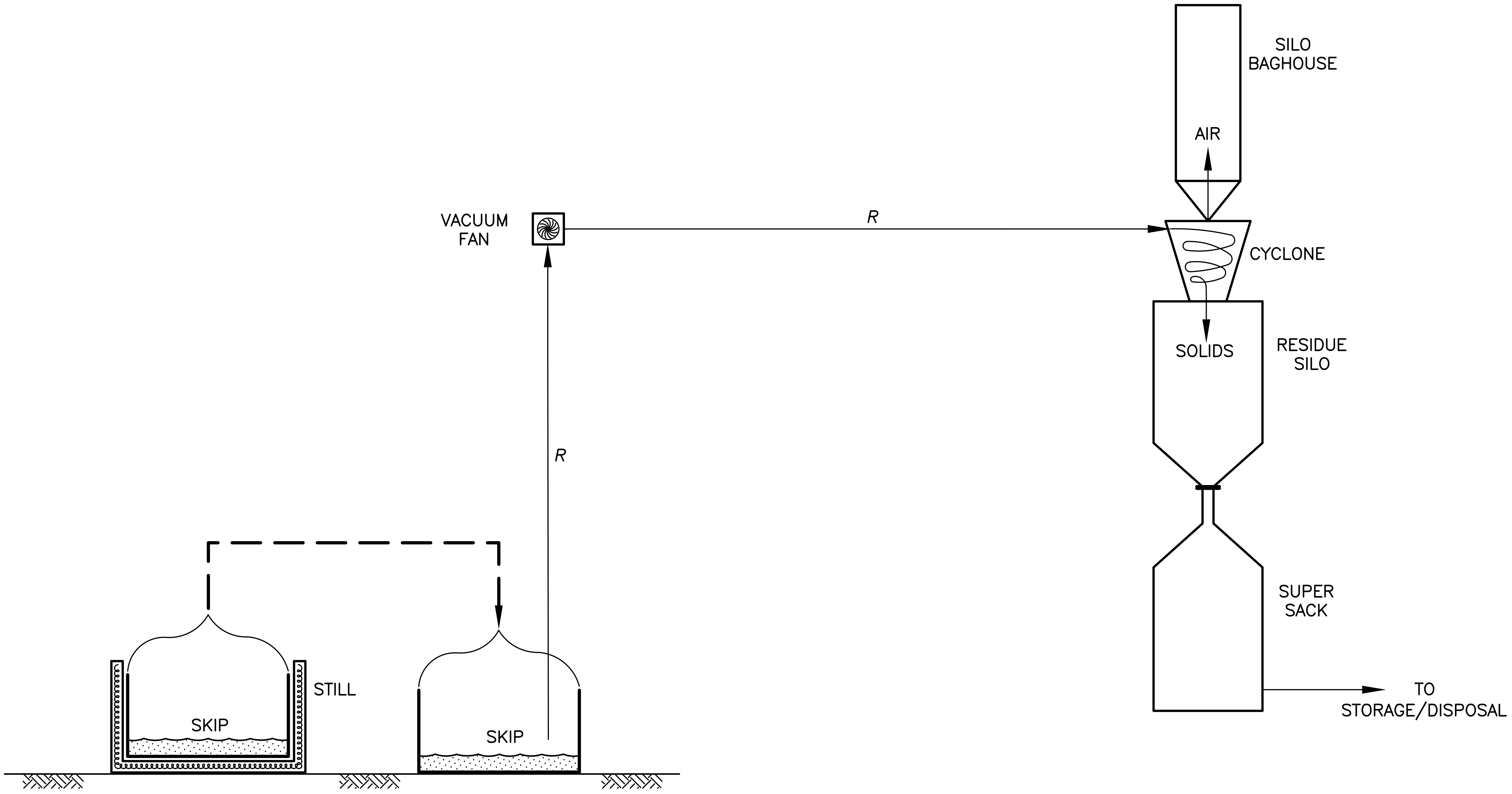


Figure 3–7

CONCEPTUAL
MUD STILL PROCESS FLOW DIAGRAM
PROCESS 1 AND 2
Silver Bow Plant
Butte, Montana

PROCESS 3: PROCESS RESIDUE MANAGEMENT



CP – CRUDE PHOSPHOROUS
N_2 – NITROGEN (SWEEP GAS)
P_4 – PHOSPHORUS
R – RESIDUALS
V – VAPOR
W – WATER

Figure 3–8

CONCEPTUAL
MUD STILL PROCESS FLOW DIAGRAM
PROCESS 3
Silver Bow Plant
Butte, Montana

CADD USER: Rick Gustner FILE: M:\ADEPTWORK\RLG\2646000630_MUD STILL PFD P3.DWG PLOT SCALE: 1:1 PLOT DATE: 10/2/2014 9:19 AM
. . rlg M:\AdeptWork\RLG\2646000630_Mud Still PFD P3.dwg Plot at 0 10/02/2014 09:17:55

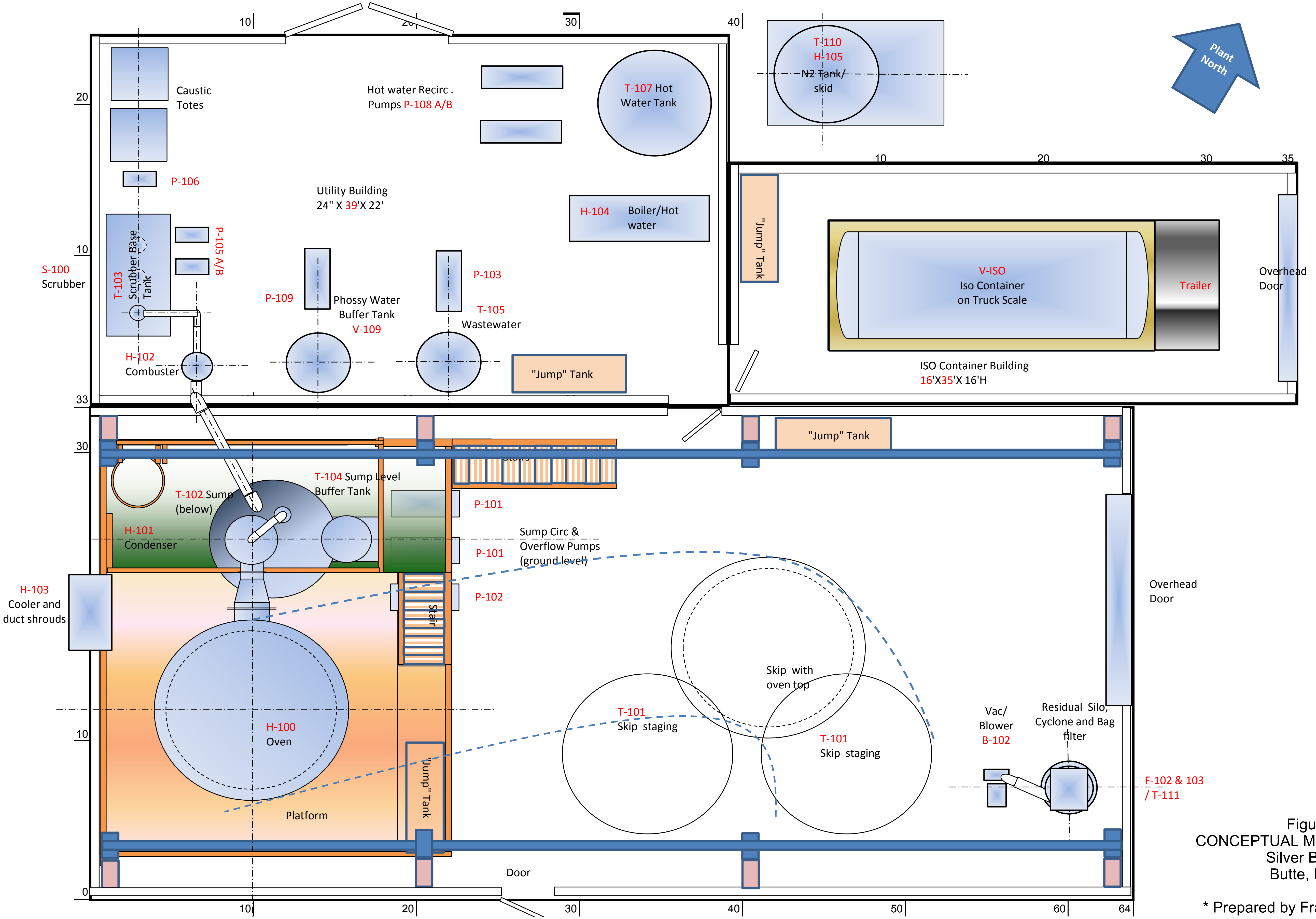
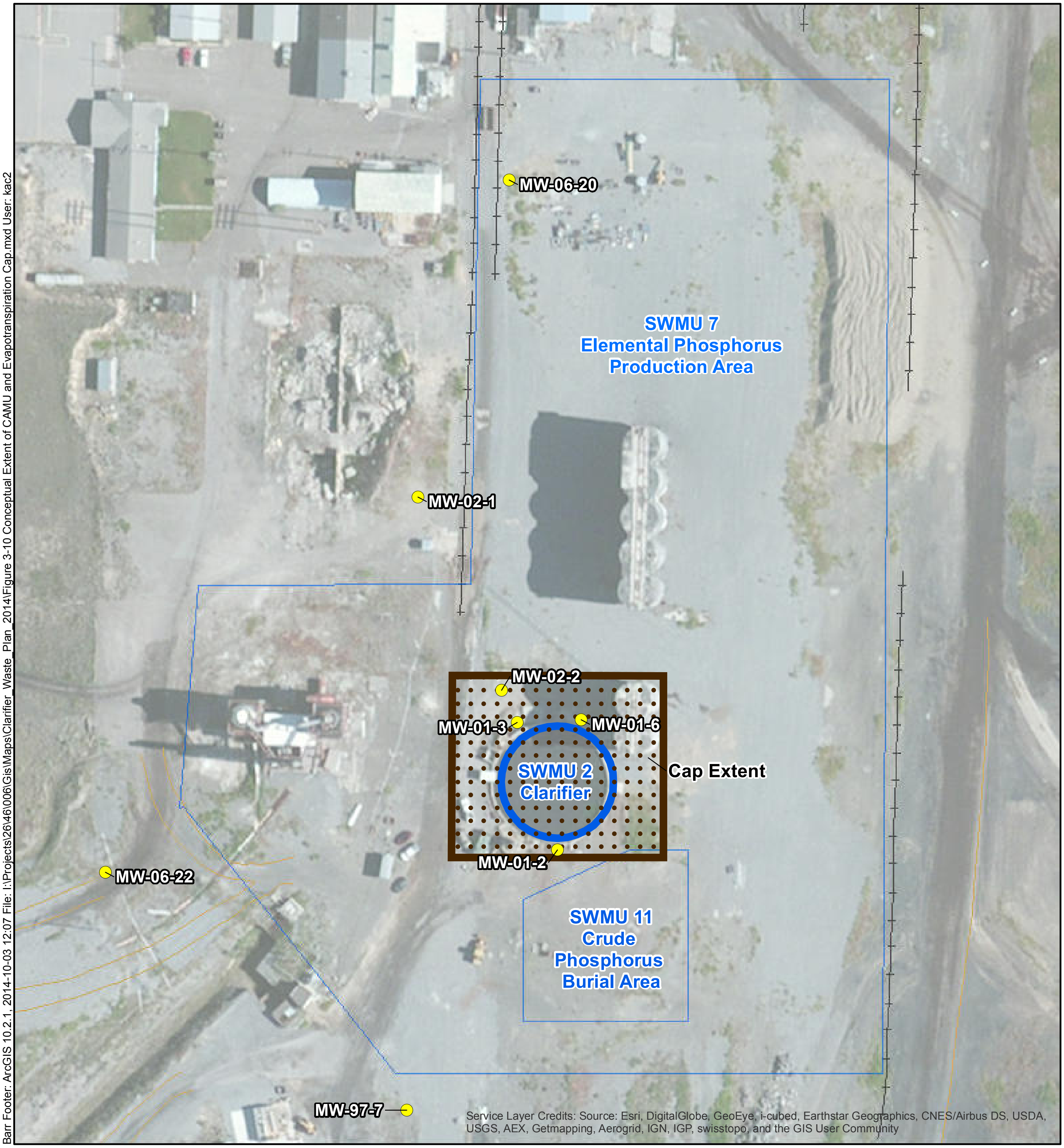


Figure 3-9
CONCEPTUAL MUD STILL LAYOUT
Silver Bow Plant
Butte, Montana

* Prepared by Franklin Engineering

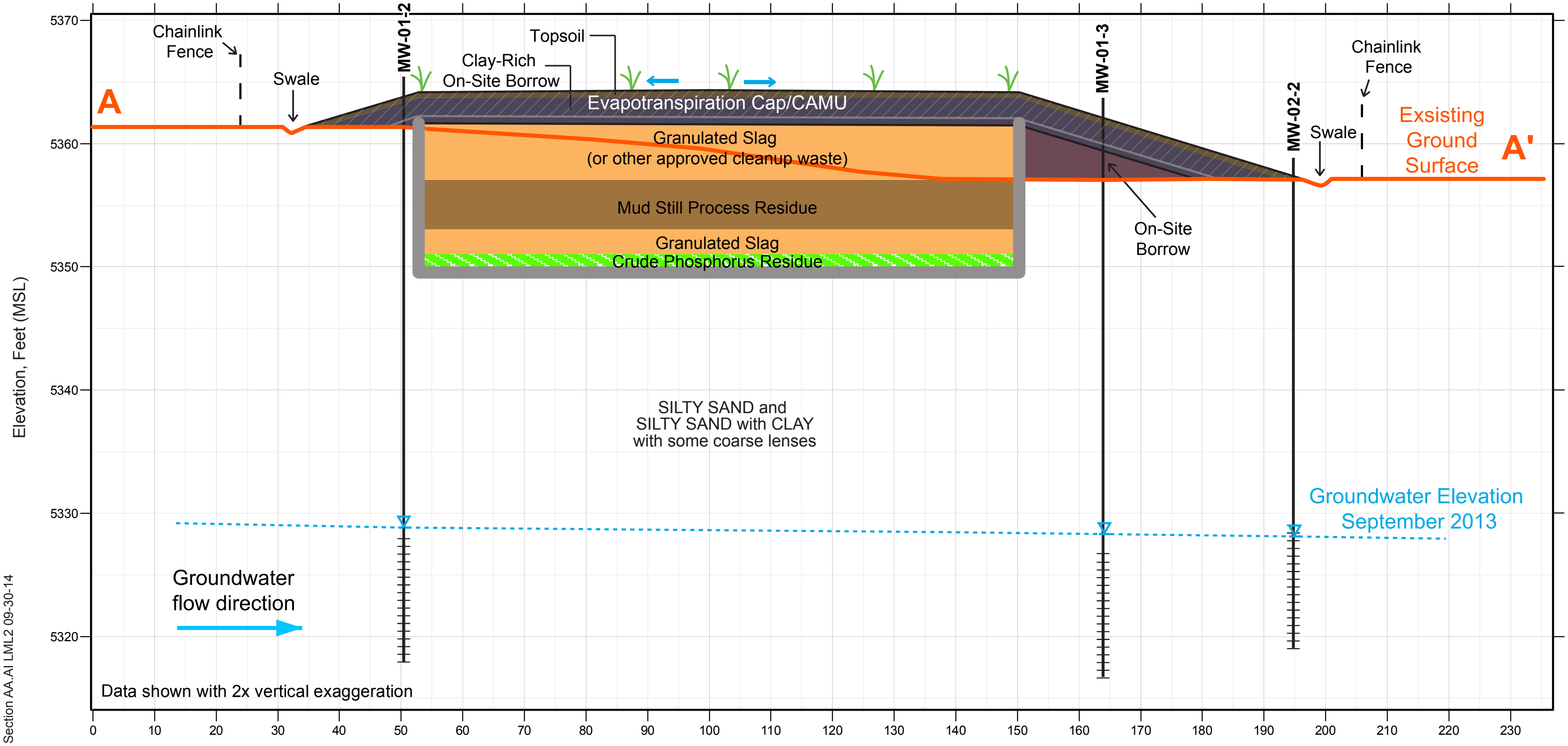


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 3-10

CONCEPTUAL EXTENT OF CAMU AND EVAPOTRANSPIRATION CAP
Silver Bow Plant
Butte, Montana

Barr Footer: ArcGIS 10.2.1, 2014-10-03 12:07 File: I:\Projects\26\46\006\Gis\Maps\Clarifier_Waste_Plan_2014\Figure 3-10 Conceptual Extent of CAMU and Evapotranspiration Cap.mxd User: kac2



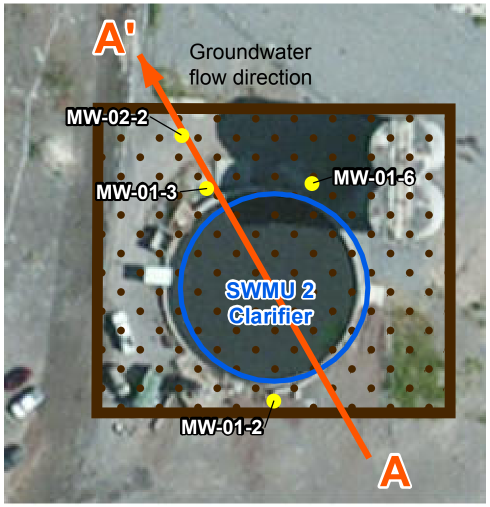


Figure 3-11

CONCEPTUAL EVAPOTRANSPIRATION CAP DETAIL
Silver Bow Plant
Butte, Montana

P:\Mpls\26 MT\46\2646006\WorkFiles\Figures_Graphics\AI\2014\Figure X Cross Section AA.AI LML2 09-30-14

Appendix A

7003 Order (amended December 27, 2000)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 300
DENVER, CO 80202-2466
http://www.epa.gov/region08

DEC 27 2000

Ref: 8ENF-L

Ken Kastner
Bryan Cave LLP
700 Thirteenth Street, NW
Washington, DC 20005-3960

Re: In the Matter of Rhodia, Inc.
RCRA-8-2000-07

Dear Ken:

Enclosed please find an amended order in the above referenced case. This amended order merely incorporates extensions of time previously agreed to by the U.S. Environmental Protection Agency. Section VII, Paragraph F has been amended to include the new due date for the Interim Measures Work Plan (September 18, 2000). Section VII, Paragraph K has also been amended to state that the Waste Plan is now due January 31, 2001.

Please call me at 303-312-7054 if you have any questions.

Sincerely,

Lauren C. Buehler

Lauren C. Buehler

cc: Tina Diebold
Dan Bersanti
Ken Platt

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

00 DEC 27 PM 2:42
FILED
EPA REGION VIII
HEARING CLERK

Docket No. RCRA-8-2000-07

IN THE MATTER OF:

Rhodia Inc.
P.O. Box 3146
Butte, MT 59702

EPA ID No. MTD 057 558 546

Respondent.

AMENDED ADMINISTRATIVE ORDER

Proceeding Under § 7003 of the Solid Waste Disposal Act, as amended, 42 U.S.C. § 6973

I. JURISDICTION

The United States Environmental Protection Agency Region VIII ("EPA"), has the authority to issue and therefore is issuing this Amended Administrative Order ("Order") pursuant to Section 7003(a) of the Solid Waste Disposal Act, as amended (the "Act"), 42 U.S.C. § 6973(a) ("Section 7003").

II. INTRODUCTION

A. Rhodia Inc. ("Respondent") is a corporation authorized to do business in Montana.

B. Respondent owns the Silver Bow facility which is located off German Gulch Road in Silver Bow County, approximately seven miles west of Butte, Montana and approximately one mile south of Ramsey, Montana

C. Respondent is a "person" within the meaning of Section 1004 (15) of the Act, 42 U.S.C. § 6903(15).

D. Respondent has handled and stored "solid waste" within the meaning of Section 1004(27) of the Act, 42 U.S.C. § 6903(27) at all times relevant to the Order.

E. Based on evidence received, EPA has determined that Respondent's handling of solid waste at the Silver Bow facility may present an imminent and substantial endangerment to health or the environment within the meaning of Section 7003 of the Act, 42 U.S.C. § 6973.

F. Pursuant to Section 7003(a) of the Act, EPA has notified the State of Montana in this matter.

G. EPA hereby takes this action pursuant to Section 7003 having determined that the issuance of this Order is necessary to protect health or the environment.

III. PARTIES BOUND

A. This Order shall apply and be binding upon Respondent, including all agents, employees, firms, corporations, contractors, and consultants acting under or on behalf of Respondent in connection with implementation of this Order.

B. Respondent shall provide a copy of all applicable portions of any plan submitted pursuant to this Order to all contractors, subcontractors, laboratories, and consultants retained to conduct or monitor any portion of the work performed under the Order within seven (7) calendar days of the date of such retention, and shall condition all such contracts on compliance with terms of this Order.

C. Respondent shall give notice to EPA thirty (30) or more days prior to transfer of ownership or operation of the Silver Bow facility.

IV. FINDINGS OF FACT

A. Respondent is a corporation doing business in the State of Montana.

B. At all times pertinent to this Order, Respondent has been duly registered with the Montana Secretary of State.

C. Elemental phosphorous was produced at the Silver Bow facility. In 1997, the Silver Bow facility was shut down for decommissioning and closure.

D. The Silver Bow facility is located in a rural area, with scattered residences within one-half to one mile. Livestock are grazed on adjacent lands. A silicon production plant and the Port of Montana are located on adjacent land. The area is heavily frequented by water fowl.

E. EPA inspected the Silver Bow facility from May 1-4, 2000 ("May 2000 Inspection"). At the time of the inspection, EPA observed a 100' diameter, open-topped, in-ground tank. This tank is known as the clarifier. Calculations indicate that the clarifier contains approximately 500,000 gallons of sludge and a "cap" of several feet of water.

F. Respondent has stated that the sludge is a phosphorous sludge and the water cap is used to prevent the sludge from contacting air.

G. EPA inspectors observed two wet areas of ground adjacent to the above-ground portion of the concrete wall of the 100' diameter tank. At one of the wet areas an inspector dug a hole into the ground and observed infiltration of liquid from the clarifier. Water leaked from the clarifier in quantities sufficient to lower the level of the clarifier several inches during the May 2000 Inspection.

H. In the process of sampling the leaking clarifier, an inspector inadvertently spilled a small amount of phosphorous sludge on the top edge of the wall of the leaking clarifier. As the phosphorous sludge dried, it spontaneously started to smoke, then ignited, and burned persistently. The inspector doused the fire with several quarts of water. The phosphorous sludge continued to smolder and smoke. The inspector moved on to the adjacent sampling location. While sampling at the new location, the previously spilled phosphorous sludge re-ignited and burst into flame. Repeated dousing with several quarts of water was insufficient to extinguish the flames. The fire ultimately burned out. The ambient air temperature was 57 degrees Fahrenheit at the time of ignition.

I. The inspectors also placed varying quantities of phosphorous sludge, selected from different locations within the leaking clarifier, in three separate metal pans. As the material in each pan dried out, it smoked and spontaneously ignited in the same manner as the spilled sludge described above in paragraph H. The phosphorous sludge burned so persistently that it left scorch marks on the metal pans.

J. Phosphorous, when combined with water, will react to form phosphine gas. Inhalation of phosphine gas is acutely harmful, and is a severe health hazard. Exposure may cause damage to respiratory membranes, resulting in increased bronchial secretions, shortness of breath, weakness, fatigue, dizziness and fainting. Abdominal pain and vomiting may also occur. Phosphine is a central nervous system depressant and is toxic to the kidneys, resulting in albuminuria and hematuria. Lethal exposures result in pulmonary edema, convulsions and coma. Chronic exposures may result in permanent disturbances of sight, speech, motor functions and skeletal injuries. Phosphine is also considered highly flammable and may spontaneously combust in the air.

K. The inspectors utilized phosphine measuring devices above the surface of the leaking clarifier. This sampling indicated that the toxic gas phosphine was present above the surface of the leaking clarifier at concentrations as high as 1.08 parts per million (ppm). The OSHA time weighted average limit is 0.3 ppm. The NIOSH threshold limit value short term exposure limit is 1.00 ppm.

L. The inspectors discovered piles of used furnace brick and carbon furnace liner, also known as refractory, at various locations within the facility. Some of the used brick and furnace liner were located in the slag pile at the facility, and some were agglomerated in a pile south of the leaking clarifier. Brick sizes vary from about the size of a cinder block to as large as a refrigerator. The pile of bricks and furnace liner south of the leaking clarifier is approximately 100' by 30' by 5'. In an effort to gauge the volatility of the used brick, an inspector threw a small stone at a brick. The brick caught fire and burned vigorously and persistently. The inspectors extinguished this fire with sand, for fear the entire pile of used brick and furnace liner, as well as the surrounding dry grass, might ignite. An inspector turned over a fragment of used brick/refractory. The mere act of overturning the fragment was sufficient to cause the fragment to immediately erupt into flames and burn so vigorously as to approach temperatures of 1,000 degrees Fahrenheit.

M. Respondent does not have a hazardous waste management permit to operate a treatment, storage or disposal facility.

N. As part of its closure activities, Respondent has moved slag from the slag pile to a manmade impoundment of water within the facility boundary that is roughly equivalent to 60 acres. This constant shifting of slag materials may result in a higher incidence of used brick and furnace liner exposure and ignition.

O. As part of its closure activities, Respondent has expressed an intent to the Montana Department of Environmental Quality to bury the leaking clarifier in place.

P. Respondent manages the phosphorous sludges in the 100' diameter leaking clarifier, and the used brick and furnace liner located south of the leaking clarifier and in the slag pile in a manner that presents an imminent and substantial endangerment to health or the environment, as follows:

1. <u>Leaking Clarifier</u>
   (a) The storage of extremely large quantities of ignitable and reactive phosphorous sludge in the 100' leaking clarifier constitutes an imminent hazard to surrounding populations. If the supply of water to the leaking tank is ever interrupted, for whatever reason, the "cap" of water used to maintain a barrier with the air will quickly disappear through the cracks in the leaking tank and through evaporative processes. The entire contents of the leaking tank, hundreds of thousands of gallons of phosphorous sludge, will then be subject to auto-ignition that will emit toxic gaseous compounds that could negatively impact wildlife and the health of nearby populations. A fire in the leaking tank could also ignite a wildfire on adjoining land.

   (b) Even if the water cap on the leaking clarifier is maintained, phosphine gas is constantly exsolved. In the immediate vicinity of the leaking tank, concentrations of phosphine can reach toxic, possibly ignitable levels. Birds and wildlife are unable to differentiate the leaking tank from non-toxic, natural watercourses. If animals stray into the vicinity of the leaking tank, they could succumb to phosphine poisoning.

   (c) The facility maintains no signs warning of the hazardous nature of the wastes on-site. There is but a single, eight foot, chain-link perimeter fence that is topped with barbed wire. There are only three employees at the site during regular business hours, and no staff after the close of business. Extremely hazardous areas within the perimeter fence are not segregated or distinguished in any way. Thus, a trespasser that climbed the perimeter fence would be in extreme danger from unmarked and unrestricted hazards on-site.

2. Used Brick and Furnace Liner

(a) The used brick and furnace liner located in the pile south of the leaking clarifier and throughout the slag pile constitute an immediate hazard to surrounding populations. If even casually disturbed (from meteorological, human or animal activities), the refractory is subject to auto-ignition that will emit toxic gaseous compounds that could negatively impact wildlife and the health of nearby populations. A refractory fire could also ignite a wildfire on adjoining land.

(a) The same lack of security, signage and segregation which cause the leaking clarifier to constitute an exposure risk make the brick pile and slag piles a risk to public health and the environment.

V. CONCLUSIONS OF LAW

A. Respondent is a "person" within the meaning of Section 1004(15) of the Act, 42 U.S.C. § 6903(15).

B. Wastes generated, managed, and stored at the Silver Bow facility are solid wastes as defined in Section 1004(27) of the Act, 42 U.S.C. § 6903(27).

C. Respondent has contributed and/or is contributing to the handling and storage of solid waste at the Silver Bow facility within the meaning of Section 7003 of the Act, 42 U.S.C. § 6973.

D. Respondent's contribution to and/or handling and storage of solid waste at the Silver Bow facility may present an imminent and substantial endangerment to health or the environment within the meaning of Section 7003 of the Act, 42 U.S.C. § 6973.

VI. ORDER

Based on the foregoing Findings of Fact and Conclusions of Law and other information contained in the administrative record for this order, EPA has determined that the activities required by this Order are necessary to protect health or the environment. EPA, therefore, hereby orders Respondent to undertake and complete the following actions. All work undertaken pursuant to this Order shall be performed in a manner consistent with this Order, including all documents incorporated herein pursuant to this Order, and all applicable laws.

VII. WORK TO BE PERFORMED

A. Within 15 calendar days of the effective date of this Order, Respondent must:

(1) Install a security fence around the leaking clarifier and the pile of used brick and furnace liner located south of the clarifier; and
(2) Post signs across the perimeter of the facility and upon the security fences referenced in (1), above, stating "Danger - Unauthorized Personnel Keep Out," which must be legible from a distance of at least 25 feet from each sign. The signs shall be placed at the facility entrance and at a maximum spacing of 750 feet around the perimeter of the facility.

B. Within 30 calendar days of the effective date of this Order, Respondent must assess interim measures necessary to protect public health and the environment, including wildlife, develop an interim measures work plan ("IM Work Plan"), and submit such IM Work Plan to EPA for approval.

C. Interim measures shall include, but not be limited to:

(1) A method for permanently and continuously eliminating wildlife contact with the solid wastes described above, including covering by netting, or other suitable devices;
(2) A method for ensuring the maintenance of the water "cap" over the sludge in the 100' leaking clarifier and measuring phosphine gas and capturing or preventing the release of unacceptable levels of phosphine gas; and
(3) A method of ensuring that operations in the slag pile will not create conditions that could cause used brick and furnace liner to spontaneously ignite.

D. The IM Work Plan shall describe:

(1) The selected interim measures;
(2) The procedures and a schedule required for implementation; and

(3) An operations and maintenance plan and schedule which, if followed, will result in uninterrupted effectiveness of the chosen measure(s) for the scheduled period.

E. EPA shall notify Respondent in writing of any comments it may have on the IM Work Plan which must be incorporated into the IM Work Plan before it can be approved.

F. Respondent must incorporate EPA's comments into the IM Work Plan and resubmit the IM Work Plan ("final submittal") by September 2000.

G. If Respondent fails to timely incorporate EPA's comments and resubmit the IM Work Plan, EPA will either approve, approve with modifications, or disapprove of the IM Work Plan as submitted. If Respondent fails to submit an approvable IM Work Plan by the final submittal date, Respondent shall be in violation of this order.

H. EPA will notify Respondent in writing of its approval, approval with modifications, or disapproval of the IM Work Plan.

I. Within 15 calendar days of receipt of EPA's written approval or approval with modifications, Respondent shall implement the interim measure(s) in accordance with the procedures and schedules contained in the IM Work Plan as approved.

J. Respondent shall include in the IM Work Plan a schedule for providing a written report (Interim Measures Implementation Report) to EPA detailing and confirming the completion of the activities conducted pursuant to the IM Work Plan.

K. Respondent shall submit by January 31, 2001, a written work plan that evaluates alternatives for the lawful disposition of the contents of the leaking clarifier and used brick and furnace liner ("Waste Plan"). The Waste Plan shall include at least one alternative for the lawful removal and disposal of the contents of the leaking clarifier and the used brick and furnace liner.

L. EPA shall notify Respondent in writing of any comments it has on the Waste Plan which must be incorporated in the Waste Plan before it can be approved.

M. Respondent must incorporate EPA's comments into the Waste Plan and resubmit it to EPA within 15 calendar days of receipt of EPA's comments ("final submittal").

N. If Respondent fails to timely incorporate EPA's comments and resubmit the Waste Plan, EPA will either approve, approve with modifications, or disapprove of the Waste Plan as submitted. If Respondent fails to submit an approvable Waste Plan by the final submittal date, Respondent shall be in violation of this Order.

O. EPA will notify Respondent in writing of its approval, approval with modifications, or disapproval of the Waste Plan.

P. Within 15 days of EPA's notification of approval or approval with modifications regarding the Waste Plan, Respondent shall begin implementation of the Waste Plan as approved by EPA in accordance with the procedures and schedules contained in the Waste Plan.

Q. The Respondent shall include in the Waste Plan a schedule for providing a written "Waste Implementation Report" to EPA detailing and confirming the completion of activities conducted pursuant to the Waste Plan.

R. Respondent shall submit three (3) copies of the IM Work Plan and Waste Plan required under this Order for EPA review and approval to:

John Wardell, Office Director
U.S. EPA, Region 8, Montana Office
301 S. Park Ave, DWR 10096-0026
Helena, Montana 59626-0096

VIII. ACCESS

Respondent shall permit full site access as permitted by law to EPA employees, contractors, agents, consultants, designees, representatives, State of Montana and local government representatives, as may be necessary for the purposes of oversight and implementation of this Order.

IX. AVAILABILITY AND RETENTION OF INFORMATION

A. Upon request, Respondent shall make available to EPA, and shall retain, during the pendency of this Order and for a period of five years after its termination, all records and documents in its possession, custody or control, or in the possession, custody or control of its contractors and subcontractors, which relate to the performance of this Order, including but not limited to documents reflecting the results of any sampling, tests, or other data or information generated or acquired by Respondent, or on Respondent's behalf, with respect to the implementation of this Order.

B. After the document retention period, Respondent shall notify EPA at least 90 calendar days prior to the destruction of any such documents, and upon request by EPA, shall deliver the documents to EPA.

X. GENERAL PROVISIONS

A. All plans and documents submitted under any paragraph of this Order shall, upon approval by EPA, be incorporated by reference in this Order as if set forth fully herein.

B. Respondent shall include in the IM Work Plan and Waste Plan the name, title, and qualifications of the personnel to be used in implementing the work required by this Order.

C. Respondent shall obtain any permits or approvals which are necessary to perform work on or outside the Silver Bow facility under applicable law and shall submit timely applications and requests for any such permits and approvals.

XI. FAILURE TO COMPLY

Pursuant to Section 7003(b) and the Federal Civil Penalties Inflation Adjustment Act of 1990, as amended by the Debt Collection Improvement Act of 1996, 31 U.S.C. § 3701, and regulations codified at 40 C.F.R. § 19.4, any failure by Respondent to comply with this Order shall subject Respondent to civil penalties of not more than $5,500.00 for each day of each failure to comply with this Order.

XII. RESERVATION OF RIGHTS

A. Nothing in this Order shall limit the information gathering, access, and response authority of the United States under any other applicable law, nor shall it limit the authority of EPA to issue additional orders to Respondent as may be necessary.

B. This Order shall not be construed as a waiver or limitation of any rights, remedies, powers and/or authorities which EPA has under the Act, the Comprehensive Environmental Response, Compensation, and Liability Act, or any other applicable law.

C. EPA hereby reserves all of its statutory and regulatory powers, authorities, rights, remedies, both legal and equitable, which may pertain to Respondent's failure to comply with any applicable laws and regulations and with any of the requirements of this Order, including but not limited to, the right to disapprove of work performed by Respondent, to request that Respondent perform additional tasks, and the right to perform any portion of the work herein.

D. Compliance by Respondent with the terms of this Order shall not relieve Respondent of its obligation to comply with the Act and/or any other applicable State or Federal law or regulation including without limitation, Montana Code Annotated Section 75-10-401, *et seq.* and associated Administrative Rules of Montana, and any condition of any permit issued under the Act or any other applicable law or regulation.

E. EPA reserves its right to seek reimbursement from Respondent of its costs to the fullest extent allowed by law.

XIII. OPPORTUNITY TO CONFER AND MODIFICATION

A. Respondent has the opportunity to confer informally with EPA concerning the terms and applicability of this Order. If Respondent desires a conference, Respondent must contact EPA Region VIII to schedule and attend such a conference within fourteen (14) calendar days of receipt of this Order.

B. If EPA determines that any element of this Order, including work to be performed or schedules, warrants modification after a conference is held, EPA will modify the Order in writing, file the modification with the Regional Hearing Clerk and issue a copy to Respondent.

C. Except as otherwise provided in this Order, no modification to this Order shall be effective unless and until it is issued in writing by EPA and filed with the Regional Hearing Clerk.

XIV. NOTICE OF INTENT TO COMPLY

A. Respondent shall provide, within two calendar days of the effective date of this Order, written notice to EPA stating whether Respondent will comply with the terms of the Order. The absence of a response by EPA to the notice required by this paragraph shall not be deemed to be acceptance of any assertions that Respondent may make in their notice(s), and shall not affect Respondent's obligation to implement the Order.

B. Failure of Respondent to provide notification to EPA of intent to comply within this time period shall be deemed a violation of this Order.

XV. EFFECTIVE AND TERMINATION DATES

A. This Order shall become effective on the fifteenth (15) calendar day after the date Respondent receives a copy of the executed Order.

B. Modifications made by EPA to this Order are effective on the date such modification is filed with the Regional Hearing Clerk, so long as Respondent is sent a copy by certified mail or has hand delivered to it a copy of the modification as expeditiously as possible after the modification is filed with the Regional Hearing Clerk.

C. This Order shall terminate upon Respondent's receipt of written notice from EPA that Respondent has demonstrated, to the satisfaction of EPA, that the requirements of this Order, including any additional tasks determined by EPA to be required pursuant to this Order, but not including record retention, have been satisfactorily completed.

XVI. SEVERABILITY

If any provision or authority of this Order or the application of this Order to any party or circumstance is held by any judicial or administrative authority to be invalid, the application of such provision to other parties or circumstances and the remainder of this Order as Modified shall not be affected thereby and shall remain in full force.

IT IS SO ORDERED:

ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

Date: 12/18/00

By: John F Wardell
John F. Wardell, Director
Montana Office
EPA Region VIII

By: Michael T. Risner 12/27/00
Michael T. Risner
Legal Enforcement Program
EPA Region VIII

IN THE MATTER OF: Rhodia Inc. and Rhône-Poulenc
Proceeding Under § 7003 of the Solid Waste
Disposal Act, as amended, 42 U.S.C. § 6973

CERTIFICATE OF SERVICE

I hereby certify that the foregoing **Amended Administrative Order** was sent to the following persons in the manner indicated, this **27th day** of **December, 2000**.

ORIGINAL FILED BY HAND DELIVERY TO:

Ms. Tina Artemis
Regional Hearing Clerk
U.S. Environmental Protection Agency, Region VIII
999 18th Street, Suite 500
Denver, CO 80202-2466

COPY BY CERTIFIED MAIL, RETURN RECEIPT REQUESTED TO:

CT Corporation System
40 West Lawrence, Suite A
P.O. Box 1166
Helena, MT 59624

COPY BY REGULAR MAIL TO:

Ken Kastner
Byran Cave LLP
700 Thirteenth Street., NW
Washington, DC 20005-3960
Facsimile No. 202-508-6200

Lauren C. Buehler
Lauren C. Buehler

Appendix B

3008(h) Order (December 22, 2003)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 8

IN THE MATTER OF:)
)
Rhodia Inc.) **DOCKET NO.: RCRA-08-2004-0001**
119130 German Gulch Road.)
Ramsey, Montana) **CORRECTIVE ACTION**
59750) **ORDER ON CONSENT**
)
EPA ID No. MTD0575585546)
)
Respondent.)

Contents

I. JURISDICTION

A. This Corrective Action Order on Consent ("Order") is issued by the United States Environmental Protection Agency Region 8 (EPA) to Rhodia Inc. ("Respondent" or "Rhodia"), the owner and operator of a former elemental phosphorus facility with the address 119130 German Gulch Rd., located near Butte, in Silver Bow County, Montana. Rhodia SA is also a signatory to this Order as guarantor (hereafter "Guarantor"), as provided for in Section XIII.

B. This Order is issued pursuant to the authority vested in EPA under Section 3008(h) of the Resource Conservation and Recovery Act ("RCRA") (42 U.S.C. § 6928(h)).

C. This authority has been delegated to the EPA signatory below.

D. The parties to this order understand and agree that the Federal hazardous waste program in Montana is largely embodied in State law and regulations. Because the State regulations incorporate the Federal regulations by reference, and for the convenience of the parties, citations herein to the regulations are to the Code of Federal Regulations ("CFR").

E. The parties to this Order understand and agree that Respondent is required to comply with this Order as a condition of probation in the Plea Agreement in United States v. Rhodia Inc. (D. MT) ("Plea Agreement") during the entire term of Respondent's probation in that matter. Respondent understands that EPA may refer violations of this Order to the U.S. Probation Office to compel compliance with this Order in and through the U.S. District Court during the period of probation.

F. Respondent and Guarantor individually consent to and agree not to contest EPA's jurisdiction to issue this Order or to enforce its terms. Further, Respondent and Guarantor consent to and agree to not contest EPA's jurisdiction to compel compliance with this Order in any subsequent enforcement proceedings, either administrative or judicial, to require Respondent's full or interim compliance with the terms of this Order, or to impose sanctions for violations of this Order.

II. APPLICABILITY/PARTIES BOUND

A. This Order shall apply to and be binding upon Respondent and Guarantor and their respective successors, assigns, heirs, trustees, receivers, and upon EPA.

B. Respondent shall provide a copy of this Order to all contractors, subcontractors, laboratories, and consultants retained to conduct or monitor any portion of the work performed pursuant to this Order within fourteen (14) days of the effective date of this Order, or within fourteen (14) days after retaining the services of such contractors, subcontractors, laboratories or consultants, whichever is later. Respondent shall require its contractors, subcontractors, laboratories and consultants to perform work which meets the requirements of this Order and Respondent shall be responsible for such work meeting the requirements of this Order.

C. Respondent will be responsible for and liable for any failure to carry out all activities required of Respondent by the terms and conditions of the Order, regardless of Respondent's use of employees, agents, contractors or consultants to perform any such tasks.

D. No change in ownership or corporate status relating to the Facility will in any way alter Respondent's responsibility under this Order. Any conveyance of title, easement or other interest in the Facility, or a portion of the Facility, shall not affect Respondent's obligations under this Order.

E. Respondent shall give written notice of this Order to any successor in interest prior to transfer of ownership or operation of the Facility or any portion thereof, and shall notify EPA at least twenty (20) days prior to any such transfer of ownership or operation.

F. Respondent agrees to undertake all actions required by this Order, including any portions of this Order incorporated by reference.

III. DEFINITIONS

For purposes of this Order the following definitions shall apply. Unless otherwise expressly provided herein, terms used in this Order shall have the definitions given to them in RCRA or the federal regulations promulgated thereunder.

<u>7003 Order</u> shall mean the Amended Administrative Order issued by EPA Region 8 in RCRA Docket-8-2000-07 to Respondent on June 30, 2000 and amended in December, 2000 under Section of RCRA 7003, 42 U.S.C. § 6973, to address crude phosphorus waste in the clarifier and the spent carbon brick and liner waste from the furnace.

<u>Acceptable</u> shall mean that the quality of submittals or completed work is sufficient in addressing the principle components of the required submittal or work so as to warrant EPA review in order to determine whether the submittal or work meets the terms and conditions of this Order, including all attachments, scopes of work, approved work plans and/or EPA's written comments, and relevant guidance documents. Acceptability of submittals or work, however, does not necessarily imply that they are approvable or will be approved pursuant to this Order. Approval by EPA of submittals or work, however, establishes that those submittals were prepared, or work was completed, in a manner acceptable to EPA.

<u>Additional Work</u> shall mean any activity or requirement that is not expressly covered by this Order or attachments but is determined by EPA to be necessary to fulfill the purposes of this Order, which is to protect human health and the environment considering site-specific factors.

<u>Administrative Record</u> shall mean the record compiled and maintained by EPA in connection with the implementation of this Order.

<u>Advanced Notice of Proposed Rulemaking or ANPR</u> shall mean the body of the Federal Register notice found at 61 Fed. Reg. 19432 (May 1, 1996), which was created to provide a strategy to cleanup solid waste management units at hazardous waste management facilities under RCRA and to provide guidance to the corrective action program. Although the majority of the ANPR was subsequently withdrawn from the rulemaking process (64 Fed. Reg. 54604 (Oct. 7, 1999)), the ANPR continues to be considered the primary corrective action implementation guidance (64 Fed. Reg. at 54607).

<u>Areas of Concern</u> shall mean any area of the Facility at or from which a release to the environment of any hazardous waste or hazardous constituent has occurred, is suspected to have occurred, or may occur, regardless of the time, frequency or duration of the release, and which may present an unacceptable risk to human health or the environment regardless of whether such area meets the definition of a SWMU. The term Areas of Concern includes, but is not limited to, areas and discernible units at which solid wastes have been placed, at any time, irrespective of whether the area or unit was intended for the management of solid or hazardous waste. Examples of Areas of Concern include, but are not limited to, landfills, surface impoundments, pits, waste piles, land treatment units,

incinerators, tank systems (including any storage, treatment, or accumulation tank system), container storage units, waste or wastewater treatment system units, and recycling units, or other areas or systems that received solid or hazardous waste or hazardous constituents, or released hazardous waste or hazardous constituents at any time.

CERCLA shall mean the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. § 9601, *et seq*.

Constituent of Potential Concern ("COPC") shall mean any hazardous constituent that has been released at or from the Facility and which may pose a risk to human health or the environment, as determined in the RFI.

Comply or compliance may be used interchangeably and shall mean completion of work required by this Order including submittal of documents of a quality acceptable to EPA, in accordance with work plans approved by EPA and in the manner and time specified in an approved work plan, this Order or any modification thereof. Respondent must meet both the quality (see definition of acceptable) and timeliness components of a particular requirement to be considered to be in compliance with the terms and conditions of this Order.

Contractor shall mean any person including, but not limited to, any consultant, laboratory or subcontractor retained by Respondent to conduct or monitor any portion of the work performed pursuant to this Order.

Corrective Action Management Unit or CAMU shall mean an area within the Facility that is designated pursuant to 40 C.F.R. 264.552 by EPA for the purpose of implementing corrective action requirements under this Order. A CAMU shall only be used for the management of CAMU-eligible wastes pursuant to implementing such corrective action requirements at the Facility.

Corrective measures shall mean those measures or actions appropriate to control, prevent or mitigate the release, potential release or movement of hazardous waste or hazardous constituents into the environment or within or from one media to another.

Corrective Measures Implementation or CMI shall mean those activities appropriate to initiate, monitor, maintain, and complete the remedies EPA has selected or may select.

Corrective Measures Study or CMS shall mean the investigation and evaluation of potential alternative remedies to protect human health and/or the environment from the release or potential release of hazardous wastes, or hazardous constituents, into the environment from and/or at the Facility.

Day shall mean a calendar day unless expressly stated to be a business day. Business day shall mean a day other than a Saturday, Sunday or Federal Holiday. In computing any period of time under this Order, where the last day would fall on a Saturday, Sunday or Federal Holiday, the period shall run until the end of the next business day.

Decision Document shall mean the document issued by EPA after completion of the CMS setting forth EPA's selection of the corrective measure alternative(s) to be implemented at the Facility to achieve final cleanup objectives.

Environmental Indicators (EI) shall mean the EI for current human exposures and the migration of contaminated groundwater, as described in the EPA Memorandum dated February 5, 1999, entitled "Interim-Final Guidance for RCRA Corrective Action Environmental Indicators", from Elizabeth Cotsworth, Acting Director, Office of Solid Waste.

EPA shall mean the United States Environmental Protection Agency, and any successor departments or agencies of the United States.

Facility shall, for the purposes of this Order, mean the property of Respondent located at 119130 German Gulch Road, in Butte-Silver Bow County, Montana, including all contiguous property under the control of Respondent.

Final Corrective Action Plan or Final CAP shall mean the document (May 1994 OSWER Directive 9902.3-2A with identification no. EPA 520-R-94-004) created to provide guidance which program implementors and facility owners/operators can use to develop and direct site-specific corrective action activities.

Groundwater shall mean the water in the saturated zone beneath the land surface.

Guarantor shall mean Rhodia SA, a corporation incorporated in France, with ADRs traded on the New York Stock Exchange. The authorized representative of Rhodia SA for purposes of this Order is Myron Galuskin.

Hazardous constituents shall mean those constituents listed in Appendix VIII to 40 C.F.R. Part 261 or any constituent identified in Appendix IX to 40 C.F.R. Part 264 or any approved subset of Appendix IX to 40 C.F.R. Part 264.

Hazardous waste shall mean "hazardous waste" as defined Section 1004(5) of RCRA, 42 U.S.C. § 6903(5) and 40 C.F.R. Part 261.

Hazardous Waste Management Unit shall mean "hazardous waste management unit" as that term is defined in 40 C.F.R. 260.10.

Imminent Threat shall mean any release, or threatened release, of hazardous waste or hazardous constituent, on or from the Facility, which may present an imminent endangerment to human health and/or the environment.

Interim Measure or IM shall mean those actions which can be, or are, initiated in advance of implementation of the final corrective action for the Facility and which are designed to achieve stabilization and/or control or abate immediate threats to human health and/or the environment and/or minimize the spread of COPCs.

MDEQ shall mean the Montana Department of Environmental Quality.

Order shall mean this Corrective Action Order on Consent and all attachments hereto, and all specifications, reports, schedules, and work plans approved by EPA pursuant to this Order, and all documents incorporated into this Order, as provided herein.

Receptors shall mean those humans, animals, or plants and their habitats which are or may receive or be affected by releases of hazardous waste or hazardous constituents at, or migrating from, the Facility.

Release shall mean any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, seeping, leaching, dumping, placing, or disposing into the environment of any hazardous waste, hazardous constituents or COPC.

Resource Conservation and Recovery Act or RCRA shall mean the Solid Waste Disposal Act, as amended.

RCRA Facility Investigation or RFI shall mean the investigation and characterization of the source(s) and/or releases of hazardous wastes and hazardous constituents and the nature, extent, direction, rate, movement, and concentration of such releases of hazardous wastes and/or hazardous constituents, that have been, or may be released or may reasonably be expected to be released into the environment from or at and/or to migrate from the Facility.

Solid Waste Management Unit or SWMU shall mean any discernable unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility at which solid wastes have been routinely and systematically released.

<u>Stabilization</u> shall mean the actions employed to control or abate releases that pose an actual or potential threat to human health and the environment, to control off-site releases from the migration of contaminated groundwater, and to contain or remove source areas for actual or potential releases.

<u>Submittal</u> shall mean any document Respondent is required to send to EPA and MDEQ pursuant to this Order, including but not limited to all work plans, reports and progress reports.

<u>Violation(s)</u> shall mean any actions, omissions, failures, or refusals to act by Respondent that result in a failure to meet any term or condition of this Order.

<u>Work or obligation</u> shall mean any activity Respondent must perform to comply with the requirements of this Order.

<u>Work plan</u> shall mean the detailed plans prepared by Respondent as required under this Order. All work plans and modifications or amendments thereto are incorporated into this Order and are an enforceable part of this Order when approved in writing by EPA.

IV. FINDINGS OF FACT AND CONCLUSIONS OF LAW

For purposes of this Order, and based on the Administrative Record, EPA makes the following findings of fact and conclusions of law:

A. Respondent and Guarantor are each a "person" within the meaning of 40 C.F.R. 260.10 and Section 1004(15) of RCRA.

B. Respondent's former elemental phosphorus production facility comprises approximately 120 acres, and is located in Sections 23, 24, 25 and 26, Township 3 North, Range 9 West.

C. At all times relevant, Respondent was and is presently a Delaware corporation registered to conduct business in the State of Montana.

D. Respondent and its predecessors began manufacturing operations at the facility around 1950. Certain solid wastes and constituents released at the Facility by Respondent are hazardous wastes and/or hazardous constituents.

E. During the years of operation, a variety of wastes, including but not limited to characteristic hazardous wastes (including D001) were generated, treated, stored, or disposed of.

F. In 1980, pursuant to Section 3010 of RCRA, Stauffer Chemical Company, a predecessor to Respondent, notified EPA of its hazardous waste activity at the Facility. In its notification, Stauffer Chemical Company identified itself as a generator of hazardous waste.

G. The principal activities at the plant were the manufacture of elemental phosphorus.

H. Environmental investigations at the Facility have been undertaken by Respondent and government agencies to assess environmental contamination at the Facility. The data collected in these investigations will be used to identify some of the SWMUs or Areas of Concern requiring further investigation and/or possible interim measures.

I. Hazardous constituents, including elemental phosphorus, fluoride, arsenic, and cadmium, have been detected at the surface and in the subsurface onsite and/or offsite.

J. In 2000, Respondent, in response to the 7003 Order issued by U.S. EPA Region 8, installed a series of engineering controls (fencing, netting and other covering, etc.) to restrict access to two unpermitted hazardous waste management units, a 100-foot clarifier containing crude phosphorus and a pile of spent carbon refractory brick. However, decisions regarding the ultimate disposition of the material in the 100-foot clarifier or carbon refractory brick have not occurred as of the date of this Order.

K. Elemental phosphorus in groundwater and subsurface soils has been detected adjacent to the 100-foot clarifier.

L. Offsite elemental phosphorus in the sediments of Silver Bow Creek and Sheep Gulch has been reported by EPA.

M. Certain heavy metals have been detected in groundwater extending northward and westward to Silver Bow Creek and Sheep Gulch.

N. There has been a release of fluoride from the facility impacting offsite land.

O. There is or has been a release of hazardous waste into the environment at the Facility.

P. The actions required by this Order are necessary to protect human health and/or the environment.

V. ORDER

Pursuant to Section 3008(h) of RCRA, Respondent agrees to and is hereby ordered to perform the work required by this Order, in the manner and by the dates specified herein.

VI. STATEMENT OF PURPOSE AND INTEGRATION OF REMEDIAL AUTHORITIES

A. By entering into this Order, the mutual objectives of EPA and Respondent are for Respondent to perform investigation and, as appropriate, remediation activities in accordance with the requirements of this Order to address releases of hazardous waste and hazardous constituents at and from the Facility as necessary to protect human health and the environment considering site-specific factors.

B. The Parties acknowledge and agree that investigation and remedial decisions regarding the clarifier, the spent carbon brick and liner material, and remediation of any releases therefrom are expected to be addressed by EPA through and in accordance with the 7003 Order. Further, removal and plugging of the discharge pipe in the non-floodplain portion of Parcel 26 is expected to be undertaken in accordance with an Administrative Order on Consent (AOC) pursuant to Section 7003 of RCRA between EPA and Respondent, which AOC is presently being negotiated by EPA and Respondent. In addition to this provision, the only other provisions of this 3008(h) Order that apply to the 7003 Order are Section XIII -- Financial Assurance, Section XX -- Other Applicable Laws, and Section XXIII -- Dispute Resolution and Judicial Review.

VII. NOTIFICATION, SUBMITTAL AND CERTIFICATION REQUIREMENTS

A. Unless otherwise specified, reports, notices, approvals, disapprovals, or other submittals relating to or required under this Order shall be in writing and shall be sent to the parties' respective Project Managers, with a copy to MDEQ care of:

Jan Sensibaugh, Director
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

B. One copy of all documents relating to evidence of financial assurance should be sent to:

Ms. Daniela Golden
Mail Code: ENF-T
EPA, Region 8
999 Eighteenth Street, Suite 300
Denver, CO 80202-2466

C. Any report or other document submitted by Respondent pursuant to this Order which makes any representation concerning Respondent's compliance or noncompliance with any requirement of this Order shall be certified by a responsible corporate officer of Respondent or a duly authorized representative of such responsible corporate officer. A responsible corporate officer may include a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation. Respondent may delegate this requirement to its Project Manager if a responsible corporate official provides EPA a written declaration defining the scope of the Project Manager authority to act on behalf of the corporation.

D. The certification required by paragraph C. above, shall be in the following form:

"I certify that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to evaluate the information submitted. I certify that the information contained in or accompanying this submittal is true, accurate, and complete, except for the following portions of this submittal which I cannot personally verify: [ ]. As to those identified portions of this submittal which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Signature:________________________
Name: ___________________________
Title: ____________________________
Date: ____________________________

E. Two copies of all documents required to be submitted pursuant to this Order shall be hand delivered, sent by certified mail, return receipt requested, or by overnight express mail or courier to the EPA Project Manager, and one copy to the MDEQ representative, unless the EPA Project Manager approves the submission of fewer documents or a different method of submission.

VIII. WORK TO BE PERFORMED

A. CURRENT CONDITIONS/RELEASE ASSESSMENT

1. Respondent has one hundred and twenty days (120) calendar days from the effective date of this Order to provide a Current Conditions/Release Assessment ("CC/RA") Report which lists and evaluates all available data relating to the release of hazardous waste or hazardous constituents at or from the Facility.

2. The CC/RA Report shall address the entire Facility and shall meet the requirements for current conditions description and release assessment set forth in the CAP and the ANPR.

3. The purpose of the CC/RA Report is to assess the completeness and quality of the existing data which will be used, in whole or in part, to define the nature and extent of releases of hazardous wastes or hazardous constituents at and/or from the Facility. The CC/RA Report shall also identify potential threats to human health and the environment from releases or potential releases at or from the Facility.

4. Respondent may include within the CC/RA report a Conceptual Site Model.

5. The CC/RA Report shall address:

a. the identification of COPCs;

b. the identification of SWMUs or Areas of Concern;

c. the quality of the existing data used in assessing site conditions or used in a risk assessment;

d. the areas of the Facility for which existing data are adequate to define releases and supply information for identification and evaluation of interim measures;

e. the areas of the Facility for which existing data are adequate to demonstrate that there are, or have been, no releases of hazardous waste and/or hazardous constituents above levels of preliminary concern from any source and that no additional consideration is needed; and

f. the areas of the Facility for which existing data are not adequate.

B. INTERIM MEASURES

1. Respondent may submit any Interim Measures Work Plan at any time during implementation of this Order.

   EPA may require Respondent to submit additional Interim Measures Work Plans based on the CC/RA Report or the RFI Summary Report and a determination that the specific interim measure is appropriate to achieve stabilization in order to control or abate threats to human health and the environment from releases of hazardous waste or hazardous constituents while long-term corrective measures alternatives are being evaluated. EPA shall provide written notice of the requirement to submit an Interim Measures Work Plan and explain in such notice its determination. Respondent shall submit Interim Measures Work Plans within thirty (30) days following notification by EPA.

2. Each Interim Measures Work Plan is subject to EPA approval pursuant to the requirements of this Order.

3. Within fifteen (15) calendar days of receipt of EPA's written approval or approval with modifications, Respondent shall begin to implement the interim measure(s) in accordance with the

procedures and schedules contained in the IM Work Plan as approved and shall complete the Interim Measures in accordance with the schedule contained in the Work Plan.

4. Within fifteen (15) calendar days of implementation of the IM Work Plan, Respondent shall provide a written report (Interim Measures Implementation Report) to EPA detailing and confirming the completion of the activities conducted pursuant to the IM Work Plan.

5. Respondent shall make the IM Work Plan available to the public in the local repository established pursuant to this Order.

C. IMMINENT THREAT

1. In the event Respondent identifies a potential imminent threat to human health or the environment at or originating from the Facility, Respondent shall orally notify the EPA Project Manager within twenty four (24) hours of discovery and notify EPA in writing within ten (10) days of such discovery, summarizing the immediacy and magnitude of such threat(s), and proposed appropriate response action(s) on the part of the Respondent to mitigate the threat(s). EPA will review reported potential imminent threats and determine if and when a work plan is necessary.

2. If EPA identifies an imminent threat to human health and/or the environment at or originating from the Facility, EPA will notify Respondent in writing. Within fifteen (15) days of receiving EPA's written notification, Respondent shall submit an IM Work Plan in accordance with the Final CAP that identifies interim measures which will be implemented to mitigate the threat.

3. If EPA determines that immediate action is required, the EPA Project Manager may orally authorize or require Respondent to act prior to Respondent's receipt of EPA's written notification, including the taking of immediate action to abate the threat or harm.

4. Any oral requirements made pursuant to this subsection shall be immediately incorporated into this Order by reference and are immediately enforceable, unless EPA does not provide to

Respondent in writing, a description of such requirements within 72 hours of oral notification.

D. RCRA FACILITY INVESTIGATION (RFI) WORK PLANS

1. If, after reviewing the Final CC/RA Report, EPA determines that an RFI is necessary for one or more COPCs in one or more media, areas of the Facility, or areas beyond the Facility boundaries if there has been migration off-site, within one hundred and twenty (120) days of receipt of EPA's determination, Respondent shall submit to EPA for review and approval a Work Plan for a RCRA Facility Investigation ("RFI Work Plan") for such COPC(s), media and area(s). Any RFI Work Plan shall use the CAP and relevant EPA guidance as a guideline and incorporate any elements noted in the CAP as appropriate for facility-specific conditions.

2. Relevant EPA guidance may include, but is not limited to: the "RCRA Facility Investigation (RFI) Guidance" (Interim Final, May 1989, EPA 530/SW-89-031 (OSWER Directive 9502.00-6D)); and "RCRA Ground-Water Monitoring Technical Enforcement Guidance Document" (OSWER Directive 9950.1, September 1986); the Advanced Notice of Proposed Rulemaking at 61 Fed. Reg. 19432 (May 1, 1996); and "Interim Guidance on Financial Responsibility for Facilities Subject to RCRA Corrective Action" (Sept. 30, 2003).

3. The RFI Work Plan shall document the procedures Respondent will use in conducting investigations necessary to:

    a. characterize the source(s) of hazardous waste or hazardous constituent releases or potential releases of any hazardous waste or hazardous constituent;

    b. identify and determine the nature, extent, and the rate of migration of releases of hazardous wastes or hazardous constituents at or from the Facility;

    c. determine the likely routes of migration of releases of hazardous waste or hazardous constituents, if any, at or from the Facility including characterization of the geology and hydrology of the Facility;

d. determine the degree and extent of, or threat of, migration of releases of hazardous waste and hazardous constituents at or from the Facility;

e. identify actual and potential receptors;

f. support the development of corrective measure alternatives; and

g. be definitive enough to support the selection of corrective measures.

4. In addition to the work required under paragraph VIII.D.3.e. immediately above, the RFI Work Plan may describe the methods to be used to gather information to support a risk assessment of the conditions at the Facility, and to conduct an assessment of risk to identified receptors and their environment.

5. The RFI Work Plan shall address all hazardous waste or hazardous constituents which have been released, or can be expected to have been released at or from the Facility.

6. The RFI Work Plan shall describe the investigation to be done at each SWMU or AOC including an investigation of the complete lateral and vertical extent of any releases of hazardous waste or hazardous constituents from such areas. However, Respondent may propose risk-based concentrations or other investigation endpoints that, if approved by EPA, would be used to limit the scope of the investigation to delineate the extent of contamination at the Facility. EPA's decision to approve the use of such risk-based concentrations or other investigation endpoints shall be based on a demonstration that delineation beyond the risk-based concentrations or other investigation endpoints is not necessary to determine: a) whether corrective measures should be undertaken; or b) what the corrective measures, if any, should be.

7. The RFI Work Plan shall define the methods of analysis to evaluate the presence, magnitude, extent, direction, and rate of migration of any releases of any hazardous waste or hazardous constituents.

8. The RFI Work Plan shall be developed so that, if followed, Respondent can elicit data of adequate technical quality to

support the development and evaluation of corrective measure alternatives during any Corrective Measures Study; and to support a risk assessment.

9. If significant new information relating to hazardous waste or hazardous constituent releases not included in the CC/RA Report is discovered at the Facility, Respondent shall include such information in its next progress report.

10. The RFI Work Plan shall be modified within sixty (60) days of notification from EPA to address newly identified releases, threatened releases, or Areas of Concern.

11. The RFI Work Plan shall include:

    a. a Project Management Plan;

    b. a Data Collection Quality Assurance Plan;

    c. a Data Management Plan for each unit/area or groups of units/areas as appropriate;

    d. a Health and Safety Plan;

    e. a Community Relations Plan;

    f. a Borehole Abandonment Plan; and

    g. a schedule for implementation of all activities described in the RFI Work Plan, including preparation and submission of preliminary and final reports to EPA.

12. The RFI Work Plan and activities conducted pursuant to the RFI Work Plan are subject to acceptance and approval by EPA based on the criteria identified in this Section VIII. D. Such approval shall not be unreasonably withheld by EPA.

E. RFI Reports

1. In compliance with the schedule developed in the RFI Work Plan, Respondent shall prepare an analysis and summary of the RFI and its results. The objective is to ensure that the investigative data collected pursuant to the RFI Work Plan are sufficient in quality and quantity to describe the nature, extent and rate of releases of hazardous waste or hazardous

constituents, threat(s) to human health and/or the environment (including risk assessment analysis), and to support any Corrective Measures Study.

2. Data Analysis

   a. Respondent shall analyze all data collected pursuant to this Section and prepare reports on whether the gathering and analysis of such data met quality assurance and quality control and other applicable data gathering and analysis procedures.

   i. The reports shall describe the extent of all releases of hazardous wastes or hazardous constituents in relation to site or background levels, or other approved risk-based endpoints, at

      (A) the source;

      (B) the boundaries of the Area to be Investigated; and

      (C) off-site locations, if any, to which the releases have migrated. Background groundwater values for all applicable hazardous constituents described in the RFI Work Plan shall be obtained from analyses of water extracted from appropriate upgradient wells.

   ii. All sampling and analyses shall be conducted in accordance with the Data Collection Quality Assurance Plan included as part of the approved RFI Work Plan.

   iii. All sampling locations, methods and equipment used shall be documented in a field log and all locations shall be identified on detailed site maps.

3. Laboratory, Bench-Scale, and Field Pilot-Scale Studies.

   a. With prior EPA approval, Respondent may conduct laboratory and/or bench-scale studies and field and pilot-scale testing to determine the applicability of a corrective measure technology or technologies to site conditions.

   b. If Respondent proposes to conduct studies pursuant to RFI Work Plan, the Respondent shall provide to and obtain from EPA approval of a work plan defining proposed laboratory and bench scale studies and field and pilot-scale testing.

c. If Respondent proposes to conduct studies pursuant to RFI Work Plan, Respondent shall analyze the technologies based on literature review, vendor contacts, and past experience, to determine the testing requirements.

F. CORRECTIVE MEASURES STUDY (CMS) Work Plan

1. Within forty-five (45) calendar days following the receipt of notification in writing by EPA of EPA's approval of the RFI Summary Report, Respondent shall prepare and submit to EPA a Corrective Measure Study ("CMS") Work Plan to evaluate corrective measures for each release of hazardous waste or hazardous constituent that EPA has determined may require a corrective measure based on such being necessary to protect human health and the environment considering site-specific factors. The CMS Work Plan shall use and be in accordance with relevant EPA guidance including: the Final CAP, the ANPR, and the Post Closure Rule.

2. The CMS Work Plan may be divided into a number of sections for logical reasons and analyze different options for different sections. Site-specific corrective measure objectives for the investigation shall be stated in the CMS Work Plan.

3. The CMS Work Plan shall be designed to identify corrective measure alternatives and to provide an evaluative and investigative strategy capable of identifying the effectiveness of each alternative; to recommend and justify the selection of the most effective corrective measure(s) to employ at the Facility over the duration of the cleanup effort; and to obtain all the necessary data needed to compose all of the CMS investigation findings into a CMS Summary Report. The CMS Work Plan is subject to approval by EPA.

4. All corrective measure alternatives shall be developed based upon the results of the CC/RA Report, the RFI Summary Report, and an evaluation of human health and ecological risk existing at the facility.

5. Respondent shall develop, evaluate and propose corrective measure alternatives, and EPA will select the final corrective measure(s) to be implemented at the Facility, in light of site-specific factors and based on consideration of the factors identified in the Final Corrective Action Plan and the ANPR, which are:

   a. Protect human health and the environment;

   b. Attain media cleanup standards;

   c. Control the source of releases so as to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment;

   d. Comply with applicable standards for management of wastes;

   e. Long-term reliability and effectiveness;

   f. Reduction of toxicity, mobility, or volume;

   g. Short term effectiveness;

   h. Implementability; and

   i. Costs.

6. Appropriate media cleanup standards shall be selected by EPA for the impacted media. The standards shall:

   a. reflect actual and potential risks at the Facility by considering hazards, toxicity levels, exposure pathways to the hazards and/or toxicity levels, and fate and transport characteristics;

   b. consider current and future land use of the Facility and corresponding exposure scenarios;

   c. be derived based upon existing legal requirements and the results of the RFI Summary Report and an evaluation of human health and ecological risk posed by the Facility.

7. The CMS Work Plan shall describe the strategy Respondent will utilize to evaluate each alternative against the criteria identified in Section VIII.F.5.

8. The CMS Work Plan shall provide a strategy to predict the time frame that each remedial option is capable of meeting protective standards at the points of compliance.

9. The CMS Work Plan shall describe field activities which will be employed to support the findings of the investigation. Such data shall include boring log data, sampling analysis data, contour maps, groundwater elevation data, etc.

10. The CMS Work Plan shall identify remedial options which are capable of successfully satisfying the criteria identified in Section VIII.F.5.

11. Respondent shall make the CMS Work Plan available to the public in the local repository established pursuant to this Order.

G. CMS SUMMARY REPORT

1. Based upon a review of the CC/RA Report, the RFI Report, an evaluation of the human health and ecological risk posed at the Facility and the findings obtained from the implementation of the CMS Work Plan, Respondent shall evaluate each corrective measure alternative and recommend corrective measure alternative(s) which could be implemented at the Facility.

2. Sixty (60) calendar days following the completion of the implementation of the CMS Work Plan, Respondent shall provide a CMS Summary Report for EPA review and acceptance. EPA's written acceptance of the CMS Summary Report does not constitute an approval or selection of the corrective measure alternative(s) proposed and/or recommended in the CMS Summary Report.

3. The CMS Summary Report shall contain the findings of any additional investigations conducted pursuant to the CMS Work Plan, the recommended final corrective measures to be employed, technological limitations posed by utilizing the final remedies for the release of COPCs, and all information used to justify the use of the proposed final corrective measures.

H. CORRECTIVE MEASURES IMPLEMENTATION (CMI) Work Plan

1. After Respondent submits a CMS Summary Report with the proposed final corrective measure alternative(s) to EPA for review, EPA shall tentatively identify the appropriate corrective measure alternative(s) to be implemented based on the evaluation criteria in Section VIII.F.5.

2. Following EPA's tentative identification of the corrective measure(s) to be performed, EPA will conduct a public comment period, in accordance with RCRA and EPA's "RCRA Public Participation Manual", to provide the public with the opportunity to submit comments to EPA regarding the corrective measure(s) identified by EPA. EPA will issue a public notice in a major local newspaper, and, as determined appropriate by EPA, through a radio broadcast, and/or through a notice mailed to the affected community, to notify the public of the comment period. EPA will issue and make available to the public for review and comment a Statement of Basis describing EPA's proposed corrective measure(s) and the rationale and basis for such corrective measure(s). EPA will consider public comments submitted regarding the proposed corrective measure(s).

3. After the public comment period, EPA shall select the corrective measure(s) to be implemented and notify Respondent of EPA's decision in a notification letter, entitled "EPA Decision Document." The EPA Decision Document will describe the rationale and basis for the corrective measure(s) selected with regard to each of the evaluation criteria in Section VIII.F.5, and will include EPA's response to all significant comments made during the public comment period.

4. Respondent shall provide a Corrective Measures Implementation (CMI) Work Plan with implementing schedules after receiving the EPA Decision Document.

    a. The CMI Work Plan shall be developed in accordance with relevant EPA guidance including, but not limited to, the ANPR and the Final CAP.

    b. The CMI Work Plan shall be submitted to EPA ninety (90) days following the receipt of the EPA Decision Document. The Work Plan shall contain initial conceptual design plans and specifications. The initial conceptual design plan with specifications shall clearly describe the size, shape, form, and content of the proposed corrective measure(s); conceptual drawings and schematics; key components required; and the procedures and schedules required to implement the corrective measure(s). The plan shall also contain an operation and maintenance plan, a final design and specification plan, a construction work plan, and a health and safety plan.

i. The operation and maintenance plan shall contain procedures for performing operations, long term maintenance, and monitoring the performance of the corrective measure(s). The performance monitoring section of the plan shall be designed to identify ways to maximize the efficiency and cost-effectiveness of the corrective measure(s) and to ensure protection of potential human or ecologic receptors. Performance monitoring tasks shall accommodate changing concentrations and distribution of contamination.

ii. A final design plan with specifications shall contain drawings and specifications needed to construct the corrective measure(s). Some of the elements that may be featured in the plan include: general site plans, process flow diagrams, mechanical drawings, electrical drawings, structural drawings, piping and instrumentation diagrams, excavation and earthwork drawings, equipment lists, site preparation and field work standards, and preliminary specifications for equipment and material.

iii. The construction plan shall contain procedures that will accommodate seasonal precipitation changes and nearby groundwater usage, etc. for the proposed corrective measures. The plan shall discuss overall management strategies, construction quality assurance/quality control procedures, and contain schedules for constructing the corrective measure(s).

iv. The health and safety plan must include the following: a description of the goals and objectives of the plan in conjunction with insuring the health and safety of on-site personnel and visitors; a list of COPCs which may be encountered by field personnel; a description of personal protection/monitoring equipment and procedures; and a list of Facility organization and emergency contacts. EPA will not approve the health and safety plan but will review the plan to confirm that all necessary elements are included.

c. The CMI Work Plan shall contain a plan to document the achievement of cleanup goals.

d. The CMI Work Plan shall contain a plan to identify necessary or appropriate future land use restrictions, if any, and the method proposed to achieve and maintain them and to provide ongoing effective public notice of the land use restriction. The Work Plan shall contain a schedule to implement land use restrictions.

e. Respondent shall make the CMI Work Plans available to the public in the local repository established pursuant to this Order.

I. CMI SUMMARY REPORT

1. Respondent shall submit a CMI Summary Report to EPA for review and approval two hundred and seventy (270) days following the completion of the activities provided in the CMI Work Plan and the achievement of clean up goals.

2. The CMI Summary Report shall document the criteria used to evaluate the achievement of final cleanup goals.

3. The CMI Summary Report shall include a summary of work completed, analytical data, and monitoring results.

4. Following EPA's review of the CMI Summary Report a public comment period will be conducted.

5. Following EPA's review of the CMI Summary Report and EPA's response to comments made during the public comment period, EPA will provide written comments on the CMI Summary Report to Respondent.

6. Respondent shall modify and resubmit the CMI Summary Report within fifteen (15) days of receipt of EPA's written comments, if necessary.

7. EPA shall provide a written approval/disapproval of the CMI Summary Report to Respondent following the agency's final review of the report.

J. AGENCY APPROVALS

1. EPA will provide Respondent with its written comments or approval, conditional approval, approval with modification, rejection as not acceptable, disapproval with comments and/or modifications, or notice of intent to draft and approve, for any work plan, report (except progress reports), specification or schedule submitted pursuant to or required to be submitted for EPA approval pursuant to this Order.

2. EPA may reject in writing and not comment on any submittal which EPA determines is not acceptable. Submittal of a document which is not acceptable is a violation of this Order, unless such document is resubmitted prior to or on the due date for each submittal and EPA determines that the resubmitted document is acceptable.

3. Respondent shall revise any work plan, report, specification or schedule in accordance with EPA's written comments. Respondent shall submit to EPA any revised submittals within fifteen (15) calendar days upon receipt of EPA written comments or in accordance with a due date specified by EPA. Revised submittals are subject to EPA approval, approval with conditions, rejection as not acceptable, disapproval with comments and/or modifications, or notice of intent to draft and approve.

4. Any report, work plan, specification or schedule approved by EPA, including those drafted by EPA, shall be automatically incorporated into this Order upon written approval.

5. Prior to written approval, no report, work plan, specification or schedule shall be construed as approved and final, except as otherwise expressly provided in the Imminent Threat provisions of this Order. Oral advice, suggestions, or comments given by EPA will not constitute an official approval, nor shall any oral

approval or oral assurance of approval be considered binding on either party, except as otherwise expressly provided for elsewhere in this Order.

6. Within thirty (30) calendar days of Respondent's receipt of written approval, or approval with modifications of any Work Plan, or receipt of a document drafted by EPA after failure by Respondent to draft an approvable document, Respondent shall commence work to implement the tasks required by the Work Plan in accordance with the standards, specifications and schedules set forth in the Work Plan approved by EPA.

7. EPA shall review all draft or final reports or Work Plans, and notify Respondent in writing of EPA's determination regarding the report, work plan or any part thereof. Within thirty (30) calendar days of receipt of EPA's disapproval of a report, Respondent shall amend and submit a revised report, unless an extension is requested by Respondent and granted by EPA.

K. ADDITIONAL WORK

1. Based upon new information and/or changed circumstances, and with regard to releases of hazardous waste or hazardous constituents at or from the Facility, EPA may determine or Respondent may propose that certain tasks, including investigatory work, engineering evaluations, or procedure/methodology modifications, are necessary in addition to or in lieu of the tasks included in any EPA-approved work plan in order to protect human health and the environment, considering site-specific factors.

2. If EPA determines that it is necessary for Respondent to perform additional work, EPA shall specify in writing the technical support and other basis for its determination.

3. Unless Respondent is specifically directed to begin additional work immediately pursuant to the Imminent Threat provisions of this Order, within ten (10) business days of the receipt of such determination, Respondent may request a conference with EPA to discuss the additional work. If Respondent does not request such a meeting, Respondent has waived the right to a meeting. The meeting will be held within ten (10) business days of request.

4. If required by EPA, Respondent shall submit for EPA approval a work plan for additional work or revise an existing work plan. Such work plan(s) shall be submitted within sixty (60) calendar days of receipt of EPA's determination that additional work is to be performed, or according to an alternative schedule established by EPA.

5. Upon approval of a work plan modified to reflect additional work, Respondent shall implement the work plan in accordance with the revised schedule and provisions contained therein.

L. PROPOSED CONTRACTOR/CONSULTANT

1. All work performed pursuant to this Order shall be under the direction and supervision of a professional engineer registered in Montana, hydrogeologist, geologist, or environmental scientist, with expertise in hazardous waste site investigations and remediation. This person shall have the technical expertise sufficient to perform and/or direct all aspects of work for which he or she is responsible.

2. Within fourteen (14) days of retention by Respondent of a contractor different from Barr Engineering, Respondent shall notify EPA in writing of the name, title, and qualifications of the engineer, hydrologist, geologist, or environmental scientist and of any contractors and/or consultants Respondent then plans to use in carrying out the terms of this Order.

3. EPA hereby approves the use of Barr Engineering to undertake the consulting work for Respondent, but reserves the right to disapprove for sufficient cause, any other contractor/consultant that Respondent may identify in the future. If EPA disapproves of an identified contractor/consultant, then Respondent must, within thirty (30) days of receipt of written notice of disapproval, notify EPA, in writing, of the name, title, and qualifications of any replacement.

IX. QUALITY ASSURANCE

A. All sampling and analytical activities undertaken pursuant to this Order shall follow EPA-approved quality assurance, quality control, and chain-of-custody procedures, which procedures shall be part of the Work Plan.

B. In addition, Respondent shall, except to the extent alternate arrangements have been made with and approved by EPA:

1. follow EPA QA guidance for sampling and analysis contained in the document entitled "U.S. EPA Region VIII Minimum Requirements for Field Sampling Activities" September 1996;

2. consult with the EPA Project Manager in advance regarding which laboratories will be used by Respondent and use its best efforts to ensure that EPA personnel and EPA-authorized representatives have reasonable access to the laboratories and personnel used for analyses;

3. require that laboratories used by Respondent for analyses perform such analyses according to EPA methods as found in "Test Methods for Evaluating Solid Wastes," Third Edition (SW-846), or other methods approved by EPA, which such other methods will be identified in advance and approved in writing by EPA if not addressed in an approved Work Plan. If methods other than SW-846 are proposed, Respondent shall submit all alternative protocols to EPA at least forty five (45) calendar days prior to the commencement of analyses for EPA approval;

4. require that laboratories used by Respondent for analyses have a quality assurance/quality control program at least equal to that which is followed by EPA. As part of such a program, and upon written request by EPA, Respondent shall cause such laboratories to perform analyses of samples provided by EPA to demonstrate the quality of the analytical data; and

5. Use EPA guidance to evaluate all data to be collected during the implementation of this Order. This evaluation shall be provided to EPA as part of the sampling plan contained in each Work Plan and shall be updated as necessary.

C. Existing data may be evaluated by EPA for adequacy based on technical quality, to support all CC/RA and RFI Report analyses and conclusions, and development and evaluation of the corrective measures alternatives. Guidance documents on data quality analysis and data collection methods shall be used as guidelines to assess the quality of existing data, with EPA's best scientific and engineering judgments used as the determining factor on data quality.

X. PUBLIC PARTICIPATION

A. Respondent shall develop a Public Participation Plan in consultation with EPA and using the "RCRA Public Participation Manual", September 1996, as guidance and submit the plan to EPA within sixty (60) days of the effective date of this Order. The public participation plan shall assess the community's concerns, obtained through community interviews and identify ways to address those concerns.

B. The following activities must be addressed in the Public Participation Plan:

1. Creating, using, and updating a mailing list of the affected community and other stakeholders;

2. Providing the name and telephone number of a person who may be contacted and is responsible for providing information concerning the implementation of this Order to the public;

3. Maintaining an easily accessible repository (such as in a local town hall or public library) for documents relating to the Order, including approved work plans and reports; and

4. Informing the public when substantial decisions are made, and when RFI Summary Reports have been submitted to EPA and placed in the locally established repository and at other important points in the process.

D. All activities, work products, and information material for public release developed pursuant to this Order, will be submitted by Respondent to EPA for review at least fourteen (14) days prior to public release and implementation. Respondent shall provide information to the public and conduct public activities following the receipt of EPA approval.

XI. QUARTERLY PROGRESS AND NEW INFORMATION REPORTS

A. The Quarterly Progress Reports deliverable pursuant to this Order shall be sent to EPA no later than the tenth day of the third month of each quarter (March 10, June 10, September 10, December 10) and shall at a minimum:

1. describe the actions, progress, and status of projects which have been undertaken pursuant to this Order;

2. identify any requirements under this Order that were not completed in a timely manner, and problem areas or anticipated problem areas affecting compliance with the Order;

3. describe projects completed during the prior quarter, as well as the activities scheduled for the next quarter;

4. describe and estimate the percentage of the studies completed;

5. include a description and summaries of all findings;

6. describe actions being taken to address and rectify problems;

7. identify changes in key personnel during the reporting period; and

8. include copies of the results of sampling and tests conducted and other data generated pursuant to work performed under this Order since the last Progress Report. Respondent may also submit data that has been validated and confirmed by Respondent to supplement any prior submitted data. Updated, validated, and confirmed data shall be included with the RFI Report if not delivered before.

B. Respondent shall notify EPA in writing of any newly-identified AOCs, SWMUs, or potential SWMUs, discovered during the course of groundwater monitoring, field investigations, or other means, no later than fifteen (15) calendar days after discovery.

C. In the event Respondent identifies a potential imminent threat to human health or the environment, Respondent shall comply with the Imminent Threat provisions of this Order.

D. Respondent's responsibilities regarding information relevant to financial assurance are set forth in Section XIII.

XII. CORRECTIVE ACTION MANAGEMENT UNIT OR CAMU

Respondent may request designation of an area at the Facility to manage CAMU-eligible wastes. Such request shall be submitted to EPA in writing with supporting information as determined necessary by EPA. In accordance with 40 C.F.R. § 264.552, EPA may approve or reject the proposed CAMU designation after reviewing Respondent's written request and other pertinent submittals. EPA will inform Respondent in writing of its determination regarding any request for a CAMU designation.

XIII. FINANCIAL ASSURANCE AND GUARANTY

A. FINANCIAL ASSURANCE

1. Respondent agrees to provide and maintain during the pendency of this Order financial assurance in an amount equal to the total of all cost estimates for the performance of work to be performed pursuant to this Order and the 7003 Order upon the following schedule:

   a. With regard to the 3008(h) Order, financial assurance shall be demonstrated within sixty (60) days of EPA's approval of any RFI Work Plan, imminent threat (IT) Work Plan to the extent a work plan is required by EPA and the work is not expected to be completed within sixty (60) days of approval of the IT Work Plan, IM Work Plan, Additional Work Work Plan, CMS Work Plan, and CMI Work Plan in an amount equal to the total of the cost estimate for the work to be performed under such approved Work Plan. If, however, there is dispute resolution or judicial review under Section XXIII of EPA's decision on any of these Work Plans, Respondent shall demonstrate the financial assurance within sixty (60) days of EPA's decisions being upheld or mutually agreed to.

   b. With regard to remedial work under the 7003 Order, financial assurance shall be demonstrated within ninety (90) days of approval of each Waste Plan remedy under the7003 Order. If, however, judicial review is had of EPA's decisions under the 7003 Order, Respondent shall demonstrate the financial assurance within ninety (90) days of EPA's decision(s) being upheld or mutually agreed to.

2. Except as allowed under Section XIII. B. 2. below, financial assurance may only be provided by one or more of the following: performance or surety bond, liability insurance, an escrow performance guarantee account, a letter of credit, or trust fund, as these mechanisms generally are described for closure and post-closure financial assurance under 40 C.F.R. Part 264. EPA

will review any submitted financial assurance document and either approve or disapprove such document. Any disapproval will be subject to Section XXIII.

3. Respondent shall develop and maintain a single cost estimate annually for the remaining work to be performed pursuant to this Order. Annual cost estimates after the initial year of the demonstration for each remedy shall include an adjustment for inflation in accordance with 40 C.F.R. 264.142. Annual cost estimates shall be submitted with the first Quarterly Progress Report of the year.

4. In any calendar year, if Respondent can show that the estimated cost to complete the remaining work under any work plan has diminished below the amount calculated at the end of the prior calendar year (or as previously recalculated during the calendar year), Respondent may submit a proposal for reduction to EPA, and may reduce the amount of the financial assurance upon approval by EPA, consistent with 40 C.F.R. Part 264, Subpart H, as if such requirements apply to corrective measures.

5. In any calendar year, if Respondent becomes aware, or should become aware, that the estimated cost to complete the remaining work under any work plan has increased by ten percent (10%) or more above the amount calculated by the end of the prior calendar year, such increase shall be reported and documentation of financial assurance for that increase shall be provided in the next due Quarterly Progress Report.

6. Should any change(s) in circumstances occur which causes, or Respondent anticipates might reasonably cause in the short term, the financial assurance mechanism(s) then in place to fail to meet the requirements of this Section, Respondent shall immediately either begin use of a different means for financial assurance, or upgrade its existing affected mechanism(s) to bring it into compliance. Respondent shall have no more than sixty (60) days from the date on which Respondent became aware or should have become aware of such change(s), to comply with this paragraph. Further, Respondent shall provide notice of such change in circumstances in the next due Quarterly Progress Report, or pursuant to the Imminent Threat provisions of this Order if appropriate.

7. Respondent's inability to maintain financial assurance hereunder at any time during the pendency of this Order shall not excuse or be a defense to allegations of failure to perform any requirements of this Order.

8. In the event of a dispute regarding financial assurance, Respondent may only lower the amount of and/or alter the form of the financial assurance in accordance with determinations made by the ARA and the Court under Section XXIII, or mutually agreed to resolution of the dispute.

B. PARENT GUARANTY

1. By signing below, the Guarantor, which is Rhodia SA the parent of Respondent, represents and warrants that it will be responsible for undertaking and paying for all work under this Order that Respondent is unwilling to undertake or pay for, or unable to undertake or pay for due to insolvency, corporate dissolution, or otherwise. In that event, Respondent's obligations and rights of this Order shall become the obligations and rights of Rhodia SA, and Rhodia SA will thereafter be considered the "Respondent" hereunder. The Guarantor here by submits to the jurisdiction of the United States District Court for the District of Montana for the purpose of perfecting this Guaranty.

2. At the time the Guarantor assumes the obligations and rights of Rhodia Inc. pursuant to Section XIII.B.1. above, the Guarantor, as Respondent, is expected to and shall cause to be maintained any existing financial assurance obligations, unless and until EPA approves any changes proposed by the Guarantor as Respondent. In addition, subsequent to the Guarantor's assumption of the obligations and rights of Rhodia Inc., the Guarantor as Respondent shall provide any additional financial assurances required under Section XIII.A. above as such obligations thereafter become due pursuant to this Order. After assuming the obligations and rights of Rhodia Inc., the Guarantor, unlike Rhodia Inc., may propose to provide financial assurance based on the financial test and corporate guarantee mechanism.

C. CHANGED FINANCIAL CONDITIONS

1. In the Quarterly Reports required under Section XI, Respondent shall identify any substantial and material change in the financial conditions of itself or the Guarantor that could potentially threaten the ability of Respondent to provide and maintain the financial assurances set forth in Section XIII. A. or of the Guarantor to provide and maintain the guaranty in Section XIII.B. An annual report of the financial condition of Rhodia SA shall also be provided to EPA, which will be considered satisfied by inclusion of Rhodia SA's semi-annual financial statements on its web site ("www.Rhodia.com") and notice to EPA's project manager that such statements have been posted in the prior quarter or will be posted in the future quarter. In addition to the notice required under Section II. E., Respondent shall also notify EPA in the Quarterly Reports of any corporate reorganization or divestiture of Respondent or Rhodia SA that could result in the transfer of Respondent's or Rhodia SA's obligations to another entity.

2. Based on the foregoing information or otherwise, and after conferring with Respondent, EPA may require Respondent to modify the financial assurance and guaranty requirements set forth in Sections XIII. A. and B. above, subject to the provisions of Section XXIII regarding such requirement. Any requirement by EPA to modify the financial assurance and guaranty requirements, and any judicial affirmance of such a modification, shall be based on and consistent with a finding that there has been a substantial and material change in the financial condition of the Respondent, or a substantial and material change in the corporate structure or ownership of either Guarantor or Respondent, that threatens the ability of Respondent to provide and maintain the financial assurances in Section XIII. A. or of the Guarantor to provide and maintain the guaranty in Section XIII. B.

XIV. ON-SITE AND OFF-SITE ACCESS

A. Upon reasonable notice, and at all reasonable times, EPA, and/or any authorized EPA representative shall be authorized to enter and freely move about all property at the Facility during the effective dates of this Order for the purposes of, inter alia: interviewing Facility personnel and contractors regarding information relevant to the implementation of this Order; inspecting records, operating logs, and contracts related to this Order; conducting tests, sampling or monitoring; using a camera, sound recording, or other documentary type equipment verifying the reports and data submitted to EPA by Respondent; and any other activities to review the progress of Respondent in carrying out the terms of this Order.

B. Respondent shall permit such persons to inspect and copy all files, photographs, documents, and other writings, including all sampling and monitoring data, that pertain to work undertaken pursuant to this Order. To the extent that such information is considered by Respondent to be business confidential or proprietary, Respondent shall so advise such persons in writing. Notwithstanding the above, EPA's right to inspect, conduct interviews, etc. under this Section XIV does not extend to materials that are protected by the attorney-client or attorney-work-product privileges. For purposes of the Order, documents prepared by non-lawyers relating to work under this Order will not be considered privileged except for draft documents prepared for the review by Respondent's lawyers in connection with submissions hereunder, and any document when prepared for use in evaluating or presenting Respondent's position in any dispute resolution or judicial review process in Section XXIII or in anticipation of any litigation by a third-party.

C. EPA shall provide Respondent with split samples of any samples taken by EPA.

D. To the extent that work required by this Order, or by any approved Work Plans prepared pursuant hereto, must be done on property not owned or controlled by Respondent, Respondent shall use its best efforts to obtain site access agreements from the present owner(s) of such property within thirty (30) days following transmittal of the Work Plan to EPA.

E. "Best efforts" as used in this Section shall include, at a minimum, a certified letter (showing actual receipt) from Respondent to the present owner(s) of such property requesting the execution of reasonable access agreements to permit Respondent and EPA and their authorized representatives to obtain access to such property.

F. Any such access agreement shall be submitted to EPA with the next following Quarterly Progress Report.

G. In the event that agreements for access are not obtained within thirty (30) days of the date of receipt of Respondent's certified letter to the property owner, Respondent shall notify EPA in writing within seven (7) days thereafter regarding both the efforts undertaken to obtain access and its failure to obtain such agreements. EPA may, at its discretion, assist Respondent in obtaining access.

H. Nothing in this section limits or otherwise affects EPA's right to access and entry pursuant to applicable law.

I. Nothing in this section shall be construed to limit or otherwise affect Respondent's liability and obligation to perform work required under this Order including such work required beyond the facility boundary, notwithstanding the lack of access.

XV. SAMPLING AND DATA/DOCUMENT AVAILABILITY

A. Unless notified by EPA in writing, Respondent shall submit to EPA the results of sampling and/or tests or other data generated by, or on behalf of Respondent, in the Quarterly Progress Reports. In addition, Respondent shall submit to EPA the results of all validated and confirmed sampling and/or tests or other data generated by, or on behalf of Respondent performed pursuant to this Order, with the RFI Report, if not before.

B. Respondent shall notify EPA in writing at least seven (7) calendar days before conducting any well drilling, installation of equipment, or sampling. Respondent shall provide a reasonable amount of, or allow EPA or its authorized representatives to take, split samples of all samples collected by Respondent pursuant to this Order.

C. Except as noted below, Respondent may assert a business confidentiality claim covering all or part of any information provided to EPA or its representatives pursuant to this Order. Any assertion of confidentiality shall be substantiated by Respondent when the assertion is made, or the right to assert the claim shall be waived. Physical or analytical data either generated and/or submitted pursuant to this Order cannot be claimed confidential and/or privileged.

XVI. RECORD PRESERVATION

During the pendency of this Order and for a minimum of three (3) years from EPA approval of the CMI Summary Report, Respondent shall preserve all submittals and data generated and/or submitted in its possession or in the possession of its divisions, officers, directors, employees, agents, contractors, attorneys, successors and assigns which relate to performance under this Order or to hazardous waste management at the Facility. For a period of three (3) years from EPA approval of the CMI Summary Report, Respondent shall make such records available to EPA for inspection or copying or shall provide copies of any such records to EPA. Respondent shall notify EPA twenty (20) calendar days prior to the destruction of any such records, and shall provide EPA with the opportunity to take possession of any such records. Preservation and transfer of records under this Section is subject to the same protections for privileged documents as appears in Section XIV. B.

XVII. PROJECT MANAGERS

A. On or before the effective date of this Order, EPA and Respondent shall designate Project Managers. Each Project Manager shall be responsible for overseeing the implementation of this Order. The EPA Project Manager shall be EPA's designated representative at the Facility. To the maximum extent possible, all communications between Respondent and EPA, and all documents, reports, approvals, and other correspondence concerning the activities performed pursuant to the terms and conditions of this Order, shall be directed to the Project Managers.

B. The EPA project manager is:

RCRA Project Manager for Rhodia Inc., Silver Bow Plant
U.S. EPA Region 8, Montana Office
10 West 15th Street, Suite 3200
Helena, MT 59626

C. The Respondent's Project Manager is:

Dan Bersanti
Rhodia Inc.
P.O. Box 3146
Butte, MT 59702

D. The parties agree to provide at least seven (7) calendar days' notice prior to changing Project Managers.

E. The absence of the EPA Project Manager from the Facility shall not be cause for the stoppage of work unless so directed by the Project Manager pursuant to the Imminent Threat Provisions of this Order.

F. Pursuant to the Power of Attorney from Rhodia SA, which is Attachment 1 hereto, the Guarantor, Myron Galuskin, President of Rhodia Inc., will act as a contact for Rhodia SA and as a representative of Rhodia SA to accept service of process at the following address:

Myron Galuskin
President
Rhodia Inc.
CN 7500
Cranbury, NJ 08512-7500

XVIII. RESERVATION OF RIGHTS

A. EPA expressly reserves all rights and defenses that it may have, including the right both to disapprove of work performed by Respondent that is not in compliance with this Order and to require that Respondent perform tasks in addition to those stated in the Work Plans required by this Order in accordance with Section VIII.K. Such disapprovals and requirements to undertake additional work are subject to the provisions set forth in Section XXIII.

B. All statutory and regulatory powers, authorities, rights, remedies, both legal and equitable, which pertain to Respondent's failure to comply with any of the requirements of this Order, including the assessment of penalties, are reserved. Such determination of failure would be made by the court if judicial review is had under Section XXIII.

C. Except as provided in Sections IV and XX, this Order shall not be construed as a covenant not to sue, release, waiver or limitation of any rights, remedies, powers and/or authorities, civil or criminal, which EPA has under RCRA or any other statutory, regulatory, or common law authority.

D. Except as provided in Section XX, compliance by Respondent with the terms of this Order shall not relieve Respondent of its obligations to comply with any other applicable local, state or federal laws and regulations.

E. This Order shall not limit or otherwise preclude EPA from taking additional action pursuant to Section 7003 of RCRA, 42 U.S.C. § 6973, should EPA determine that such actions are warranted to address an imminent and substantial endangerment not known by EPA at the time of this Order, and such endangerment is not being addressed effectively by this Order or the 7003 Order.

F. Except as provided in Section XX, this Order is not intended to be nor shall it be construed as a permit, and this Order does not relieve Respondent of any obligation to obtain and comply with any local, state, or Federal permit.

G. In the event Respondent fails to adequately perform work pursuant to this Order, including the submittal of acceptable documents, EPA reserves the right to perform any portion of the work required hereunder or any additional site characterization, feasibility study, and response or corrective actions as EPA deems necessary or appropriate to protect human health and the environment considering site-specific factors, including drafting final work plans and other documents, which become binding on Respondent upon notice by EPA, subject to the provisions of Section XXIII.

XIX. OTHER CLAIMS AND PARTIES

Except with regard to the protections accorded Respondent under Section VI. -- Statement of Purpose and Integration of Remedial Authorities, and Section XX. -- Other Applicable Laws, nothing in this Order shall constitute or be construed as a release from any claim, cause of action or demand in law or equity, against any person, firm, partnership, or corporation for any liability it may have arising out of or relating in any way to the generation, storage, treatment, handling, transportation, release, management or disposal of any hazardous constituents, hazardous substances, hazardous wastes, hazardous materials, pollutants, or contaminants found at, on, or under, taken to or from, or migrating to, from or through the Facility.

XX. OTHER APPLICABLE LAWS

The Parties recognize and agree that the storage, treatment or disposal of any hazardous waste at the Facility may continue under this Order and the 7003 Order without Respondent having to meet applicable hazardous waste management standards or obtain a hazardous waste management permit, and Respondent shall not be deemed out-of-compliance with any applicable law or regulation relating to hazardous waste, including the requirement to obtain a hazardous waste permit, provided Respondent is otherwise in compliance with this Order, which compliance will be determined pursuant to Section XXIII, and the 7003 Order, which compliance will be determined pursuant to Section XXIII. B. and C.

XXI. INDEMNIFICATION OF THE UNITED STATES

A. Neither the United States, nor its agencies, departments, agents, or employees, shall be held out or construed to be a party to any contract entered into by Respondent in carrying out activities pursuant to this Order.

B. The United States and its agencies, departments, agents, or employees, shall not be liable for any injury or damages to persons or property resulting from acts or omissions of Respondent or its contractor(s) in implementing the requirements of this Order, or any EPA-approved work plans or planning documents submitted pursuant to this Order.

C. The United States and its agencies, departments, agents, or employees, shall not be considered an agent, independent contractor, receiver, trustee and assign, in carrying out activities required by this Order.

XXII. SUBSEQUENT MODIFICATION

A. This Order may only be modified or amended in writing signed by the authorized signatories below and each modification shall be effective on the date on which it is signed by EPA.

B. Any reports, plans, schedules, and attachments required by this Order shall be incorporated into this Order upon written approval by EPA.

C. If EPA determines that activities in compliance or noncompliance with this Order have caused or may cause a release of hazardous waste or hazardous constituents within or from the Facility, or have caused or may cause a threat to human health or the environment, or if EPA determines that Respondent is not capable of undertaking any studies or corrective measures required pursuant to this Order, EPA may order Respondent to stop further implementation of this Order for such period of time as EPA determines may be needed to abate any such release or threat and/or to undertake any action which EPA determines is necessary to abate such release or threat.

D. No informal advice, guidance, suggestions, or comments by EPA regarding reports, plans, specifications, schedules, and any other writings submitted by Respondent will be construed as relieving Respondent of its obligations to obtain written approval, if and when required by this Order.

XXIII. DISPUTE RESOLUTION AND JUDICIAL REVIEW

A. DISPUTE RESOLUTION

1. If Respondent disagrees, in whole or in part, with any decision made or action taken pursuant to this Order, Respondent shall notify EPA's Project Manager of the dispute in writing within fourteen (14) days of receipt of the decision or notice of the action.

2. The Project Managers will attempt to resolve the dispute informally within ten (10) business days. If the Project Managers cannot resolve the dispute informally, Respondent may pursue the matter formally by placing its objections in writing and placing them in the mail within fourteen (14) days of the close of business of the tenth business day of informal dispute. The written description must set forth the specific points of the dispute.

3. EPA and Respondent shall then in good faith attempt to resolve the dispute through formal negotiations within fourteen (14) days of EPA receipt, or longer if agreed in writing by EPA. During formal negotiations, either party may request a conference with appropriate senior management to discuss the dispute, which opportunity to confer shall not be unreasonably refused.

4. If the parties are unable to reach agreement within this fourteen (14) day period, Respondent may submit additional written information to the Assistant Regional Administrator for Enforcement, Compliance and Environmental Justice ("ARA") within twenty-one (21) days of the close of the fourteen (14) day period described in Section XXIII.A.3. EPA will maintain a record of the dispute, which will contain all statements of position and any other documentation submitted pursuant to this Section. The ARA may allow submission of relevant supplemental statements of position by Respondent. Based on the record, EPA will respond to Respondent's arguments and evidence and place such response in the record, with a copy to Respondent. After review of the record of dispute as supplemented, the ARA shall provide Respondent with EPA's written decision on the dispute signed by the ARA.

a. If EPA believes Respondent has undertaken dispute resolution in bad faith and desires a determination of same by the ARA, EPA shall include a statement of position with support regarding bad faith, to which Respondent may respond. When deciding the issues raised under this Section XXIII.A., if requested by EPA, the ARA will also determine whether Respondent's request for dispute resolution, as asserted by EPA, has been in bad faith, and provide such determination in writing to EPA and Respondent.

5. Any agreement or decision made pursuant to this Section by EPA shall be reduced to writing, shall be deemed incorporated into this Order without further order or process, and shall be binding on the parties, subject to the excused performance in Section XXIII.C.2.

B. JUDICIAL REVIEW

1. Judicial review of EPA's decisions and actions pursuant to this Order and the 7003 Order would be on the record and pursuant to 5 U.S.C. § 706, and shall be in the United States District Court for the District of Montana, and if appealed, in the United States Court of Appeals for the Ninth Circuit.

   a. If EPA determines that Respondent is in violation of a requirement that previously has been the subject of dispute resolution under Section XXIII.A., any review of such EPA determination shall be made solely upon the record made by Respondent and EPA during the dispute resolution proceedings.

2. It is EPA's position that judicial review of any order issued by EPA pursuant to Section 3008(h) or Section 7003 of RCRA is only available when EPA initiates an enforcement action for violation of such orders; it is Respondent's view that such review is available without EPA having to initiate such enforcement action. The Parties reserve their rights to advocate their respective positions on this matter in any proceeding under Section XXIII.B.

3. Respondent agrees that compliance with this Order and the 7003 Order is a condition of probation as set forth in the Plea Agreement in <u>United States v. Rhodia Inc.</u> (D. MT). After

completion of dispute resolution as set forth in Section XXIII.A. for this Order, and judicial review under Section XXIII.B.1 for this Order or the 7003 Order, if EPA determines that Respondent has failed to comply with this Order, EPA may refer the matter to the U.S. Probation Office for the District of Montana. The U.S. Probation Office may then petition the U.S. District Court pursuant to Federal Rule of Criminal Procedure 32.1, to seek revocation or modification of the condition of probation.

C. GENERAL PROVISIONS RELATING TO DISPUTE RESOLUTION AND JUDICIAL REVIEW

1. Within twenty (20) days of receipt by Respondent of the ARA's written decision pursuant to Section XXIII.A. or a written decision under the 7003 Order, Respondent shall advise EPA in writing of its intent to comply or not comply with the decision.

2. During the period of dispute resolution under Section XXIII.A. and judicial review under Section XXIII.B., Respondent shall be excused from performing the requirements, obligations, and deadlines that are the subject of the dispute resolution and judicial review processes, except: (1) regarding the 3008(h) Order, to the extent the District Court affirms any finding by the ARA that Respondent requested dispute resolution in bad faith; or (2) regarding the 7003 Order, to the extent the District Court, on request of EPA, finds that Respondent's refusal to comply in order to expedite judicial review is in bad faith. During the period of dispute resolution under Section XXIII.A. and XXIII.B., Respondent shall not be excused from performing the requirements, obligations or deadlines that are not the subject of the dispute resolution process.

XXIV. FORCE MAJEURE

A. Respondent shall perform the requirements of this Order within the schedules and time limits set forth herein, unless performance is prevented or delayed by events which constitute a force majeure. A force majeure is defined as any event, arising from causes not reasonably foreseeable and beyond the control of Respondent, which could not be overcome by due diligence and which delays or prevents performance by a date required by this Order. Respondent shall have the burden of raising and of proving such a force majeure.

B. Within seventy-two (72) hours of the time that Respondent knows or has reason to know of the occurrence of any event which Respondent has reason to believe may prevent Respondent from timely compliance with any requirement under this Order, Respondent shall provide verbal notification to EPA. Within seven (7) calendar days of the time that Respondent knows or has reason to know of the occurrence of such event, Respondent shall submit to EPA a written description of the event causing the delay, the reasons for and the expected duration of the delay, and actions which will be taken to mitigate the duration of the delay.

C. EPA's decision to agree or disagree that a force majeure has occurred, or the agency's decision to approve or disapprove Respondent's proposed actions for mitigating the delay shall be submitted to the Facility in a written response.

XXV. TERMINATION AND SATISFACTION

The provisions of this Order shall be deemed satisfied upon Respondent's receipt of written notice from EPA that EPA has approved the CMI Summary Report. At that time, this Order shall terminate except the requirements will remain in effect in Section XVI -- Record Preservation.

XXVI. EFFECTIVE DATE

The effective date of this Order shall be the date on which this Order is accepted as a term of probation at the time of sentencing by the United States District Court for the District of Montana.

**FOR THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,
REGION 8,
CO-COMPLAINANT.**

Date: _**12/22/03**_______ By: _**Eddie A. Sierra for/**___________________________
Carol Rushin, Assistant Regional Administrator
Office of Enforcement, Compliance and
Environmental Justice

**FOR RHODIA INC.
RESPONDENT.**

Date: _**12/18/03**_______ By: _**SIGNED**______________________________________
Myron Galuskin
President, Rhodia Inc.

**FOR RHODIA SA
GUARANTOR.**

Date: _**12/18/04**________ By: _**SIGNED**____________________________________
Myron Galuskin
President, Rhodia Inc.
As Authorized Agent for Rhodia SA

THIS DOCUMENT WAS FILED IN THE REGIONAL HEARING CLERK'S OFFICE ON DECEMBER 22, 2003.

Appendix C

Team Members

Appendix C

Team Members

Solvay USA Inc

- Fred Ellerbusch – Director, Remediation, Redeployment, and Real Estate
- Jeffery Lang – Attorney
- Dan Bersanti – Plant Manager
- Floyd (Cam) Balentine - Environmental Manager

KPRyan Consultancy

- Kevin Ryan – former Manager of Phosphorus Technology

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- Arnold Feldman – Principal & Chemical Engineer

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Appendix D

Short-term Effectiveness – Worker Risk Evaluation

Appendix D

Short-term Effectiveness - Worker Risk Evaluation Supplemental Waste Plan

Inherent in most of the evaluation criteria is the concept of risk. Under short-term effectiveness, the health and safety risks from construction and implementation of the decommissioning alternative are considered. The criterion of reduction of toxicity, mobility and volume considers the risks that may remain from the material of concern after the decommissioning is completed. The criterion of implementability considers how long the current perceived risk of phosphine and fire generation would remain until the decommissioning option is completed.

These risk concepts are considered for each alternative evaluated in this Supplemental Waste Plan. In some cases, just outlining the risk concept relates immediately to common practical experience and enables a simple and obvious choice to emerge. In other cases, the various activities required to implement the alternative and the inherent risk factors involved with each activity are more complex. Nonetheless, in this Supplemental Waste Plan, Solvay identifies the activities associated with each alternative and evaluates the short-term risk of fatality and serious injury for each.

For each remedial alternative, the principal construction activities associated with that alternative are identified based on the collective experience of the Solvay team with other remediation, construction, and decommissioning activities, especially considering sites with phosphorus-bearing materials.

The principal foundation for the risk rates in this Supplemental Waste Plan is derived from a report from the Oak Ridge National Laboratory study entitled: “Methodology for Assessing Worker Risks During Remediation at the United States Department of Energy’s Hazardous Waste Sites” (Datskou & Sutherland, 1995). It describes a case study in which the risk assessment method developed by the Oak Ridge Center for Risk Management is applied to a sample site. The following section provides a brief overview of information used from that study and explains the development of the site-specific risk rates used in the Waste Plan.

1.0 Risk Rate Development

The risk calculations in this Waste Plan focus on the potential risk of either: 1) fatality or long-term disabling injury (hereafter referred to simply as “fatality”), or 2) serious, time-lost injury (hereafter referred to simply as “serious injury”). For this analysis, serious injury is defined as temporary disability or loss of at least one day of work. Accordingly, calculation of the frequencies of occurrence of the risks associated with the activities required to implement an alternative (*e.g.*, moving materials, filling drums) are subdivided into two categories: one for fatalities and one for serious injuries. The risks for all the activities that make up an alternative are summed for each of these two separate categories to obtain a total risk estimate for each category for the alternative (expressed, for example, as 8.9 E-03, for serious injury and 2.4 E-04 for fatalities).

The development of risk rates for the implementation of remedial alternatives at the Silver Bow Plant involves several assumptions and conventions. Table 1 provides summary documentation of the basis for each of the frequencies of the risks associated with the major component activities of the studied alternatives. This table also includes references for each of the risk rates chosen. The basis for these choices is explained in more detail below.

1.1 Oak Ridge National Laboratories Risk Rates

The risk rates used in this Waste Plan for construction work were based on the rates in a study entitled "Methodology for Assessing Worker Risks during Remediation at the United States Department of Energy's Hazardous Waste Sites" (Datskou & Sutherland 1995). This study, release-dated June 13, and presented at the July 29-August 2, 1995 Summer National Meeting of the American Institute of Chemical Engineers (Session 15d), is closely related to a study entitled "U.S. Department of Energy Worker Health Risk Evaluation Methodology for Assessing Risks Associated with Environmental Restoration and Waste Management" (Blaylock, *et al* 1995). The Blaylock, *et al*. paper, though not cited directly by Datskou and Sutherland, has J. Sutherland as a coauthor, and appears to be the parent document from which the risk rate information was adopted for their case study at a specific Oak Ridge site.

The Datskou and Sutherland paper selected the risk rates they deemed most appropriate for evaluating remediation construction activities. They condensed the information given in the Blaylock paper into a set of four risk values, two for construction-related accidents and two for heat stress. The first two, for construction-related accidents, were a fatality risk of 1.65 E-7 per person-hour and an injury risk rate of 4.6 E-5 per person-hour. Unlike the evaluation in this Waste Plan that only considers serious injuries involving loss of one day or more of work, injury in the Datskou and Sutherland case study included all reported injuries, without regard to the seriousness of the injury. These rates were applied for all construction and operational activities in the example case study, including work involving earth-moving equipment, electrical work, constructing buildings, and demolishing structures. The study assumed that all operations requiring personal protective equipment (PPE) would be using it. (The implication is that if the PPE were not used for the more dangerous activities, higher risk rates for the “unprotected” workers would have been appropriate). The second two risk values were for heat stress, are in addition to the construction risk rates, and are applicable when PPE is employed in any portion of the construction work. The risk rates related to heat stress selected by Datskou and Sutherland were a fatality risk of 1.6 E-9 per person-hour and a heat stress illness rate of 2.6 E-7 per person-hour.

The methodologies for computing worker risks are described in detail in the Blaylock, et al. Study (1995). As with the risk analysis methods commonly used by the EPA for evaluating long-term risks of RCRA or CERCLA remediation plans, the Department of Energy site-restoration risk estimation method identifies a risk rate for each short-term worker exposure scenario and then multiplies the rate by the number of person-hours estimated for the subject activity. The total risk is simply the sum of the component exposures for the total construction project. To compare or prioritize remediation options, the total risks for the several alternatives are compared. This procedure has been followed in estimating the remedial construction risks and the operation and maintenance risks for the alternatives in the Waste Plan.

1.2 Site-Specific Risk Rate Development

The risk evaluation conventions and professional judgment applied in the development of the risk rates are presented in this section. The risk evaluations for the remedial alternatives consider two cases: 1) a baseline case, assuming no extra worker protection beyond the normal construction attire of long sleeved shirts, long pants, gloves, hardhat, and steel-toed boots (henceforth referred to as “baseline worker”); and 2) a “protected worker” case which assumes a project health and safety plan (HASP) is designed and implemented to mitigate the special risks associated with working with phosphorus-bearing materials. For example, in situations involving access to phosphorus at distances greater than several feet, protective gear required by the HASP would normally be a respirator for emergency escape use, continuous personal air monitoring for phosphine, and in some cases face shields for splash protection. For situations involving handling of phosphorus-bearing materials (*e.g.*, drum packaging), the protective gear would normally include silvers (fire-resistant suits) and fire-resistant gloves, continuous personal air monitoring for phosphine, a respirator for emergency escape use, and face shields for splash protection as appropriate. The development of the risk rates for the “baseline worker” case is presented below, followed by the adjustments for the “protected worker” case. For situations in which the individual risks for specific activities are extraordinary or unacceptable, special considerations must be applied. One such situation was found: the cleaning of the crude phosphorus residue from the bottom of the clarifier following removal of the clarifier contents. In that case, no “baseline worker” scenario is developed, as the activity simply would not be performed by a worker with only baseline protections. The “protected worker” scenario is developed, however, that accounts for the level of safety risks and concomitant safety support for the activity.

“Baseline Worker” Risk Rate Basis

The risk rates for the “baseline worker” are summarized and their derivation explained in Table 1, Part A. The rationale for the important judgments and adjustments are also explained here. The baseline worker rates of injury and fatality for construction-type activities are consistent with the Oak Ridge case study (Datskou & Sutherland, 1995). This 1995 case study applied a recordable injury rate based on information from the National Safety Council, 1991. Currently, the Bureau of Labor Statistics tracks and publishes annual reports on occupational fatalities and injuries. The BLS data were used to calculate a fatality rate of 4.8 E-8 fatalities/person-hr (BLS 2013a) and a serious injury rate of 1.6 E-6 serious injuries/person-hr (BLS 2013b) for construction workers. The serious injury rate relied on the data for cases with days away from work, job transfer or restriction (i.e., more “serious injuries” rather than merely “reportable injuries”).

Most of the component activities of the alternatives for the clarifier materials are like typical construction activities. Consequently, as a starting point, a single set of fatality and serious injury rates are used to evaluate all activities that could be described as “construction-like” activities. As explained above, the serious injury risk rate of 1.6 E-6 and the fatality rate of 4.8 E-8 adopted here are based on the Oak Ridge case study and current fatality and injury statistics published by the BLS. These construction risk rates are applied to all activities associated with the alternatives studied in this Waste Plan where the worker would not have access to or directly handle phosphorus-bearing materials that have the potential to generate fire or phosphine gas. The rationale is that in such cases, the activities are essentially like standard construction activities that involve standard construction risks.

For the “baseline worker” version of the risk evaluation, risk rates are increased for situations where there is direct access to phosphorus-bearing materials, with the risk increasing the most for workers who directly handle or work very close to the phosphorus-bearing material. In these situations it is standard practice in the risk management profession to expect the risk of injury would increase due to the potential of these materials to generate fire and phosphine gas at hazardous levels when exposed to air and water (this standard practice is reflected in the “protection factors” attributed to safety gear that is employed to mitigate these risks). To account for this, two categories of more direct exposure to hazardous materials have been evaluated for the baseline case. In the first the risk rate is multiplied by a factor of 3 to reflect the difference between the risk associated with normal construction activities and those that involve working in the general vicinity of phosphorus-bearing materials in situations where they may ignite or generate phosphine. For example, placement of subgrade material directly in the clarifier increases the risk of phosphine release, and so is assigned a risk rate 3 times higher than general construction work, such as site preparation prior to placement of the subgrade material in the clarifier. In the second category, a risk of more extreme exposure was deemed possible for those situations in which a worker would be directly handling, or working in very close proximity to phosphorus-bearing materials (*e.g.*, within a few feet of such materials). In these cases, the base construction risk rate is increased to 10 times the general construction risk rate. So, for example, drumming the clarifier material will be considered to have 10 times the risk rate of ordinary site preparation. These adjustments are only made for the "baseline worker" scenarios. Reduced risk rates are used for the "protected worker" as discussed separately below.

Not all of the activities involved in the decommissioning would be expected to have as high a set of risk rates as those of "construction-like" activities. Two notable exceptions are the restoration and revegetation task and the monitoring, cap maintenance, and inspection task (associated with alternatives involving capping of materials left in place).

The BLS reports include specific injury rates that are applicable to agricultural workers engaged in crop production. Those rates (2.5 E-6/person-hr serious injury) are similar to the rates presented for general construction (1.6 E-6/person-hr). The fatality risk for agricultural workers engaged in crop production was calculated at 1.1 E-7/person-hrs. These are the serious injury and fatality rates used to represent the risk rates for revegetation and restoration work for all alternatives.

The BLS also presents fatality rates for "services" industries, and includes injury rates for "engineering and management services". These risk rates appear to be representative for the groundwater monitoring, report writing, cap inspection, operation and maintenance of the cap monitoring systems, and general long-term cap maintenance, required for post-closure care of cap systems. Accordingly, the rates for serious injury (4.5 E-7/person-hr), and fatality (5.7 E-9/person-hr) for post-closure work are based on these risk rates, rather than those typical of the construction industry.

The risk rates for the "baseline worker" scenarios are summarized in Table 1, Part A. The "baseline worker" scenario risk calculations are in Appendix M. Appendix L provides the development of task durations and construction crew size estimates that are used in Appendix M.

"Protected Worker" Risk Rate Basis

A second set of risk evaluations was performed for the remedial alternatives using risk rates based on a "protected worker." In contrast with the "baseline worker" cases described above, the "protected worker" scenario assumes that an appropriate HASP has been implemented and will limit the risk to rates similar to those not involving close proximity to hazardous materials like elemental phosphorus that is not under water (see Table 1, Part B). This means, in effect, that the protective measures selected for the workers are assumed to balance the increased risk that would be posed by the hazards of the material and activity. In terms of risk rates, the fatality risk for "protected workers" performing tasks in proximity to phosphorus-bearing materials is therefore 1.4 E-7/person-hr, and the serious injury risk is 4.7 E-6/person-hr, the same as the risk rates for "baseline workers" performing general construction. In order to account for some of the effects of using protective equipment on the total risk for implementing an alternative, three adjustments are made to the risks associated with protected worker activities: (1) the time required for task performance was increased; (2) field safety supervision was added; and (3) a risk factor from "heat-stress" was added to the risk rate. These adjustments are discussed below:

First, the length of time it takes to perform tasks using protective gear is adjusted to be greater than that without such gear. Protective gear will be more cumbersome, and the time for completing a particular task will typically increase. In addition, extra time will be needed to suit-up and suit-down at the beginning and end of each shift, meal, and break, to attend daily safety meetings, to maintain their respirators and emergency escape equipment, and to use the personal phosphine monitors. This extra time is estimated at 20 minutes, 4 times a day for suiting up and suiting down, 20 minutes for the daily safety meeting, 20 minutes over the course of the day for phosphine monitoring, and 20 minutes for safety gear maintenance. A factor of 1.4 is applied to the task duration for "protected workers" in "silvers," workers who are handling phosphorus-bearing materials, to account for this extra time. A factor of 1.1 is applied to the task duration for "protected workers" who are several feet from phosphorus-bearing materials, do not work directly with the material, and do not wear "silvers". This factor allows 20 minutes daily for phosphine monitoring and 20 minutes for safety meetings and safety gear maintenance. The task duration adjustments for "protected workers" are incorporated in the spreadsheets for calculation of task durations in Appendix M.

Second, safety officers, air monitoring staff, or other additional personnel are needed for HASP implementation. It was assumed this additional safety effort could be met with the equivalent of ½ an additional person per crew for the tasks that would have had a 3x risk rate applied for "baseline workers." The additional safety effort was expected to require the equivalent of 1 additional person per crew for the tasks that would have had a 10 times risk rate applied for "baseline workers." The application of these adjustments is shown in the spreadsheets in Appendix M.

Third, workers that wear "silvers" and other protective gear are likely to experience greater heat stress. Thus, the risk rates for "heat stress" are added to the evaluation for all "protected worker" scenarios. The calculations of risk (see Appendix M) under the "protected worker" scenarios explicitly identify the incremental heat stress risk rate. These incremental risk rates are 2.6 E-7/person-hr for serious injury and 1.6 E-9/person-hr for fatality, as presented in the Oak Ridge case study[1/] (Datskou & Sutherland, 1995). These rates are identified as "incremental" because they are in addition to the normal construction risk rate. The Oak Ridge case study risk rates for heat stress were based on the entire worker population, even though only a portion (about 12 percent) of the workers were in protective gear. Accordingly, consistent with the Oak Ridge methodology, the heat stress increment is applied to all the construction workers in a remedial alternative in order to account for the incremental risk due to heat stress for the "protected worker" scenarios.

In summary, based upon the assumptions discussed above, the risk of implementing each alternative under this Waste Plan has been calculated both in terms of serious injury and fatality. (See Appendix M and Appendix L). One set of total risks, the baseline case, assumes the "baseline worker" scenario. The second set of total risks, for the "protected worker" case, assumes implementation of a HASP which is well-suited to each alternative, and effectively mitigates the extra risk that may otherwise be associated with working in close proximity to, or with close

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[1/] Although the injury risk rates used for this evaluation of remedial actions used serious injury rates one-tenth those for total "reportable" injuries cited by the Oak Ridge case study, an exception from this rationale is made here for the use of "heat stress" injury rates. The serious injury rate used here is the same as the "reportable" heat stress injury rate identified in the Oak Ridge case study. That is because, by their nature, heat stress injuries are more difficult to diagnose and document. Therefore, one has to rely more on practical operational experience from long-term observation of field crew behavior and results obtained from health and safety management programs to assess the likelihood of reporting of minor and major symptoms of heat stress. It is the judgment of the authors of this report that heat stress injury rates are most likely to represent cases in which symptoms were of a serious nature, otherwise the heat stress event may not have been reported. This is because recovery from minor symptoms is sufficiently rapid that the worker is often able to return to work after a short resting period. Thus, the Oak Ridge case study rates, 2.60 E-7/person-hr, were used without adjustment to represent the potential for serious injury. Fatalities are quite rare, and the quoted rate for heat-stress-related fatalities from the Oak Ridge case study, 1.60 E-9/person-hr, was also directly adopted here.

handling of phosphorus-bearing materials. Note that, for purposes of comparing the alternatives and recommending their selection in the Comparative Evaluation and Recommendation Sections of this Waste Plan, we have assumed that the workers will follow the appropriate HASP, and be properly protected for each task. Consequently, only the risks to the protected worker are considered in the Comparative Evaluation and Recommendation Sections. This way, the true risks that would be experienced are not overstated.

1.3 Non-Transportation Risk Rate Frequency Summary

Table 1, Parts A and B, summarizes all of the risk rates assumed for both the "baseline worker" that were derived from the Oak Ridge study, and the alternative set of rates used for the "protected worker" operating under an appropriate health and safety plan to mitigate the special risks associated with working with phosphorus-bearing materials.

Many of the risk rates are the same for the "protected worker" and the "baseline worker" scenarios, except that "heat stress risks are only included in the "protected worker" scenarios. It should also be noted, however, that the heat stress incremental risk is added to all the work in the "protected worker" scenarios, not just the work where protective gear is being worn, in order to be consistent with the Oak Ridge case study and its application of the methodology. That incremental risk is 1.60 E-9/person-hour for fatalities and 2.60 E-7/person-hour for injury that is, in this case, assumed to be serious if reported.

2.0 Transportation Risk Rate Frequency Summary

Three primary sources were used to determine the frequencies of transportation-related risks. The first was a thorough study performed in 1989 for transportation of hazardous waste to the Clean Harbors Rotary Kiln Incinerator facility in Braintree, MA (Battelle, 1989). The second was the U.S. DOT's Hazardous Material Information System (HMIS), an online data system now used to track reports of hazardous waste spills and consequences (U.S. DOT HMIS 2013). The third was a report entitled Large Truck Crash Overview 2011 (USDOT 2013).

The base rate of hazardous waste shipping incidents identified in the Clean Harbors study was selected for use in the risk evaluations in this Waste Plan, because the study was carefully done to avoid the typical problems associated with self-reporting of transportation incidents that plague many databases. That incident rate of 2.5 E-6 hazardous waste truck spill incidents/mile serves as the foundation for all other transport risk calculations in this evaluation. There is a range of fatality and injury rates reported for the trucking industry. For instance, the latest DOT data indicates a rate of serious injury of 2.0 E-7 for 2010 and a rate of 2.3 E-7 for 2011, both very close to the rate adopted here.

The Clean Harbors study did not include a rate of serious injury versus a rate of fatality. The U.S. DOT HMIS database, however, is helpful in predicting the rates of fatality and serious injury that might occur for hazardous materials incidents. HMIS contains reports of these accident consequence statistics for a ten-year period (1990-1999). For transportation incidents, we will assume that all injuries reported were potentially serious, since minor injuries would not likely be reported. The database shows that there has been a ratio of injuries to fatalities of approximately 30 to 1 for that period. That ratio was approximately the same as that found for construction-type accidents discussed earlier. For simplicity, the same 30 to 1 ratio will be utilized for all calculations. The final rates are given in Table 1, Part C.

As shown in Table 1, the fatality rate for truck transportation used in this Waste Plan evaluation is 2.5 E-9/mile. The recently available FMCSA report identifies a fatality incidence rate of 2.2 E-8/mile for all large truck crashes (incidents), which is much higher than the fatality rate in Table 1. Other data may indicate an injury to fatality ratio of approximately 25, compared with the factor of 30 noted above. However, since the rates used in Table 1 are based on information specific to the transport of hazardous materials, and reflect the additional training and care enforced for these drivers, the authors of this report believe that the rates presented in Table 1 are most appropriate for the trucks transporting phosphorus-bearing materials and returning.

To promote an easier comparison of stationary facility risk rates with those for transportation of hazardous materials to an off-site location, the published rates, which are on a “per mile” basis, were converted to a “per hour” basis. This has no effect on the risk calculated for the transportation component of the remedial alternatives (the risk is the same whether calculated on a per-mile or per-hour basis). Translating the per-mile risk rate to a per-hour risk rate requires an assumption of a transport speed, however. Since the only transport that is considered in the evaluations presented below is for relatively long distances, an average highway-dominated rate of 50 mph is assumed. This assumption is based on the expectation that the trucks are normally on interstate or other primary roads with truck speed limits ranging from 50 to 70 mph. The lower end of this range was selected to account for some secondary road transportation to and from the origin and destination, truck stops, restaurants, motels, and to account for delays caused by rush hours, accidents, highway construction, and equipment breakdown.

Since implementation of the off-site options will necessitate truck transportation outbound and a return trip for another load, the risk for the round trip was considered. The risk rate for return empty shipments was assumed to be the same as for loaded outbound shipments. Although this assumption may appear to be counter-intuitive, the evidence given in the FMCSA report would imply that the risk rate for empty shipments is actually somewhat higher than that for the transport of hazardous materials. The returning drivers would, however be more likely to be those with the same training and expected safety performance as those transporting the waste materials off site. Therefore, to simplify the analysis, the same risk rate was applied for outbound and inbound transportation for the evaluation of remedial alternatives in this report.

Comparing adjusted values in Table 1, Part C reveals that the hourly rate of risk to the truck driver is lower than the hourly rates of risk for many of the identified on-site activities. If there is a large volume of material to be shipped, or the distances traveled are large, the total risk from that component can become a significant contribution to the overall risk.

3.0 Assessment of Risks for Incineration Activities

For those options that include shipment to an off-site incinerator, there are incremental risks to workers at the incinerator facility, due to the incremental volume of material that the incinerator workers will have to unload and convey through the incinerator. The present evaluation, therefore, applies the relevant risk rates to the activities of workers during receiving and handling operations for the volume of material that is estimated for shipment under each of the incineration alternatives.

The receiving and handling steps at the incinerator would produce additional worker exposures to risks associated with phosphorus-bearing materials. The number of hours involved in handling Silver Bow Plant shipments at the incinerator and the risk rates will be matched to the facility procedures that would be most appropriate for the clarifier material in drums, or the brick and block material in special bulk containers. Since the TSD personnel will be opening the drums of phosphorus-bearing material and handling those open drums, the risk rate is set at the same rate as that used to characterize drum filling and packaging operations.

The use of an offsite incinerator for final removal of the alleged ignitability and reactivity characteristics also raises an added question of the potential risks to the public associated with products of complete and incomplete combustion. However, Solvay has not added the risks of air emissions from the incinerator to workers or neighbors. Current permitting requirements for these incineration facilities already address compliance with air quality standards, and with allowable risks for commercial combustion facilities. The existing risk guidance requires all such facilities to demonstrate that the long-term risk levels associated with all of their emissions does not exceed a level of 1 E-5 risk in 30 to 70 years of exposure of surrounding residents. These risk rates are far below the rates of risk under examination here for the decommissioning alternatives. Since the risk from incremental air emissions would make an insignificant contribution, they will not be included in this evaluation. However, the degree of public concern for any new activity that noticeably increases the operational load of the existing facilities can be quite significant, even if the added risks are not.

4.0 Assessment of Risk for Each Alternative

Appendix M contains risk tables, two for each of the alternatives that pass the Phase I screen of being technically and legally feasible. One table estimates the likelihood of fatalities and a second table estimates the likelihood of serious injuries. These tables are developed for both the “baseline worker” and the “protected worker” scenarios. The tables reflect the outcome of this evaluation in that they show the total risk associated with implementation of each remediation option. The tables show the general activities to be performed in completion of each alternative. The details of the construction team crew sizes and task durations for the construction activities are developed in Appendix L. The crew sizes and task durations for each activity, repeated in Appendix M, are multiplied together to arrive at the duration of exposure in person-hours. This duration is multiplied by the estimated risk rate for the activity (in risk/hour), as listed in Table 1, to arrive at the risk product. The risk products for each activity comprising the alternative are then summed to calculate the total risk product for completing the entire option, for each of the two categories: fatalities and serious injuries. Based on the individual tables in Appendix M, summary tables were also prepared, and are referenced in the discussion of the remedial alternatives.

5.0 Risk Characterization

The risk of serious injury and fatality associated with implementation is calculated for each of the alternatives passing the Phase I screening criteria. As an aid in characterizing the risk for each decommissioning alternative, a risk matrix is used to help describe, evaluate, and rank these risks. The matrix is illustrated in Table 2. This matrix method is very similar to the one recommended by the American Institute of Chemical Engineers (AIChE) for application to Process Safety Management and Risk Management Planning programs in the U.S. *See* Guidelines for Hazard Evaluation Procedures, Center for Chemical Process Safety of the American Institute of Chemical Engineers, Chapter 7 and § 7.1, (AIChE, 1992a); *see also* Plant Guidelines for Terminal Management of Chemical Process Safety, Center for Chemical Process Safety of the American Institute of Chemical Engineers, Appendix 6B (AIChE, 1992b) A very similar version was also utilized in the

A&W study just mentioned.

The matrix presented in Table 2 shows the relationship among:

- Severity of the potential injury (“minimal”, “minor”, “moderate”, and “severe”);
- Anticipated frequency of occurrence, from “very unlikely” to “very likely”, with quantitative ranges for these categories also indicated (in both absolute risk rate and percent chance of occurrence); and
- Assignment of a descriptive term for the level of risk for each combination of injury severity and frequency of occurrence. The descriptive terms, which characterize the overall risk for each combination, range from “low” to “very high”.

For instance, if the evaluation of an activity concludes that the activity could result in serious short-term injury (defined as a “moderate” risk in the matrix) and the calculated probability of occurrence was between 0.1 to 1 percent (defined as “unlikely” in the matrix), the activity would be described as a “moderately low” risk. The descriptive characterizations in the matrix are intended to be helpful for grouping risk levels, but are not intended to substitute for the quantitative risk evaluation performed for each remedial alternative. This method of cross-tabulation illustrates that the importance of a risk is not merely the frequency of occurrence, nor is it only the severity of the injury; rather, it is a combination of the two.

The frequency ranges utilized in the risk matrix are in steps of a factor of ten. This promotes easier comparisons between events that happen infrequently (“unlikely”), or quite rarely (“very unlikely”), and those that happen quite often (“very likely”). These characterizations of the relative likelihood of each frequency follow conventional approaches presented in the AIChE and A&W references mentioned above.

The risk calculations in this Waste Plan focus on the potential risk of either: 1) fatality or long-term disabling injury or 2) serious, lost-time injury. These are categorized as “severe” and “moderate” respectively in the Table 2 matrix. A quantitative estimate of the risk of fatalities and serious injuries is developed for each retained alternative. As an aid in understanding the general level of risk for construction of that alternative, the risk matrix is reviewed to select which cells of the matrix corresponds to the total risk product (likelihood) for fatalities and for serious injuries for the alternative. Thus, in addition to the quantitative probabilities calculated for fatalities and for serious injuries the Table 2 descriptive levels of overall risk corresponding to the calculated values (*e.g.*, “very high”, “high”, “medium”, “moderately low”, or “low”) are assigned to the alternative. The outcome of the risk evaluation as reflected in each table is discussed as part of the short-term effectiveness evaluations for each decommissioning alternative later in the Waste Plan. A spreadsheet with the details of these calculations is provided for each alternative in Appendix M.

References

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Tables

Table 1

Basis for Assumptions Utilized in Short-term Risk Evaluation

Including **Part A: Baseline Worker**
Part B: Protected Worker
Part C: Transportation

Part A. "Baseline Worker"

Decommissioning Activities/ Exposure Situation	Risk Rates		Reference	Comments
	Fatalities	Serious Injuries		
Site preparation or construction-like activities involving construction equipment, **with no expectation of exposure to P4 or PH3**	4.7 E-8/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data.	Risks assumed similar to those for general construction workers, including those involved in remediation projects.
		1.6 E-6/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data-(NAICS: 237), decreased by 10x	Same as above, except for a 10 x reduction to reflect difference between "recordable" and serious "lost-time" injury, based upon Silver Bow Plant injury data.
Earth-moving or other construction like activities under circumstances that allow **direct access to phosphorus-bearing materials** which are likely to be exposed to open air, but work is not proximately handling the material (*i.e.*, within several feet).	1.4 E-7/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data, increased by 3x	The 3x increase is assumed to represent added risk in situations involving incidental exposure to uncovered phosphorus-contaminated materials and/or fugitive phosphine emissions.
		4.7 E-6/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data-(NAICS: 237), increased by 3x, and decreased 10x	The 3x increase is assumed to represent added risk in situations involving incidental exposure to uncovered phosphorus-contaminated materials and/or fugitive phosphine emissions. The 10x reduction reflects the difference between "recordable" and serious "lost-time" injury rates, based upon Silver Bow Plant injury data.
Removal, handling, or container packaging of phosphorus-bearing materials with **high possibility of direct contact (working within distances of several feet)**	7.0 E-9/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013 data)	BLS data: Fatal occupational injuries, total hours worked, and rates of fatal occupational injuries by selected worker characteristics, occupations, and industries, civilian workers, 2013p for the chemical manufacturing industry.
		7.0 E-7/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses Solvay NA (2014 LTAR data).	Solvay NA lost time accident rate data.

Table 1 (cont.)
Basis for Assumptions Utilized in Short-term Risk Evaluation

Part A. "Baseline Worker" (Continued)

Decommissioning Activities/ Exposure Situation	Risk Rates		Reference	Comments
	Fatalities	**Serious Injuries**		
Final surface restoration and revegetation, (no heavy construction activity)	1.1 E-7/hr		BLS 2013 Data: Fatalities reported for Crop Production Occupations	For 2013, 210 fatalities and 1,898 million total hours worked were reported for Crop Production occupations.
		2.6 E-6/hr	BLS 2013 data (NAICS: 111), decreased 10x: Industry Injury and Illness Data - 2013: SNR05. Workers engaged in Crop Production	For 2013: the incidence rate for crop production workers was 5.2. The 10x reduction reflects the difference between "recordable" and serious "lost-time" injury rates, based upon Silver Bow Plant injury data.
Long-term monitoring, sampling, and maintenance activities, (no heavy construction activity)	5.7 E-9/hr		BLS 2012 Data: Fatalities reported for Architects and Engineering Occupations	For 2013, 34 fatalities and 5,761 million total hours worked were reported for Architecture and Engineering occupations.
		4.0 E-7/hr	BLS 2013 data (NAICS: 54162), decreased 10x: Industry Injury and Illness Data - 2013: SNR05. Workers engaged in Environmental Engineering Services.	For 2013: the incidence rate for Environmental Engineering Services was 0.8. The 10x reduction reflects the difference between "recordable" and serious "lost-time" injury rates, based upon Silver Bow Plant injury data.
Incineration Operations	5.4 E-8/hr		BLS 2013 data: Fatalities for Waste management and remediation services	For 2013, 49 fatalities and 913 million total hours worked were reported for Waste management and remediation services.
		8.0E-7/hr	BLS 2013 data (NAICS: 562211), decreased 10x:	For 2013: the incidence rate for Hazardous waste treatment and disposal was 1.6. The 10x reduction reflects the difference between "recordable" and serious "lost-time" injury rates, based upon Silver Bow Plant injury data.

Table 1 (cont.)

Basis for Assumptions Utilized in Short-Term Risk Evaluation

Part B: Protected Worker

Decommissioning Activities/ Exposure Situation	Risk Rates		Reference	Comments
	Severe (Fatal)	Moderate (Serious Injury)		
Site preparation or construction-like activities involving construction equipment, **with no expectation of exposure to P4 or PH3**	4.7 E-8/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data.	Risks assumed similar to those for general construction workers, including those involved in remediation projects.
		1.6 E-6/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data, decreased by 10x	Same as above, except for a 10 x reduction to reflect difference between “recordable” and serious “lost-time” injury, based upon Silver Bow Plant injury data.
Earth-moving or other construction like activities under circumstances that allow **direct access to phosphorus-bearing materials** which are likely to be exposed to open air, but work is not proximately handling the material (*i.e.*, within several feet).	1.4 E-7/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data, increased by 3x	The 3x increase is assumed to represent added risk in situations involving incidental exposure to uncovered phosphorus-contaminated materials and/or fugitive phosphine emissions.
		4.7 E-6/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013) data, increased by 3x, and decreased 10x	The 3x increase is assumed to represent added risk in situations involving incidental exposure to uncovered phosphorus-contaminated materials and/or fugitive phosphine emissions. The 10x reduction reflects the difference between “recordable” and serious “lost-time” injury rates, based upon Silver Bow Plant injury data.
Removal, handling, or container packaging of phosphorus-bearing materials with **high possibility of direct contact (working within distances of several feet)**	7.0 E-9/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses BLS (2013 data),	BLS data: Fatal occupational injuries, total hours worked, and rates of fatal occupational injuries by selected worker characteristics, occupations, and industries, civilian workers, 2013p for the chemical manufacturing industry.
		7.0 E-7/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995), Uses Solvay NA (2014 LTAR data).	Solvay NA lost time accident rate data.
Final surface restoration and revegetation, (no heavy construction activity)	1.1 E-7/hr		BLS 2012 Data: Fatalities reported for Crop Production Occupations	For 2012, 204 fatalities and 1,817 million total hours worked were reported for Crop Production occupations.
		2.6 E-6/hr	BLS 2012 Data, decreased 10x: Industry Injury and Illness Data - 2012: SNR05. Workers engaged in Crop Production	For 2012: the incidence rate for crop production workers was 5.0. The 10x reduction reflects the difference between “recordable” and serious “lost-time” injury rates, based upon Silver Bow Plant injury data.

Table 1 (cont.)
Basis for Assumptions Utilized in Short-Term Risk Evaluation

Part B: Protected Worker (Continued)

Decommissioning Activities/ Exposure Situation	Risk Rates		Reference	Comments
	Severe (Fatal)	Moderate (Serious Injury)		
Heat stress for construction work, with a portion of the workers wearing protective clothing such as tyvek.	1.6 E-9/hr		Oak Ridge Case Study (Datskou & Sutherland, 1995)	The Oak Ridge Case Study heat stress risk rates are based on the entire population of workers, about 10% of whom were in Level C protective gear. Accordingly, the heat stress risk rate is applied to all the construction workers, including those not in protective gear, in evaluating the total risk in a protected worker scenario. The heat stress risk rate should not be added to the monitoring and maintenance function, as the Oak Ridge Case Study data are not applicable to that case.
		2.6 E-7/hr	Oak Ridge Case Study (Datskou & Sutherland, 1995)	The Oak Ridge Case Study risk rates for injury are not reduced by a factor of 10, unlike the other serious injury construction rates. It is the judgment of the authors of this Waste Plan that the heat stress injury rates most likely represent cases in which symptoms were of a serious nature, otherwise the heat stress event would not have been reported.
Long-term monitoring, sampling and maintenance activities (no heavy construction activity)	5.9 E-9/hr		BLS 2013 Data: Fatalities reported for Architects and Engineering Occupations	For 2013, 34 fatalities and 5,761 million total hours worked were reported for Architecture and Engineering occupations.
		4.0 E-7/hr	BLS 2013 Data, decreased 10x: Industry Injury and Illness Data - 2013: SNR05. Workers engaged in Environmental Engineering Services.	For 2013: the incidence rate for Environmental Engineering Services was 0.8. The 10x reduction reflects the difference between “recordable” and serious “lost-time” injury rates, based upon Silver Bow Plant injury data.
Incineration Operations	5.4 E-8/hr		BLS 2013 data: Fatalities for Waste management and remediation services	For 2013, 49 fatalities and 913 million total hours worked were reported for Waste management and remediation services.
		8.0 E-7/hr	BLS 2013 data (NAICS: 562211), decreased 10x:	For 2013: the incidence rate for Hazardous waste treatment and disposal was 1.6. The 10x reduction reflects the difference between “recordable” and serious “lost-time” injury rates, based upon Silver Bow Plant injury data.

Table 1 (cont.)
Basis for Assumptions Utilized in Short-Term Risk Evaluation

Part C: Transportation

Decommissioning Activities/ Exposure Situation	Risk Rates		Reference	Comments
	Severe (Fatal)	Moderate (Serious Injury)		
Transportation by truck to TSD classified as "hazardous waste" transport. (Return trip assumed to have same rates)	2.5 E-09/mi.: or 1.3 E-07/hr		"Hazard Identification and Accident Scenario Definition" for the Clean Harbors of Braintree, Inc. Rotary Kiln Incinerator Project (Battelle, 1989), reduced by 1000 x fatality/incident ratio from: U.S. DOT Hazardous Materials Information System Database 1999 (Hourly rate assumes average 50 mph travel rate)	Hazardous waste trucking incident rate based upon study performed for Clean Harbors incinerator in 1989: 2.5 E-6/mile. Adjusted to fatality rate estimate by ratio of fatalities to accidents given in U.S. DOT HMIS Database 1999, 2000. (The latest U.S. DOT data for Large Truck incident rates also give 2.3 E-6/mile for 1997 and 2.1E-6/mile for 1998). To maintain an hourly rate basis for all risk evaluation tables, the equivalent hourly rates assume all transport averages 50 mi/hr. The 1/1000 fatality/incident ratio is derived from the ratio of 107 fatalities in the years 1990-1999, divided by the total number of incidents reported to U.S. DOT for the same years: 111,691. (For large trucks **not carrying** hazardous waste, the 2000 U.S. DOT fatal incident rates reported for 1997 and 1998 were 2.6E-8/mile and 2.5E-8/mile, respectively—almost exactly a factor of ten higher than that observed within the hazardous waste shipment portion of the DOT database). Data from the hazardous waste shipment database is considered most representative for current use.
		7.5 E-08/mi: or 3.8 E-06/hr	Also from Battelle (1989)-derived fatality rate above, but increased by 30x injury/fatality ratio from U.S. DOT Hazardous Materials Information System Database 1999 (Hourly rate assumes average 50 mph travel rate)	The number of injuries reported for the same 1990-1999 set of 111,691 incidents was 3080, about 30 times the 107 reported fatalities. (This injury/fatality ratio is approximately the same as that estimated for the other classes of accidents identified above for construction and related activities). (For large trucks **not carrying** hazardous waste, the 2000 U.S. DOT non-fatal incident rates reported for 1997 and 1998 were 5.0 and 4.5E-7/mile, respectively, about 20 times the fatality incidence rate—and about a factor of seven higher than that observed within the hazardous waste shipment portion of the DOT database). Data from the hazardous waste shipment database is considered most representative for current use.

Table 2

Short-Term Risk Evaluation Risk Ranking Description*

Risk Ranking Description		**Frequency/Probability of Occurrence**			
		Very Unlikely **(10 E-4 to 10 E-3 : 0.01 to 0.1 % chance)**	**Unlikely** **(10 E-3 to 10 E-2 : 0.1 to 1.% chance)**	**Likely** **(10 E-2 to 10 E-1 : 1 to 10 % chance)**	**Very likely** **(10 E-1 to >1.0 : 10 to >100 % chance)**
Injury Severity	**Minimal** (No health effects)	*Low*	*Low*	*Low*	*Low*
	Minor (Temporary effects, may be OSHA recordable for worker)	*Low*	*Low*	*Moderately Low*	*Medium*
	Moderate (Serious short-term injury, with temporary disability possible, e.g., “lost days”)	*Low*	*Moderately Low*	*Medium*	*High*
	Severe (Fatality, or disabling serious injury)	*Low*	*Medium*	*High*	*Very High*

* Based upon method recommended by the Center for Chemical Process Safety of the American Institute of Chemical Engineers in Guidelines for Hazard Evaluation Procedures, Chapter 7 and § 7.1, and in Plant Guidelines for Technical Management of Chemical Process Safety, App. 6B, published by AIChE, New York, 1992

Appendix E

Cost Estimate Methodology

Appendix E

Cost Estimate Methodology
Supplemental Waste Plan

This appendix describes the general approach that was used to prepare cost estimates for the alternatives that are evaluated in this Supplemental Waste Plan. One of the evaluation criteria that must be considered is relative cost. EPA guidance requires that cost estimates include consideration of capital costs and annual operation, maintenance, and repair costs. These two cost components are to be combined in an estimate of the net present worth for each alternative, which is a way of allowing comparison between alternatives on the basis of a single figure.

The cost estimates for the alternatives were based on the conceptual plans that are described in this Supplemental Waste Plan. Various tasks and quantities in the estimates are not considered final or comprehensive as they are based on the conceptual plans, and it is not possible to identify every work item in this phase of the analysis. The estimates are, however, considered satisfactory for relative cost comparison purposes. Unit prices for each individual task of work item were obtained from various sources including:

- Means Site Work Cost Data;
- conversations with remediation vendors;
- contractor bids on similar work items; and
- engineering experience and judgment.

Mobilization and contingencies were applied to the capital costs for project systems as a percent of the subtotal estimated cost. Contingencies, which represent costs for items not detailed in these estimates, were applied to the operation, maintenance and monitoring costs for the alternatives as a percent of the subtotal estimated cost. Engineering and administration costs were represented by an estimated duration and monthly unit cost for the mud still alternative, rather than a percentage of construction cost. For the enhanced RCRA cap and incineration alternatives, engineering and administration costs were represented as a percentage of construction costs.

Present worth was calculated for all tasks that included long-term operation and maintenance, or monitoring. Except for financial assurance purposes discussed later, a maximum of 30 years was assumed for each present worth determination. The value of any work completed more than 30 years into the future is considered insignificant within the accuracy of these estimates compared to the costs incurred in the first 30 years. An interest rate of 5 percent was used to return future operation, maintenance, and monitoring costs to a present worth.

For cost estimation purposes, the duration of each alternative was estimated according to a reasonable time line. The estimates of capital cost included in this Supplemental Waste Plan are tied to the estimated time or quantity of work and associated unit cost.

The operation, maintenance, and monitoring cost estimates included in this Supplemental Waste Plan are presented as net present worth. The present worth estimates are based on 30 years and a net discount rate of 5 percent annually. That discount rate is consistent with EPA's guidance and the value used in this Supplemental Waste Plan. However, caution must be exercised in using net present worth cost estimates as economic forecasts. The discount rate is used here only for producing net present worth estimates that are commensurate for comparison purposes.

Post-closure care costs have been estimated consistent with 40 CFR Part 265, Subpart H. Under RCRA at 40 CFR §265.117, the post-closure period is 30 years, and the financial assurance must cover this post-closure period. *See* 40 CFR § 265.145. This time period can be shortened or extended through a permit modification process based on a demonstration and finding that the hazardous waste management unit is secure. Conversely, the time period can be extended based on a finding that after the 30 years, there is a continuing potential for migration of hazardous wastes at levels that may be harmful. *See* 40 CFR §264.17(a)(1) and (2)(i) and (ii). Solvay expects that within a few years after completion of the cap, the groundwater and phosphine monitoring data will demonstrate that the unit is secure and continued monitoring would not be necessary.

In the May 17, 2001 meeting, Solvay suggested to EPA and MDEQ that in light of this regulatory structure, it would be appropriate to base that financial assurance on a 30-year period, which could be shortened or extended pursuant to the regulations. Solvay noted that in the FMC Consent Decree, EPA adopted a 30-year post-closure to monitor its capped phosphorus-containing ponds. Indeed, EPA rejected the Shoshonee Bannock Tribe's suggestion for a longer period, noting that the period could be extended if necessary per 40 CFR § 265.117. *See U.S. v. FMC Corporation, Inc.*, Proposed Consent Decree, Response to Public Comments p.16 (3/29/99) (see Attachment 1). Therefore, Solvay proposed to maintain financial assurance based on a 30-year post-closure monitoring period for the *in situ* decommissioning options. At the request of the EPA, however, Solvay has also estimated the cost of financial assurance for 100 years of maintenance and monitoring of the caps.

The post-closure cost estimate includes groundwater monitoring, phosphine monitoring, and maintenance operations for the alternatives involving capping of the clarifier. Note that the “representative” cost estimates assume five years of groundwater monitoring occurring each quarter, except the winter quarter (as is typical for northern climates), and then annual groundwater monitoring for years 6 through 30. Cap inspection and maintenance would continue through year 100. These post-closure costs estimates are included in Appendix N.

The “representative cost” scenarios are based on data and assumptions that appear to represent the conditions currently known or expected at the site. We have used the assumptions of quantity and tasks that underlie the “representative” evaluation for purposes of other evaluations in this Supplemental Waste Plan, such as short-term risk and time-to-complete, *i.e.*, implementation time. As a result, the “risk” and “implementation time” calculations are based on the most reasonable known or expected assumptions at the time of this submission.

Order-of-magnitude cost estimates are prepared. This evaluation considers the capital and general operation and maintenance costs associated with the alternative. Consistent with standard practice for a feasibility-level cost estimate, where very little of the detailed design is typically completed, the cost estimates are considered to be order of magnitude estimates and are expected to provide an accuracy of plus 50 to minus 30 percent for the described scope of the alternative.

The estimated costs for the capping and off-site incineration alternatives were presented in the Waste Plan (Barr 2001). In 2003, updated cost estimates for these alternatives were provided with a revised enhanced cap proposal (Rhodia 2003). The incineration cost estimate was updated to include larger drum sizes, smaller building, and reduced transportation trips. The capping costs estimates were scaled-up to account for a larger cap area. These cost estimates were then adjusted to 2013 dollars using the Engineering News-Record’s Construction Cost Index History (CCI) to adjust for inflation (Attachment 2). The value from November 2013 in the CCI (9666) was divided by the value from November 2003 (6794) to create the multiplier value of approximately 1.4, which represents an increase in cost of approximately 40 percent.

Solvay developed the cost estimate for construction and operation of the mud still. The cost estimate was based on the results of the treatability study, the conceptual design presented on Figures 3-7 through 3-9 of this Supplemental Waste Plan, and their professional experience and expertise. The costs to construct the evapotranspiration cap over the clarifier following completion of the mud still operation and the costs associated with long-term operations and monitoring were added to the mud still alternative cost estimate using the same methodology as described above (i.e., based on the estimates in the Waste Plan (Barr 2001) scaled to current dollars).

The cost of financial assurance was estimated for each alternative based on the respective detailed cost estimates. The cost of financial assurance estimates identify the activity, year, annual expense, estimated total amount for a financial assurance document, typical cost for financial assurance, and the annual cost of financial assurance. The initial total amount of financial assurance is equal to the total estimated relative cost of each alternative. The total amount of financial assurance is adjusted each year to account for the cost of the remaining activities. The annual cost of financial assurance column is summed to generate the total cost of financial assurance. The value of the elemental product product that would be recovered by the mud still alternative was not included in the cost of financial assurance. The cost of financial assurance estimates are presented in Appendix N.

The financial assurance document was assumed to be a letter of credit, but alternative documentation may be considered after the alternative is selected.

References

Barr 2001. Waste Plan. Prepared for Rhodia Inc., Submitted to EPA Region 8, November 16, 2001.

Attachment 1

Proposed Consent Decree (U.S. v. FMC Corporation)
Response to Public Comments

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U.S. v. FMC CORPORATION, INC.

PROPOSED CONSENT DECREE:

RESPONSE TO PUBLIC COMMENTS

Regardless of what technology is selected for the treatment plant, the treated waste must meet the strict performance standards for gas emissions, leachability of metals and permanence in the Consent Decree. FMC must demonstrate that its design can meet these performance requirements before EPA will allow it to start up the plant. Continuing operation of the LDR treatment plant will include monitoring to ensure all wastes generated meet these requirements. EPA will continue to work with FMC to ensure that the system is designed and constructed so that it will meet the performance standards specified in the Consent Decree and can be operated in a safe and protective manner. EPA also will provide the public with an opportunity to comment on the design and operating plans before approving them. The plant will not be allowed to operate unless it meets the performance requirements.

As described in the United States' Response to Comment I(A), EPA worked extensively with FMC to set the shortest possible schedule for completing the treatment plant that allows adequate time for design and construction and public input, and believes that the schedule cannot be accelerated. The Tribes were represented during these meetings.

C. Summary of Comment - Pond Closure:

The Consent Decree allows FMC to cap its hazardous waste ponds without deactivating and stabilizing the waste material. This does not meet RCRA capping requirements, which require FMC to minimize long term maintenance and to prevent to the greatest extent practicable releases to the environment. Over the past 50 years, FMC has created approximately 28 ponds filled with ignitable or reactive waste covering approximately 123 acres. Contaminants from these ponds within the soil column will continue to migrate into the aquifer. Capping the waste will not prevent contaminants from migrating into the aquifer. In addition, the Consent Decree only requires monitoring of the caps for thirty years, while the hazardous phosphorus bearing waste under these caps will remain reactive and ignitable for up to 10,000 years. Although the wastes in ponds 18A and 18B eventually will be excavated, deactivated and stabilized once FMC's treatment plant is constructed, the settlement gives FMC until 2007 to do this. Excavation, deactivation through treatment and stabilization of waste in all ponds, and certainly in active ponds 16S and 17S should occur prior to disposal.

<u>Shoshone-Bannock Comments</u> at pp. 13-15.

Response:

RCRA regulations give a facility the option at closure of either removing the waste from surface impoundments OR leaving the waste in place and capping the unit as a landfill. 40 C.F.R. § 265.228. Nevertheless, and at the Tribes' request, EPA went to considerable effort to determine whether the risks associated with leaving the waste in place were sufficient to justify seeking a court order to compel FMC to remove and treat the waste. In light of the option provided at 40 C.F.R. § 265.228 to close with the waste in place and the considerable cost and technical difficulties of removing and treating waste already disposed of in the ponds, FMC made clear that it would not agree to remove and treat the waste. The Tribes were represented at a series of meetings with FMC over a period of several months during which this issue was addressed.

In evaluating the risks associated with leaving the waste in place, EPA sampled the groundwater to see if elemental phosphorus was moving into the groundwater from the ponds. To obtain analytical data regarding the mobility of phosphorus to the groundwater, EPA sampled wells at the facility for elemental phosphorus. The objectives of the sampling were 1) to determine whether the groundwater at the facility is contaminated with site related phosphorus compounds and characterize the contamination if present, and 2) determine whether the related phosphorus compounds are being discharged to the Portneuf River. The concentration of elemental phosphorus adjacent to and down gradient from Pond 8S was of specific interest as this Pond is unlined and has resulted in metal contamination of the groundwater. To achieve these objectives, on January 1 through January 15, 1998, EPA collected groundwater samples from 21 wells and a sediment sample and surface water samples from two springs down gradient. The groundwater samples were analyzed for field parameters, including dissolved oxygen, pH, temperature, specific conductivity, and oxidation reduction potential (Eh). Groundwater samples were also analyzed at the laboratory for orthophosphorous, total phosphorus, white phosphorus, nitrite and nitrate. Four samples were analyzed for total dissolved solids (TDS) and anions (chloride, fluoride, and sulfate). Spring water samples were analyzed for orthophosphorous, total phosphorus, orthophosphorous, white phosphorus, nitrate and nitrite, and Eh. Sediment samples were analyzed for total phosphorus, orthophosphorous and white phosphorus. The results of these analyses indicate that elemental phosphorus has not migrated into the groundwater as a result of releases from 8S. It appears that elemental phosphorus is relatively immobile under these conditions. These sampling results were shared with the Tribes.

In addition, because sediments in the ponds may be ignitable, reactive or radioactive, EPA determined that it would not be safe or practical to ship the waste off-site for treatment. Due to the great volume of sediment in the ponds, and the technical difficulty of removing it, treatment on-site after the treatment plant was designed and built would take many years. The cost of such on-site treatment, in excess of $75 million, was also relevant, in that FMC would not agree to this option in settlement and the prospect of obtaining this type of injunctive relief in litigation was not assured. See Weinberger v. Romero-Barcelo, 456 U.S. 305 (1982). However, as explained below, EPA is confident that the pond capping requirements of the Consent Decree will protect human health and the environment.

Under the Consent Decree, wastes in Pond 18 must be removed and treated in the LDR Treatment plant within 5 years after the treatment plant begins operation. This schedule was negotiated with FMC, with participation by Tribal representatives. FMC sought a longer schedule. Any acceleration of the schedule would require design and construction of a larger treatment plant, which FMC objected to. Given the extensive leak and toxic gas detection and pond management requirements for Pond 18, EPA is confident that this schedule is protective.

Also, in the event that FMC deposits in Pond 17 any phossy waste other than precipitator slurry treated using the NOSAP process and meeting the criteria for NOSAP waste set forth in the Pond Management Plan, Pond 17 shall be subject to the same sediment removal and treatment requirements as Pond 18.

All other ponds will be closed with wastes left in place in accordance with RCRA closure regulations. The Phase IV Ponds and Ponds 15S and 16 will be closed using techniques developed by FMC for closure of pond 8S. Caps for these ponds will be more protective than what is normally required for RCRA closure and will include, in addition to a geosynthetic barrier, a seven foot capillary barrier composed of soils and sands to enhance evapotranspiration. This cap design is comparable to one being designed for radioactive waste landfills which may be dangerous for thousands of years. This is a durable largely soil based cap that promotes evapotranspiration to minimize migration of precipitation through the cap and requires little maintenance other than maintaining the vegetative cover. In addition, a leak detection and removal system will be placed between the capillary barrier and the geosynthetic to assure that the capillary barrier is minimizing migration of liquids to the geosynthetics and underlying wastes. This minimizes the potential for groundwater contamination. Long term maintenance and monitoring will be required.

Most of the waste placed in Pond 8E has been treated using the NOSAP process. Most of the waste placed in Pond 9E has been removed. These ponds do not pose the same kinds of risks that the Phase IV Ponds and Pond 15S do. Nevertheless, the Consent Decree requires a RCRA cap for these ponds which includes soil and geosynthetic components. The requirements are the same as for the Phase IV Ponds and Pond 15S except the capillary barrier is not required. The Consent Decree does not allow FMC to create new ponds which would then be closed without waste treatment.

Removal of water from the ponds is expected to significantly reduce any migration of contamination from the ponds to the groundwater by minimizing hydrostatic pressure. Capping the units will minimize the amount of precipitation which could infiltrate the waste and carry hazardous constituents from the surface impoundments to the groundwater.

Because phosphine, hydrogen and hydrogen cyanide could be created by waste decomposition or other reactions, temperature and pressure under the caps will be measured and recorded continuously. If gases are generated at levels of concern, the gas will be collected and treated.

These features of the caps to be installed over the waste ponds are designed to minimize the need for further maintenance, and to minimize, eliminate or control releases as necessary to protect public health and the environment, and to meet other applicable RCRA requirements. FMC is required to maintain the integrity and effectiveness of the final cover. Under RCRA, post closure care must continue for 30 years. EPA may extend the post closure period as necessary to protect human health and the environment. There is no limit on extensions to the post closure period. The post closure period will be specified in the permit for the FMC facility. The public will be provided an opportunity to comment on the post closure requirements of the permit. The permit requirements for post closure will be renewed and remain in effect so long as necessary to be protective.

Under the closure and post-closure plans for the ponds, FMC will continue to analyze the monitoring wells around the ponds for elemental phosphorus after closure to ensure that phosphorus is not contaminating the ground water. In addition, sumps at each of the operating ponds will be checked weekly for the presence of leachate and the flow rate from the leachate collection wells will be evaluated to determine if it exceeds 50% of the EPA approved action leakage rate. If it does, further investigations to determine whether there are any impacts to groundwater below the pond will begin. All of these actions are described in detail in the Response Action Plans for Operating Ponds [Appendix O of the Pond Management Plan].

EPA believes that the cap construction, operation and monitoring requirements required by the Decree are protective of human health and the environment. All information obtained or developed during the course of negotiations relating to cap requirements was shared with the Tribe.

There are other ponds at the FMC facility that are not subject to RCRA hazardous waste closure requirements; these are being addressed in the CERCLA Record of Decision issued for the Eastern Michaud Flats Superfund Site ("ROD"). The Superfund program primarily focuses on cleanup of past releases of hazardous substances, and defers to RCRA to address ongoing releases of hazardous waste that are subject to RCRA regulations. The Eastern Michaud Flats Superfund Record of Decision requires the closure of older, unused ponds at the site, and is consistent with current RCRA pond closure requirement.

Attachment 2

Construction Cost Index History
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Construction Cost Index History - As of October 2014

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HOW ENR BUILDS THE INDEX: 200 hours of common labor at the 20-city average of common labor rates, plus 25 cwt of standard structural steel shapes at the mill price prior to 1996 and the fabricated 20-city price from 1996, plus 1.128 tons of portland cement at the 20-city price, plus 1,088 board ft of 2 x 4 lumber at the 20-city price.

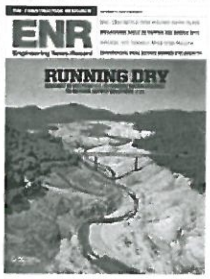
ENR'S CONSTRUCTION COST INDEX HISTORY (1908-2014)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG.
2014	9664	9681	9702	9750	9796	9800	9835	9846					
2013	9437	9453	9456	9484	9516	9542	9552	9545	9552	9689	9666	9668	9547
2012	9176	9198	9268	9273	9290	9291	9324	9351	9341	9376	9398	9412	9308
2011	8938	8998	9011	9027	9035	9053	9080	9088	9116	9147	9173	9172	9070
2010	8660	8672	8671	8677	8761	8805	8844	8837	8836	8921	8951	8952	8799
2009	8549	8533	8534	8528	8574	8578	8566	8564	8586	8596	8592	8641	8570
2008	8090	8094	8109	8112	8141	8185	8293	8362	8557	8623	8602	8551	8310
2007	7880	7880	7856	7865	7942	7939	7959	8007	8050	8045	8092	8089	7966
2006	7660	7689	7692	7695	7691	7700	7721	7722	7763	7883	7911	7888	7751
2005	7297	7298	7309	7355	7398	7415	7422	7479	7540	7563	7630	7647	7446
2004	6825	6862	6957	7017	7065	7109	7126	7188	7298	7314	7312	7308	7115
2003	6581	6640	6627	6635	6642	6694	6695	6733	6741	6771	6794	6782	6694
2002	6462	6462	6502	6480	6512	6532	6605	6592	6589	6579	6578	6563	6538
2001	6281	6272	6279	6286	6288	6318	6404	6389	6391	6397	6410	6390	6343
2000	6130	6160	6202	6201	6233	6238	6225	6233	6224	6259	6266	6283	6221
1999	6000	5992	5986	6008	6006	6039	6076	6091	6128	6134	6127	6127	6059
1998	5852	5874	5875	5883	5881	5895	5921	5929	5963	5986	5995	5991	5920
1997	5765	5769	5759	5799	5837	5860	5863	5854	5851	5848	5838	5858	5826
1996	5523	5532	5537	5550	5572	5597	5617	5652	5683	5719	5740	5744	5620
1995	5443	5444	5435	5432	5433	5432	5484	5506	5491	5511	5519	5524	5471
1994	5336	5371	5381	5405	5405	5408	5409	5424	5437	5437	5439	5439	5408
1993	5071	5070	5106	5167	5262	5260	5252	5230	5255	5264	5278	5310	5210
1992	4888	4884	4927	4946	4965	4973	4992	5032	5042	5052	5058	5059	4985
1991	4777	4773	4772	4766	4801	4818	4854	4892	4891	4892	4896	4889	4835
1990	4680	4685	4691	4693	4707	4732	4734	4752	4774	4771	4787	4777	4732

SOURCE FOR THE DATA HERE

ANNUAL AVERAGE

YEAR	AVG	YEAR	AVG	YEAR	AVG	YEAR	AVG
1989	4615	1988	4519	1987	4406	1986	4295



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Video

Appendix F

Letter from Dan Bersanti, Plant Manager

Rhodia

Silver Bow Plant
P.O. Box 3146
Butte, MT 59702
406-782-1215
406-782-4498 (FAX)

Re: Rhodia--Silver Bow Plant Operations

To Whom It May Concern:

My name is Dan Bersanti, and I am the Plant Manager of the Rhodia, Silver Bow plant. I have held this position since 1996. Before that, I held a variety of positions at the Silver Bow site. Initially hired as a process engineer, I worked in this capacity and as a production engineer until 1986. At that time, I took over responsibilities for the Maintenance Department. In 1987, I was promoted to Maintenance and Operations Manager and was responsible for all plant operations needed to produce and ship phosphorus to our downstream plants. In 1991, I became the Technical Manager for the site, responsible for all process and production engineering and all capital improvement projects. In 1996, I became Plant Manager, a position which I still hold.

The purpose of this letter is to explain the nature of the material in the clarifier and how it was processed in the roaster at the Rhodia, Silver Bow plant during its years of operation. I will also describe several technologies that were tested in the early 1980's that were designed to reduce the concentration of phosphorus in the crude phosphorus prior to the roaster operation.

The product that was produced at the Rhodia, Silver Bow plant through March of 1997 was elemental phosphorus, P4. In simple terms, as the attached Process Flow Diagram shows, phosphate ore was nodulized (calcined) in one of two rotary kilns to produce nodules, which are a baseball sized pieces of agglomerated phosphate ore. The nodules were proportionally mixed with silica and coke and were placed into the electric arc furnaces. Electric arc furnaces, which operated at temperatures over 2500 ° F, would cause the phosphate in the nodule to be reduced to elemental phosphorus. This process resulted in a vapor stream consisting of elemental phosphorus and carbon monoxide. Calcium silicate slag and ferrophosphorus, a phosphorus and iron compound, were co-products that were either sold or stockpiled on site. The vaporized elemental phosphorus stream was condensed and called crude phosphorus (a mixture of phosphorus, water, and small particles of the furnace burden). This crude phosphorus was collected in condensers, one condenser for each furnace. The crude phosphorus material in the condenser was then moved into two large process tanks called receiving tanks. There were two receiving tanks for each condenser to allow the material in one of the receiving tanks to be filtered and moved while the other receiving tank was receiving material from the condenser.

When the crude phosphorus material was moved from the receiving tank, it was filtered using a vertical tube filter. The elemental phosphorus that could be separated from the crude phosphorus material by filtering was sent to an elemental phosphorus product storage tank. The remaining crude phosphorus material was sent to another process tank where the material was stored and filtered again at a later time. The crude phosphorus material was stored in several different process tanks and was filtered two or three times. After no more product phosphorus could be removed by filtering, the crude phosphorus material was moved to the roaster for processing or the 100-foot clarifier for storage while waiting for further processing. This remaining crude phosphorus was essentially an emulsion of elemental phosphorus, water and solids, such as phosphate dust, silica dust and coke dust. Despite numerous efforts by Rhodia to break this emulsion to recover more phosphorus (*e.g.*, centrifugation, filtration, flocculation, dilution, etc.), more phosphorus could only be effectively recovered through heating. In our case, we used the roaster technology. Below is a summary of each technology designed to break this emulsion that was tested and the outcome of the test.

- Centrifugation: Several types of centrifuges were tested with the expectation that the crude phosphorus could be subjected to high centrifugal forces. These forces, similar to gravity, would accelerate and enhance the separation rate of phosphorus in the crude phosphorus and thereby increase recovery rates. Although partially successful, continuous and economical operation was not possible. Because the crude phosphorus had high solids content, steady flow conditions within the centrifuge could not be maintained. This caused the machine to become out of mechanical balance and it had to be shut down and cleaned. Additionally, the solids cause extensive wear within the centrifuge and the resulting high maintenance costs. Ultimately, this process was discontinued.
- Filtration: In addition to the vertical tube filter that was used, a high pressure, horizontal rotating filter assembly was also tested. This filter, manufactured by Artisan Filters, has a series of circular flat filter plates that used a filter cloth coated with diatomaceous earth. Between each filter plate was a rotating plate that continuously removed the filter cake. Crude phosphorus was continuously fed to this filter at pressures near 200 p.s.i. Phosphorus contained in the crude phosphorus would pass through the filter cloth and be collected in a storage tank. The remaining filter cake was collected in another tank. Again, solids concentration in the crude phosphorus made continuous operation impossible. Close mechanical tolerances within the filter could not be maintained and the filter had to be shut down and repaired. This process was also discontinued.
- Flocculation: Several different types of flocculating agents were tried to enhance separation of phosphorus from crude phosphorus. None were found that increase phosphorus recovery.
- Dilution: After the crude phosphorus had been filtered as much as possible, a technology referred to as "Washing" was used to increase phosphorus recovery. Based on discussions with colleagues in the phosphorus industry, washing was carried out on plant scale trials where hot water was bubbled up though the crude phosphorus in the settling tanks using sparging rings placed in the bottom of the tanks. The bubbling water washed and lowered or diluted the phosphorus concentrations in the P4 residue layer by promoting both cleanup of the elemental phosphorus stream and enhancing the settling action in the settling tanks. This technology had some success but did not remove all the phosphorus present. Additional processing was required to remove the remaining phosphorus in the crude phosphorus.

Before being transferred to the roaster or the 100-foot clarifier, the crude phosphorus had been moved from one tank to another tank several times. During this process, very good mixing took place. Once the crude phosphorus was placed in the large, poorly heated 100-foot clarifier, the phosphorus in the mixture partially froze (phosphorus has a freezing point of 111° F) and the mixture solidified. When there was capacity available in a roaster feed tank, the crude phosphorus in the 100-foot clarifier was heated and pumped to a roaster feed tank.

The roaster process was the final step in phosphorus production at the Silver Bow Plant. This process consisted of an externally heated, airtight stainless steel rotary kiln. A temperature of 550° C (1020° F) was maintained on the roaster shell as it rotated at approximately 20 rpm. Crude phosphorus at roughly 60° C (140° F) and nodule fines (the finer material screened during nodule production) were introduced into the feed end of the roaster. The nodule fines helped to distribute the mixture evenly within the roaster and aided in heat transfer. These nodule fines also prevented material build-up on the inside of the roaster shell.

Crude phosphorus was introduced using one of three 10,000 gallon feed tanks. The feed tank was pressurized with water and the crude phosphorus was forced out of the tank and into the roaster at a feed rate of approximately 300 gallons/hour. Nodule fines were introduced using a feed screw mounted on the feed end of the roaster at a rate of roughly (2) tons/hour. This process continued until the feed tank was empty, at which time the process was stopped and a new feed tank was put into service. Typically, the crude phosphorus fed to the roaster contained roughly 20% phosphorus. This was calculated by measuring the volume in the feed tank and phosphorus product tank before and after each batch.

The remaining phosphorus in the crude phosphorus was vaporized in the roaster. The phosphorus vapor was directed to a water-quenching spray tower and condensing system where the elemental phosphorus was condensed and collected as a liquid in a tank at the bottom of the tower. This recovered product phosphorus was filtered, loaded in railroad tank cars and shipped to other phosphorus utilization facilities for use in their processes.

The surface of the nodule fines would collect the non-phosphorus containing materials as they migrated to the discharge end of the roaster. At the discharge end, these nodule fines, now called roaster solids, were removed with a screw conveyor and stockpiled in 25-ton stockpiles. At times, roaster solids were used instead of nodule fines and reintroduced to the roaster.

Roaster operations were discontinued in 1997 due to operational problems encountered while attempting to process material from the clarifier. Detailed below are descriptions of the operational difficulties that prevented Rhodia from processing the material remaining in the clarifier.

Crude phosphorus was introduced to the roaster using a specially-designed feed system. This system consisted of feed pumps, piping, tanks, tank agitators, a flow measuring device, and a feed temperature control system. The purpose of this feed system was to insure that the crude phosphorus was introduced to the roaster at a constant rate and as a liquid slurry mixture. This allowed the roaster to operate under steady state conditions for both operating temperature and pressure. If these conditions were met, the roaster efficiently removed the phosphorus contained in the feed stream. If not met, temperature and pressure fluctuations in the roaster appeared which made operation nearly impossible. These fluctuations in operation parameters reduced efficiency and increased emissions at the discharge. Feed rate and feed temperature, the only design variables, were varied in an attempt to continue operations but no suitable combination was found that allowed steady state roaster operation. In addition to the operational difficulties caused by these clarifier materials, processing this material also increased the safety risk to maintenance and operational personnel. When the feed system plugged, it was necessary to manually clean the piping system. This involved breaking into phosphorus lines and physically washing the crude phosphorus from the lines. Although the personnel utilized for this task were trained in these procedures, the risk increased due to the increased number of time the procedures had to be performed.

Although the roaster technology was utilized in the past, processing crude phosphorus from the clarifier created operational and safety issues that made continued roaster processing untenable after March of 1997.

The material that remains in the clarifier is estimated to have about 20% elemental phosphorus. The most relevant evidence of this is the attached record from the "Plantwide Meeting" on February 19, 1997, which is shortly before the clarifier material ceased to be processed. The record shows that of the 10,033 gallons of crude phosphorus sludge that had been processed during that month, 1,841 gallons or 18.3% was recovered as product P_4. The crude phosphorus sludge in the clarifier would be expected to have a very similar percentage of elemental phosphorus since the material that was processed in February 1997 is the same material in the clarifier today. Since the P_4 in the clarifier will stay with the solids and slurry material, I would expect that if the water were removed for capping, the P_4 concentration of the remaining solids would increase slightly. But a reasonable estimate is that the clarifier material that would be capped would contain about 20% elemental phosphorus.

Sincerely,

Dan Bersanti/TDM

Dan Bersanti

Attachment

PLANTWIDE MEETING

19-Feb-97

	February MTD Actual	1997 YTD-Actual
Sludge Recovered From 100' Clarifier (gallons)	952	13,488
Sludge Processed in Roaster (gallons)	10,033	10,033
P4 Yield From Roaster Processing-BC (gallons)	1,841	1,841
P4 Yield Direct From 100' Clarifier (gallons)	0	0
Roaster Onstream Time (%)**	20	10

18.3% P4

Current Sludge Inventory: 18,541 gallons

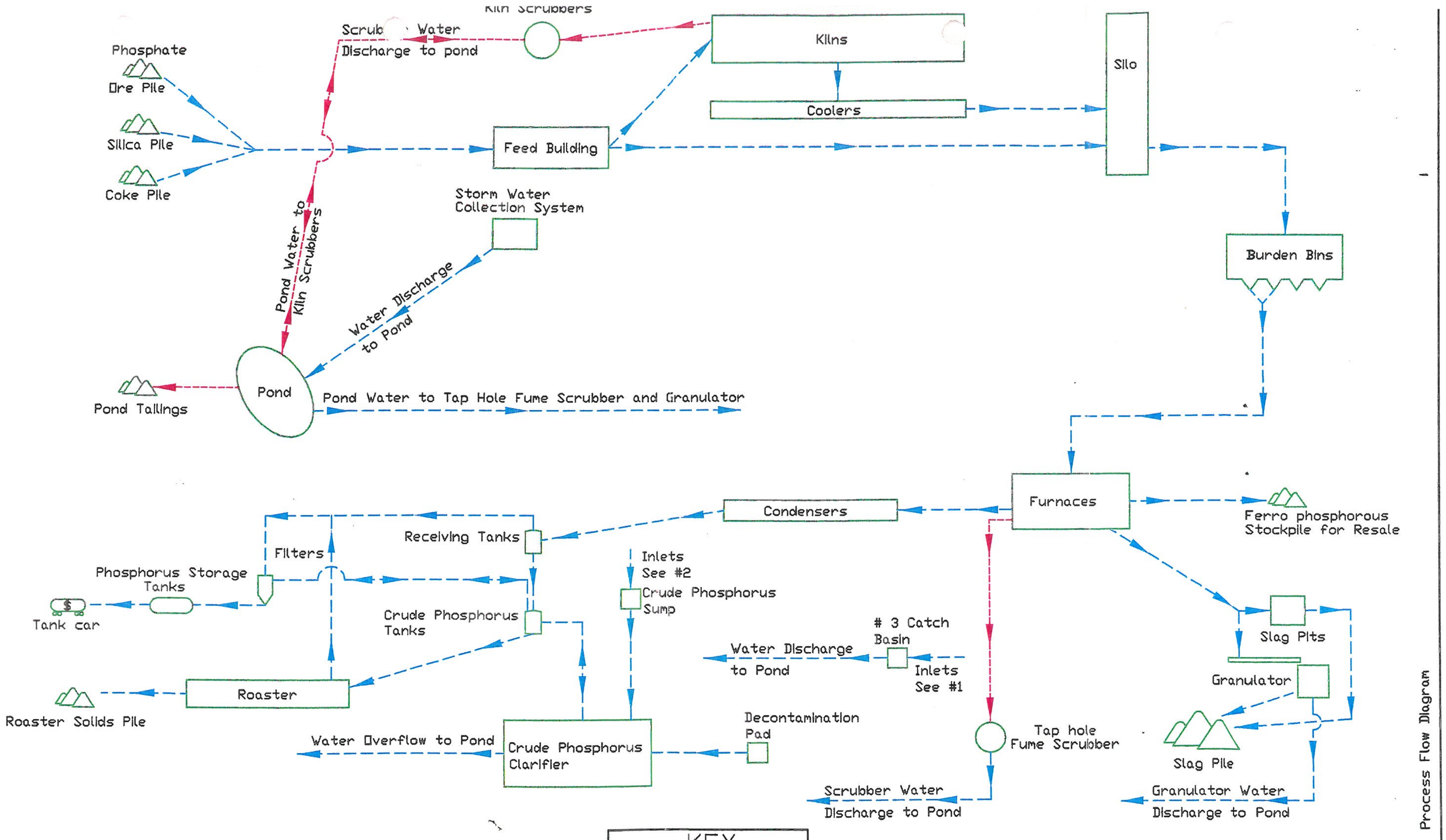
Ron Smith by Tom Goody

Ron Smith

Posting Responsibility

Main Office: Cheryl Bolton
Operations: Tom Goody
Maintenance: Tom Goody
Clock Alley: Teri Tregear
Lab: Lisa Palmer
File Copy: Teri Tregear
CC: Dan Bersanti

Post: February 21, 1997
Remove: February 28, 1997



#1 No. 3 Catch Basin: Overflow water from Condensers, Receiving tanks, Crude Phosphorus tanks and Crude Phosphorus Clarifier.

#2 Crude Phosphorus Sump: Overflow water from Condensers, Receiving tanks and Crude Phosphorus tanks.

KEY

🟩 Process Steps

○ Pollution Control Device

Stockpile

WARNING

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REFERENCE DRAWINGS

REVISIONS

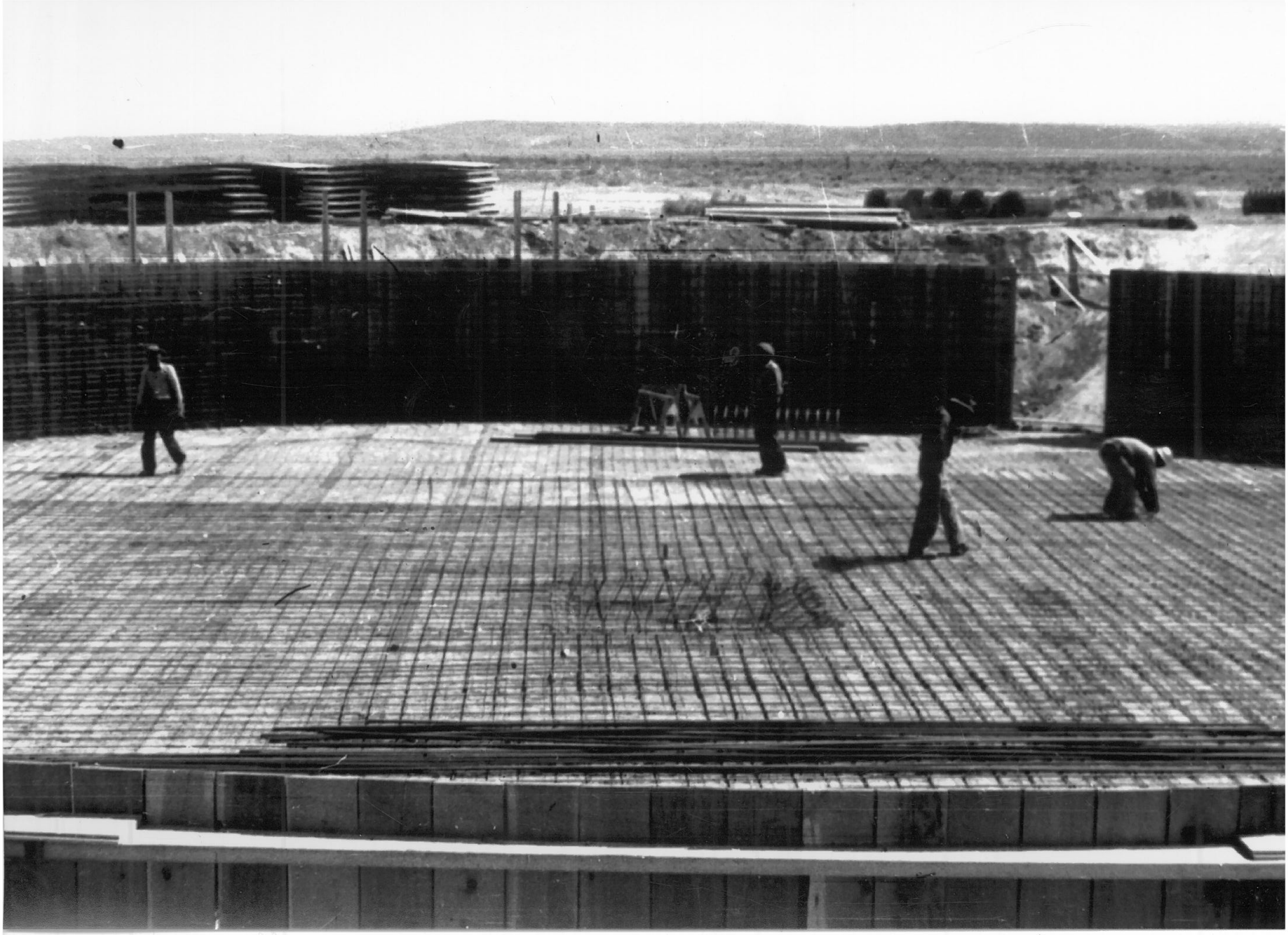
RHODIA INC.

PLANT
PROCESS FLOW DIAGRAM
SILVER BOW, MONTANA

SCALE: NTS
PROJECT No.
DATE: 4/17/00
FILE No. SB-1797-A
DWG. No. SB-1797-A
DRAWN BY:
CHECKED BY:
APPROVED BY:
PRELIMINARY DRAWING
ISSUE 1

Appendix G

Clarifier – Construction Photos, Sampling and Analysis Plan, and TCLP Analytical Data



100-Foot Clarifier
Sampling and Analysis Plan
for
February 1997

1. Introduction

The 100-foot clarifier, located near the roaster, was used for surge capacity during phosphorus production. Crude phosphorus coming from the phosphorus-handling department for processing in the roaster that could not be stored in the roaster feed tanks was sent to the clarifier. When space was available in the feed tanks, material was pumped from the clarifier to these tanks and processed in the roaster.

In 1997, closing the 100-foot clarifier in place was an option that was considered. In order to evaluate this option, representative samples of the material in the clarifier were taken and analyzed for TCLP metals.

A sampling program was designed to fulfill data objectives that included:

The samples collected were representative of the materials sampled;
Sample integrity was maintained and documented;
Proper measurements and information were recorded;
Sample volumes were sufficient for the required analytical procedures;
Analytical results adequately characterized the clarifier material; and
The sampling protocol was efficient and relatively uncomplicated.

2. Data Quality Objectives

The purpose of data quality assessment is to assure that data generated under this program is reconciled, accurate and consistent with program data quality objectives. The quality of the data will be assessed based on precision, accuracy, and completeness. Percent precision is the degree to which a measurement is reproducible and will be assessed by a comparison of duplicate sample results. A relative percent difference (RPD) of 35% for the duplicate samples is the precision goal. Percent accuracy is a determination of how close the measurement is to the true value and will be assessed via spike recovery in sample matrices. The laboratory as part of their QA/QC procedures will perform this. Spike recoveries reported by the laboratory needs to be within ±20% of the spiked amount. Completeness is a measure of the amount of valid data obtained, compared to the amount that was expected under normal conditions. Ninety percent (90%) completeness is the goal of the Sampling Plan. Resolution of data discrepancies will be conducted as outlined in Section 4 of this document.

Material from the clarifier will be analyzed for concentrations of Resource Conservation Recovery Act (RCRA) eight metals (silver, arsenic, barium, cadmium, chromium, mercury, lead, and selenium).

3. Sampling Procedures

The following section outlines the sampling procedures used to collect samples from the 100-foot clarifier.

3.1. *Sample Collection*

During routine processing of clarifier material, a clamshell attached to a crane was used to move material from various locations in the clarifier to a pumping station. The crane was set southwest of the clarifier wall where it was able to access all locations within the clarifier. For 2 ½ days prior to sampling, the crane operator took material from all locations and moved it to the pumping station. Because the clarifier was heated and the material was only partially frozen, the clamshell was able to gather material from various depths within the clarifier. The material in the pumping station was heated with a steam lance to thaw the frozen phosphorus in the material, which enabled it to be pumped to the roaster feed tanks where the samples were taken.

3.2. *Generation of Composite*

Once in the feed tanks, the material was agitated with a mechanical, paddle-type, agitator used to agitate and mix the contents of the tank. After agitation, a sample jar was lowered to the middle of the material and a sample was taken. This sample was placed in a cold water bucket and allowed to cool below the freezing point of phosphorus. It was then transported to the laboratory for packaging and shipment. This process was repeated on a second tank and another sample was obtained.

3.3. *Sampling Sequence*

The following sampling sequence was used to obtain representative samples from the 100-foot clarifier:

Clamshell material from locations within the 100-foot clarifier to the pumping station.
Heat the material in the pumping station.
Pump the material to the roaster feed tanks.
Agitate the material in the feed tanks.
Sample the material in the tanks in the center of the mixture.
Cool the sample.
Transport to the laboratory for packaging and shipment.

3.4. *Analytical Methods*

The samples were analyzed for TCLP metals using EPA SW-846 Method 1311. The results are attached. The plant Laboratory Manager was present and supervised the analytical work for these samples.

4. Data Validation

Data from the sampling event will be reviewed and evaluated based on the data quality objectives. This review includes:

A comparison of duplicate samples.
A check of laboratory quality control information.

The analytical results of the duplicate samples will be compared by calculating the RPD. The data quality objective for this comparison is ±35%. The RPD is defined by the following equation:

RPD = (A1-A2)/((A1+A2)/2)*100

Where: A1 = Analytical result from one duplicate sample
A2 = Analytical result from the other duplicate sample

Laboratory quality control information will be reviewed for every sample. The quality information that will be reviewed is the matrix spike sample results. The percent recovery must be within ±20% of the spiked amount.

If the QC results detect conditions or data that do not meet the data quality requirements, corrective action will be initiated. The nature of the action will depend on the circumstances unique to each situation and may include:

Reanalyzing the samples, if holding time criteria permit;
Re-sampling and analyzing;
Evaluating and amending sampling and analytical procedures;
Accepting data, acknowledging the level of uncertainty; and
Conducting a laboratory audit.

The following is a data review and validation of the 100' clarifier sampling data. This review and validation is based on the Data Quality Objectives described in the 100-Foot Clarifier Sampling Plan.

Data Validation

	A1 (mg/l)	A2 (mg/l)	RPD (%)	Spike Recovery A1	Spike Recovery
arsenic	0.5	0.5	0	0	2
barium	10	10	0	-9	-10
cadmium	0.1	0.1	0	3	1
chromium	0.5	0.5	0	-8	-9
lead	0.5	0.5	0	-4	-7
mercury	0.02	0.02	0	6	7
selenium	0.1	0.1	0	-9	-9
silver	0.5	0.5	0	-5	-8

A1 = Sludge #01
A2 = Sludge #02

In conclusion, the clarifier sampling data was well within the data quality objectives established in the 100-Foot Clarifier Sampling Plan. Therefore, the clarifier sampling data is considered to be valid under these conditions.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1120 SOUTH 27TH STREET • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO:
ADDRESS:

Lisa L. Palmer
Rhone-Poulenc
P.O. Box 3146
Butte, MT 59702

LAB NO.: 97-18565
DATE: 03/03/97 kr

REC'D MAR 4 1997

WASTE ANALYSIS

Sludge #01
Submitted 02/27/97
Extracted 02/27/97

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l in Extract	Spike Percent Recovery	Date Analyz
Arsenic	7440-38-2	5.0	0.5	<0.5	100	02/28/
Barium	7440-39-3	100.0	10.0	<10	91	02/28/
Cadmium	7440-43-9	1.0	0.1	<0.1	103	02/28/
Chromium	7440-47-3	5.0	0.5	<0.5	92	02/28/
Lead	7439-92-1	5.0	0.5	<0.5	96	02/28/
Mercury	7439-97-6	0.2	0.02	<0.02	106	03/03/
Selenium	7782-49 2	1.0	0.1	<0.1	91	03/03/
Silver	7440-22-4	5.0	0.5	<0.5	95	02/28/

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1120 SOUTH 27TH STREET • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Lisa L. Palmer
ADDRESS: Rhone-Poulenc
P.O. Box 3146
Butte, MT 59702

LAB NO.: 97-18566
DATE: 03/03/97 kr

WASTE ANALYSIS

Sludge #02
Submitted 02/27/97
Extracted 02/27/97

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l In Extract	Spike Percent Recovery	Dat Analy
Arsenic	7440-38-2	5.0	0.5	<0.5	102	02/28
Barium	7440-39-3	100.0	10.0	<10	90	02/28
Cadmium	7440-43-9	1.0	0.1	<0.1	101	02/28
Chromium	7440-47-3	5.0	0.5	<0.5	91	02/28
Lead	7439-92-1	5.0	0.5	<0.5	93	02/28
Mercury	7439-97-6	0.2	0.02	<0.02	107	03/03
Selenium	7782-49 2	1.0	0.1	<0.1	91	03/03
Silver	7440-22-4	5.0	0.5	<0.5	92	02/28

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1120 SOUTH 27TH STREET • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: **ADDRESS:**	Lisa L. Palmer Rhone-Poulenc P.O. Box 3148 Butte, MT 59702	**LAB NO.:** **DATE:**	Blank 03/03/97 kr

WASTE ANALYSIS

Method Blank
Extracted 02/27/97

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l In Extract	Spike Percent Recovery	Date Analyz
Arsenic	7440-38-2	5.0	0.5	<0.5	103	02/28/
Barium	7440-39-3	100.0	10.0	<10	93	02/28/
Cadmium	7440-43-9	1.0	0.1	<0.1	104	02/28/
Chromium	7440-47-3	5.0	0.5	<0.5	96	02/28/
Lead	7439-92-1	5.0	0.5	<0.5	98	02/28/
Mercury	7439-97-6	0.2	0.02	<0.02	82	03/03/
Selenium	7782-49 2	1.0	0.1	<0.1	105	03/03/
Silver	7440-22-4	5.0	0.5	<0.5	101	02/28/

Appendix H

RFI Report Section 5.5.2 – SWMU 2 Clarifier

SWMU 2 – Clarifier

Table of Contents

List of Tables

List of Figures

List of Appendices

5.5.2 SWMU 2 - Clarifier

The location of Solid Waste Management Unit (SWMU) 2 is shown on Figure 5.5.2-1a and SWMU 2 monitoring stations and sample locations are provided on Figure 5.5.2-1b. The clarifier is a 100-foot diameter concrete unit partially recessed in the ground that contains approximately 500,000 gallons of crude phosphorus covered by a water cap. Crude phosphorus is the filter cake from the filtration operations used to purify the elemental phosphorus. The crude phosphorus consists of elemental phosphorus (about 20% volume/volume [v/v]); water (about 30% v/v); and solids (about 50% v/v) such as phosphate dust, coke dust and silica dust. Until March 1997, the crude phosphorus was further processed in the Plant's roaster to produce P4 product.

5.5.2.1 RCRA 7003 Order

During an inspection at the Silver Bow Plant in May 2000, the EPA inspectors collected samples of crude phosphorus and placed the material in separate metal pans. As the material in the pans dried, it began smoking and spontaneously ignited. EPA Region 8 issued an Administrative Order (7003 Order), Docket No. RCRA-8-2000-07, under § 7003 of the Solid Waste Disposal Act, as amended (42 U.S.C. § 6973). This Order was issued on June 12, 2000 and amended on December 27, 2000 and required Rhodia to undertake immediate and interim measures to protect public health and the environment, including wildlife. The immediate and interim measures included fencing the clarifier area, installing a wind sock, installing Bird Balls™ to camouflage its surface and eliminate wildlife contact with the clarifier contents, installing a float valve to maintain the water cap over the crude phosphorus and installing a continuous phosphine gas monitoring system. These immediate and interim measures were completed before the respective deadlines under the 7003 Order.

Elemental phosphorus may generate some phosphine gas when it is in contact with water at high pH, temperature and agitation conditions. Rhodia installed the continuous phosphine monitoring system around the clarifier as required by the RCRA § 7003 Order and submits annual phosphine monitoring reports[1] to EPA. The time-weighted average values reported from the continuous monitoring for phosphine are typically 0.0 parts per million by volume (ppmv), below the EPA-approved action levels of 0.3 ppmv (8-hour time-weighted average) or 1.0 ppmv (15-minute short-term exposure limit). The detection limit is around 0.03 ppmv.

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[1] Monthly reports were submitted to U.S. EPA until the submittal schedule was changed to annual reporting as provided in the U.S. EPA's March 14, 2009 letter to Rhodia.

Phosphine has only been detected in these monitors on two occasions. The first event occurred when drums of soil cuttings containing elemental phosphorus were located near the northwest phosphine monitor immediately after installing monitoring well MW-01-3 in 2001. The second event occurred when crude phosphorus was being excavated from the clarifier for use in the pilot scale testing in 2011. The excavation operations were stopped and the phosphine concentrations decreased immediately.

The 7003 Order remains in effect, since, as stated in Section VI.B. of the 3008(h) Order, the 7003 Order is the mechanism to address investigation and closure matters regarding the clarifier. As such, this RFI Report will summarize the corrective measures that were completed and the environmental data that was collected under the 7003 Order, as well as the plan for follow-up data collection as part of the RFI.

5.5.2.2 Corrective Measures

The 7003 Order required Rhodia to develop a Waste Plan that evaluated alternatives for the lawful disposition of the contents of the clarifier, and at least one alternative that evaluated the lawful removal and disposal of the clarifier contents. The final Waste Plan was submitted to EPA on November 16, 2001 (Barr, 2001b). The Waste Plan identified three options that were considered feasible and were fully evaluated in the Waste Plan. The feasible options were: (1) a soil cap; (2) an enhanced cap with a multi-layer and multi-material cover; and (3) off-site incineration. The Waste Plan also identified processes that had been used to process similar materials at other elemental phosphorus production facilities, but the process equipment was not available. The production facilities had been shut down and the process equipment was demolished.

Rhodia and EPA agreed to further evaluate management options for the crude phosphorus through a multi-step treatability study process. The first step involved gathering all existing information for treatment of crude phosphorus solids. The second step involved developing a short list of technologies from Step 1 that are potentially feasible and merit further evaluation. The third step involved evaluation of the selected technology.

Rhodia submitted the report titled “Clarifier Waste Treatability Study, Phase 1 – Information Gathering” (Franklin Engineering Group, 2007) to EPA in October 2007. The report described several treatment and disposal options for the management of crude phosphorus, many of which were evaluated in the Waste Plan. Based on this report Rhodia, the Montana State Department of Environmental Quality (MDEQ), and the EPA agreed to further evaluate batch still technology similar to that developed by Albright and Wilson for evaporation and subsequent recovery of the elemental phosphorus. This technology was chosen because it:

- Has proven to be effective in processing similar materials
- Allows Rhodia to recover the elemental phosphorus contained in the clarifier
- Could be evaluated with pilot-scale equipment
- Reduces total volume of waste

The Clarifier Waste Treatability Study, Phase 2 Report, Pilot Plant Design and Testing describes the design of the pilot plant, and initial testing that was conducted to evaluate whether the system could volatilize the elemental phosphorus from the crude phosphorus and render the solids free of elemental phosphorus (Franklin Engineering Group, 2011a).

The initial testing conducted in 2010 demonstrated that the basic process, as designed, demonstrated a capability to safely vaporize and condense the elemental phosphorus contained in the clarifier material. Visually good elemental phosphorus was recovered from all three batches. The non-ignitable residue produced by one batch (run #2) remained hazardous due to leachable cadmium present in the still residue. The report concluded that additional evaluation was needed to evaluate whether the process can render the crude phosphorus residue to be non-hazardous.

Additional testing was conducted in 2011 as detailed in the report titled Clarifier Material Treatability Study, Phase 3 Report, Pilot Plant Operations describes the improvements to the system and the testing protocols that were conducted (Franklin Engineering Group, 2011b). The pilot plant demonstrated the ability to treat clarifier material and recover elemental phosphorus of useful quality from a variety of feed compositions. However, the solid residue in eight of the twelve tests was determined to be hazardous for cadmium. Therefore, additional treatment would be needed to render the solid residue non-hazardous for final disposal.

The next step in the process is to evaluate the overall feasibility of the distillation process including cost effectiveness of the process system. This information will be incorporated into a revised Waste Plan which will be submitted to EPA by the end of 2013.

5.5.2.3 Crude Phosphorus Characteristics

Crude phosphorus consists of elemental phosphorus (about 20% volume/volume [v/v]); water (about 30% [v/v]); and solids (about 50% [v/v]) such as phosphate dust, coke dust and silica dust. Two samples of crude phosphorus were analyzed for TCLP metals in February 1997. The analytical results are summarized in Table 5.5.2-1. The TCLP results indicate that the bulk crude phosphorus is not a characteristic waste for metals.

A sample of crude phosphorus was collected by EPA's contractor in 2003 and analyzed for metals, fluoride, elemental phosphorus, phosphorus (ortho and total), and gross alpha and beta. The analytical data is summarized in Tables 5.5.2-2 through 5.5.2-4 and the data is plotted on Figures 5.5.2-2 through 5.5.2-4. Data from SWMU 2 were compared to the background/reference area concentrations. Concentrations above the 95% upper confidence limit of the mean background/reference area concentrations are highlighted on the constituent delineation figures presented in this section. Where a 95% upper limit could not be calculated, the maximum detected concentration or the maximum detection limit was selected.

The crude phosphorus sample contained approximately 6.4% elemental phosphorus. This concentration is lower than Rhodia's estimated concentration likely because the sample was obtained from the upper level material overlying the solidified crude phosphorus in the clarifier. The concentration of elemental phosphorus is expected to be higher in the solidified portion of the clarifier. Gross alpha and gross beta were found at 720 pCi/g and 570 pCi/g, respectively (*see* Figure 5.5.2-3). Metals were also detected in the crude phosphorus sample (*see* Figure 5.5.2-4). Cadmium, chromium, lead and selenium were found at concentrations in excess of 20 times the respective hazardous characteristic standard.

The EPA also collected a sample of the water covering the crude phosphorus and analyzed this water sample for metals, fluoride, elemental phosphorus, phosphorus (ortho and total), and gross alpha and beta. The analytical data is summarized in Tables 5.5.2-5 through 5.5.2-7.

Phosphorus compounds including elemental phosphorus were reported in the water cap sample. Metals and radionuclides were present, but the concentrations are below drinking water levels.

5.5.2.4 Groundwater Monitoring Results

There is a documented release of water from the clarifier. The 7003 Order described a "leaking clarifier" based on an observation that water from the clarifier infiltrated into a hole dug in a wet area adjacent to the clarifier. After plant operations ceased in the late 1990s, groundwater has been added to maintain the water cap.

EPA required Rhodia to conduct pre-closure groundwater monitoring of the area near the clarifier under the 7003 Order. A Field Sampling Plan and Quality Assurance Project Plan (Sampling Plan)

(Barr, 2001a) for pre-closure groundwater monitoring at the clarifier was approved by EPA in a letter dated September 6, 2001. Three water table monitoring wells were installed at the clarifier in accordance with the Sampling Plan. MW-01-2 was installed upgradient (i.e., south) of SWMU 2, and MW-01-3 and MW-01-6 were installed downgradient of SWMU 2. Two additional wells (MW-02-1 and MW-02-2) were installed further downgradient of the clarifier to evaluate the potential transport of elemental phosphorus via groundwater. The monitoring well locations are shown in Figure 5.5.2-1b and the Monitoring Well Construction Logs are provided in Appendix 5.5.2-A. The Final Pre-closure Groundwater Monitoring Report (Barr 2002) provides the details of the groundwater monitoring program and the analytical laboratory reports prior to the RFI.

Three rounds of groundwater samples were collected during the pre-closure groundwater monitoring program and analyzed for general and site-specific parameters, metals, VOCs, SVOCs, and radionuclides. The results were summarized in the Final Pre-Closure Groundwater Monitoring Report (Barr 2002) and are also summarized in this report.

The SWMU 2 monitoring wells were included in the site-wide groundwater quality monitoring program included in the RFI Work Plan (Barr, 2009). A detailed and comprehensive discussion of site-wide groundwater quality is discussed in the Groundwater Quality Section (Section 5.3). Constituents of interest were outlined in Section 5.3 and only those with a potential source as the clarifier or TBWR areas will be discussed in this SWMU. The analytical results for the groundwater samples from SWMU 2 monitoring wells are summarized in Tables 5.5.2-8 through 5.5.2-13. Additionally, Figures 5.5.2-6 through 5.5.2-41 display the groundwater quality time-series plots for the general and site-specific parameters, metals and radionuclides. These parameters will be discussed in detail below.

5.5.2.4.1 General and Site-Specific Parameters

Fluoride

Non-detect values were recorded at two of the five wells, MW-01-6 and MW-02-1, surrounding SWMU 2. At all of the wells, except for MW-02-1, concentrations of fluoride have increased with time (*see* Figure 5.5.2-6). At MW-01-2, fluoride increased from 4.06 mg/L in 2001 to 7.8 mg/L in 2008. At MW-01-3, fluoride increased from 0.75 mg/L in 2001 to 1.2 mg/L in 2008. At MW-01-6, fluoride increased from 0.73 mg/L in 2001 to 2.2 mg/L in 2008. At MW-02-2, fluoride increased from 5.14 mg/L in 2002 to 7.6 mg/L in 2008. SWMU 2 may be an ongoing source of fluoride to groundwater, or it is possible that increasing fluoride concentrations may be a function of the dissolution of soluble fluoride complexes, as discussed in Section 5.3.2.2.1.

Elemental Phosphorus

Elemental phosphorus was not detected in MW-01-2, MW-02-1, and MW-02-2, except in September of 2002, when concentrations of 0.00045 J mg/L and 0.00019 J mg/L were reported at MW-02-1 and MW-02-2, respectively. These data points were “J”-qualified, indicating that the value is less than the stated laboratory quantification limit and are considered estimated values. Elemental phosphorus was detected at MW-01-3 and MW-01-6 with average concentrations of 0.791 mg/L and 0.002 mg/L, respectively. The highest elemental phosphorus concentration (i.e., 1.6 mg/L) was found in a sample collected from MW-01-3 in 2002 (*see* Figure 5.5.2-7). Elemental phosphorus concentrations MW-01-6 do not indicate increasing or decreasing trend, however elemental phosphorus concentrations at MW-01-3 are strongly decreasing with time.

Total Phosphorus

Total phosphorus was detected in groundwater sampled from all of the wells around SWMU 2. Of those, four wells indicate decreasing concentrations with time. At MW-01-2, total phosphorus decreased from 25.3 mg/L in 2001 to 17.0 mg/L in 2008. At MW-01-3, total phosphorus decreased from 128 mg/L in 2001 to 68.6 mg/L in 2008. At MW-01-6, total phosphorus decreased from 234 mg/L in 2001 to 91.4 mg/L in 2008. At MW-02-1, total phosphorus decreased from 17.6 mg/L in 2002 to 1.3 mg/L in 2008. Concentrations of total phosphorus at MW-02-2 are generally stable from 2002 to 2008 (*see* Figure 5.5.2-8). SWMU 2 is a likely source of total phosphorus to the groundwater: total phosphorus concentrations are higher downgradient of the clarifier and the total phosphorus analysis of groundwater samples likely detects the presence of phosphates resulting from the attenuation of elemental phosphorus in groundwater (*see* Appendix 5.3-C).

Sulfate

Sulfate concentrations were detected in all of the samples collected at SWMU 2. Sulfate concentrations in groundwater are slightly higher in the downgradient wells (MW-01-03, MW-01-6, and MW-02-2) than the upgradient well (MW-01-2). Sulfate concentrations are decreasing in four of the wells. At MW-01-2, sulfate decreased from 403 mg/L in 2001 to 238 mg/L in 2008. At MW-01-3, sulfate decreased from 486 mg/L in 2001 to 246 mg/L in 2008. At MW-01-6, sulfate decreased from 482 mg/L in 2001 to 271 mg/L in 2008. At MW-02-2, sulfate decreased from 392 mg/L in 2002 to 240 mg/L in 2008. However, sulfate concentrations increased at MW-02-1 from 984 mg/L in 2002 to 1350 mg/L in 2008 (*see* Figure 5.5.2-9). As MW-02-1 is located farther downgradient of SWMU-2, this increase in sulfate may be to another source within the phosphorus production area, rather than SWMU 2.

5.5.2.4.2 Metals

Antimony

Total antimony was detected in nine of the 17 samples with concentrations ranging from not detected at 0.0005 mg/L to 0.003 mg/L. The detection limits from the 2001 and 2002 analyses are much higher than the more recent detected concentrations, making time series evaluation of the data difficult (*see* Figures 5.5.2-10 and 5.5.2-11).

Arsenic

Total and dissolved arsenic were detected in groundwater samples from the five wells surrounding SWMU 2. Generally, intra-well total and dissolved arsenic concentrations appear stable (*see* Figures 5.5.2-12 and 5.5.2-13). It is possible that the clarifier has impacted downgradient arsenic concentrations; however, the groundwater data do not indicate attenuation of impacted groundwater.

Barium

Total and dissolved barium were detected in groundwater from all five wells. The highest detected concentration for dissolved barium was 0.082 mg/L at MW-02-1. The highest total concentration was 0.0425 mg/L at MW-02-1, as well. Both total and dissolved barium concentrations appear to be stable or decreasing with time (*see* Figures 5.5.2-14 and 5.5.2-15).

Beryllium

Total beryllium was detected in groundwater samples from all five wells. Of the 10 dissolved and 15 total samples analyzed, beryllium was not detected in eight of the dissolved samples and four of the total samples. The highest dissolved concentration was 0.002 mg/L and the highest total concentration was 0.03 mg/L, both from MW-01-3. No trend is visible for dissolved or total beryllium due to limited detected concentrations (*see* Figures 5.5.2-16 and 5.5.2-17).

Cadmium

Total and dissolved cadmium were detected in groundwater samples from the five wells. Concentrations were below the limits of detection in 15 of the 27 samples. Generally, intra-well total and dissolved cadmium concentrations appear to be stable (*see* Figures 5.5.2-18 and 5.5.2-19).

Chromium

Total and dissolved chromium were detected in groundwater samples from all five wells. Chromium was not detected in seven of ten samples analyzed for the dissolved fraction and six of fifteen samples analyzed for total concentrations. The highest dissolved chromium concentration was 0.005 mg/L and the highest total chromium concentration was 0.008 mg/L, both at MW-01-3. Total chromium concentrations at MW-01-2 and MW-01-6 appear to be decreasing or stable, while it is difficult to discern trends in chromium concentrations at the other wells due to limited detected concentrations (*see* Figures 5.5.2-20 and 5.5.2-21).

Cobalt

Total cobalt was detected in groundwater samples from all five wells. Dissolved cobalt was detected in groundwater samples MW-01-3 and MW-01-6. Although the total cobalt concentration increased from the upgradient well (MW-01-2) to the wells immediately downgradient of the clarifier (MW-01-6, MW-01-3, and MW-02-2), the intra-well total cobalt concentrations are decreasing over time, most notably in the downgradient wells MW-01-6 and MW-01-3 (*see* Figures 5.5.2-22 and 5.5.2-23).

Manganese

Total and dissolved manganese were detected in groundwater samples from all five wells. Manganese concentrations are higher in wells downgradient of SWMU 2 than in the upgradient well. The highest dissolved concentration was 12.5 mg/L and the highest total concentration was 13.1 mg/L, both at MW-01-3. These concentrations are generally an order of magnitude higher than the other wells at SWMU 2. In general, both total and dissolved manganese concentrations have decreased in time at the SWMU 2 wells (*see* Figures 5.5.2-24 and 5.5.2-25).

Nickel

Total and dissolved nickel was detected in groundwater samples from all five wells. The highest dissolved nickel concentration was 0.0436 mg/L at MW-02-1, which was a "BQQ"–qualified value. The next highest dissolved concentration without a BQQ qualification was 0.02 mg/L at MW-01-6. The highest total nickel concentration was 0.0420 mg/L at MW-02-1. Samples were not analyzed for dissolved nickel in 2008, so it is difficult to assess trends in those data. However, concentrations of total nickel at MW-01-2, MW-01-3, MW-01-6, and MW-02-1 appear to be decreasing over time (*see* Figures 5.5.2-26 and 5.5.2-27).

Selenium

Total and dissolved selenium were detected in groundwater samples from all five wells. Two of 13 samples analyzed for dissolved selenium and nine of 15 samples analyzed for total selenium had concentrations below the detection limit. The highest dissolved concentration was 0.009 mg/L and the highest total concentration was 0.0149 mg/L, both at MW-02-2. Samples were not analyzed for dissolved selenium in 2008, so it is difficult to assess trends in those data. However, total selenium concentrations appear to be stable. Samples were not analyzed for dissolved selenium in 2008, so it is difficult to assess trends in those data (*see* Figures 5.5.2-28 and 5.5.2-29).

Silver

Total and dissolved silver were rarely detected in groundwater samples from these wells, and were never detected at concentrations higher than the detection limits at MW-01-3 and MW-01-6. The highest detected total silver concentration was 0.0001 mg/L at MW-02-2. Dissolved silver was not analyzed in MW-02-2. Because silver was rarely detected at concentration exceeding the detection limits, trends in the data are not apparent (*see* Figures 5.5.2-30 and 5.5.2-31).

Thallium

Total thallium was detected in groundwater sampled from all five wells, while dissolved thallium was not detected above detection limits at MW-01-3, MW-01-6, or MW-02-1 (dissolved thallium was not analyzed on samples from MW-02-2). Dissolved thallium was only detected in samples from MW-01-2 and were "J"-qualified; the highest concentration was 0.00007 mg/L. The highest detected concentration for total thallium was 0.0001 mg/L at MW-01-6. As thallium concentrations were rarely recorded above the detection limits, no trends are apparent in the data (*see* Figures 5.5.2-32 and 5.5.2-33).

Uranium

Total uranium was detected in groundwater samples from all five wells, while dissolved uranium was not detected above detection limits at MW-01-3, MW-01-6, or MW-01-2 (dissolved uranium was not analyzed on samples from MW-02-2). The highest detected concentration for dissolved uranium was 0.0047 mg/L at MW-02-1, and the highest concentration of total uranium was 0.00455 mg/L, also at MW-02-1. Trends within these data are not apparent due to limited detected concentrations (*see* Figures 5.5.2-34 and 5.5.2-35).

Vanadium

Total vanadium was detected in groundwater samples from MW-01-2, MW-01-3, MW-01-6, and MW-02-2. Dissolved vanadium concentrations were not detected above the detection limits at any wells, except at MW-01-2, where samples had "BQQ" qualified values of 0.0045 mg/L. No trends are apparent in the vanadium data set (*see* Figures 5.5.2-36 and 5.5.2-37).

Zinc

Total and dissolved zinc were detected in groundwater samples from all five wells. The highest dissolved zinc concentration was 0.99 mg/L and the highest total zinc concentration was 0.902 mg/L, both at MW-01-6. Samples were not analyzed for dissolved zinc in 2008, so it is difficult to assess trends in those data. Total zinc concentrations are variable with respect to zinc concentrations (*see* Figures 5.5.2-38 and 5.5.2-39).

5.5.2.4.3 SVOCs

The analytical results for the SVOCs included in the SWMU 2 data set are summarized in Table 5.5.3-10. The majority of SVOCs detected in the SWMU 2 groundwater samples belong to a subgroup of SVOCs known as polynuclear aromatic hydrocarbons (PAHs). These multi-benzene-ringed compounds are naturally present in coke, which was used in the furnaces to scavenge oxygen and creating the reducing environment necessary to generated elemental phosphorus. Crude phosphorus contains some fraction of coke fines. The SVOC concentrations were not plotted on maps because the SVOCs were not detected in sufficient samples to gain any insight from a graphical presentation.

PAHs compounds were routinely detected in samples collected immediately downgradient of the clarifier (i.e., MW-01-3 and MW-01-6). The detected concentrations are J-qualified indicating that the concentrations are below the method reporting limit, but above the method detection limit. PAH compounds were not detected in samples collected from the next downgradient well (i.e., MW-02-2) indicating that these PAH compounds are attenuated along the groundwater flow path.

Common lab contaminants (bis(2-ethylhexyl)phthalate and diethyl phthalate) were also detected in a few groundwater samples from SWMU 2.

O-cresol and p-cresol were detected in samples from MW-01-6 and pentachlorophenol was detected in one of two samples from MW-02-2. These parameters were not detected in the further down gradient well (MW-02-1).

Inspection of the data suggests that the detected concentrations are not above drinking water standards. The data will be evaluated in the risk assessment in order to draw conclusions whether these constituents require further evaluation.

5.5.2.4.4 VOCs

The analytical results for the VOCs included in the SWMU 2 data set are summarized in Table 5.5.2-11. The majority of the VOCs detected in the groundwater samples are J-qualified indicating that the concentrations are below the method reporting limit, but above the method detection limit. The VOC concentrations were not plotted on maps because the VOCs were not detected in sufficient samples to gain any insight from a graphical presentation.

1,2,4-trimethylbenzene was detected in two of two samples from MW-01-6. 1,2,4-trimethylbenzene was not detected in the samples collected in 2008 from the further downgradient wells (MW-02-2 and MW-01-2). 1,2,4-trimethylbenzene was reported at 0.012 mg/L in the January 2002 sample from MW-01-2, but was not detected (DL = 0.00037 mg/L) in the samples collected in 2008.

Samples from MW-02-1 contain other VOCs that are commonly associated with petroleum such as 1,3,5-trimethylbenzene, butylbenzene, sec-butylbenzene, tert-butylbenzene, isopropyl benzene, propyl benzene. These VOCs were only detected in samples from MW-02-1 and indicate a source other than the clarifier. These VOCs are related to a release from an above-ground diesel storage tank that was located north of the clarifier (*see* Section 5.5.28.1).

VOCs detected in more than one sample from the wells at the downgradient edge of the clarifier include acetone, benzene, chloromethane, ethylbenzene, toluene, and o-, m-, & p- xylenes. These compounds were not detected in samples from the further downgradient wells. These VOCs are not migrating a significant distance from the clarifier and are attenuated along the groundwater flow path. Inspection of the data suggests that the detected concentrations are not above drinking water standards. The data will be evaluated in the risk assessment in order to draw conclusions whether these constituents require further evaluation.

5.5.2.4.5 Radionuclides

Gross Alpha

Gross alpha activities were detected in 17 of the 25 groundwater samples with activities ranging from not detected at 1 pCi/L to 6.5 ± 1.9 pCi/L. Concentrations are variable at the well locations, and significant trends are not evident in the gross alpha data set (*see* Figure 5.5.2-40).

Gross Beta

In general, gross beta activities immediately downgradient of the clarifier are decreasing over time (*see* Figure 5.5.2-41). At MW-01-3, gross beta decreases from 50 ± 5.0 pCi/L in 2001 to 33 ± 4.6 pCi/L in 2008 and at MW-01-6, gross beta decreases from 63 ± 6.3 pCi/L in 2001 to 39 ± 5.6 pCi/L in 2008. Gross beta activities upgradient (MW-01-2) and further downgradient (MW-02-2 and MW-02-1) are appear to be stable.

5.5.2.4.6 PCBs

The analytical results for the PCBs included in the data set are summarized in Table 5.5.2-13. PCBs were not detected in any groundwater samples from the SWMU 2 monitoring wells.

5.5.2.5 Conclusions

The clarifier is a 100-foot diameter concrete unit partially recessed in the ground that contains approximately 500,000 gallons of crude phosphorus covered by a water cap. The crude phosphorus consists of elemental phosphorus (about 20% v/v); water (about 30% v/v); and solids (about 50% v/v) such as phosphate dust, coke dust and silica dust.

Rhodia has conducted pilot scale testing to evaluate the technical feasibility of a distillation process to volatilize the elemental phosphorus from the crude phosphorus and render the solids free of elemental phosphorus. The initial testing demonstrated that the basic process, as designed, demonstrated a capability to vaporize and condense the elemental phosphorus contained in the clarifier material. Visually good elemental phosphorus was recovered. The non-ignitable residue produced by some batches remained hazardous due to leachable cadmium present in the residue. The next step in the treatability process is to evaluate the overall feasibility of the distillation process including cost effectiveness of the process system.

Although it is clear that process water has leaked from the clarifier, no distinct trends in groundwater parameter concentrations are observed at this site over time. Only fluoride concentrations appear to be increasing over time. Alternatively, total phosphorus, sulfate, total and dissolved barium, total cobalt, total and dissolved manganese, and total nickel exhibit decreasing trends over time.

PAH compounds were routinely detected in samples collected immediately downgradient of the clarifier (i.e., MW-01-3 and MW-01-6). These compounds were not detected in samples collected from the next downgradient well (i.e., MW-02-2) indicating that these PAH compounds are attenuated along the groundwater flow path.

As with the PAH compounds, certain VOCs were detected in samples collected immediately downgradient of the clarifier (i.e., MW-01-3 and MW-01-6). These compounds were not detected in samples from the further downgradient wells. These VOCs are not migrating a significant distance from the clarifier and are attenuated along the groundwater flow path.

VOCs detected at the furthest downgradient well (MW-02-1) are related to a release from an above-ground diesel storage tank that was located north of the clarifier.

There is sufficient information to conduct the risk assessment for this SWMU. The risk assessment will identify which parameters, if any, are present at concentrations that warrant corrective measures.

The dataset would be reviewed at that time and additional sampling may be necessary to inform the corrective measures study or later during the corrective measures design phase.

5.5.2.6 References

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Tables

Table 5.5.2-1

Crude Phosphorus TCLP Data Summary
Rhodia Silver Bow Plant

[concentrations in mg/L]

Station ID: Crude P4

Dates	Sample ID	Arsenic, TCLP	Barium, TCLP	Cadmium, TCLP	Chromium, TCLP	Lead, TCLP	Mercury, TCLP	Selenium, TCLP	Silver, TCLP
2/27/1997	Sludge #1	0.5 U	10 U	0.1 U	0.5 U	0.5 U	0.02 U	0.1 U	0.5 U
2/27/1997	Sludge #2	0.5 U	10 U	0.1 U	0.5 U	0.5 U	0.02 U	0.1 U	0.5 U

Table 5.5.2-2
Crude Phosphorus Data - General and Site-Specific Parameters
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/kg]

		Chemical Name	Fluoride	Orthophosphate as P	Phosphorus, elemental (white)	Phosphorus, total
Location ID	**Sample Date**	**Sample Type**				
ESI-CLW-1	07/15/2003	N	**600**	**2300**	**6460 J**	**360000**

Table 5.5.2-3
Crude Phosphorus Data - Metals
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/kg]

		Chemical Name Analysis Location	Aluminum Lab	Antimony Lab	Arsenic Lab	Barium Lab	Beryllium Lab	Cadmium Lab	Calcium Lab	Chromium Lab	Cobalt Lab	Copper Lab	Iron Lab	Lead Lab	Magnesium Lab	Manganese Lab	Mercury Lab	Nickel Lab	Potassium Lab	Selenium Lab	Silver Lab	Sodium Lab	Thallium Lab	Vanadium Lab	Zinc Lab
Location ID	**Sample Date**	**Sample Type**																							
ESI-CLW-1	07/15/2003	N	**445**	**201 ***	**86.2 ***	**10.4 B**	< 0.21	**271 ***	**15100 ***	**499 ***	**45.9**	**290 ***	**3900 ***	**1050 ***	**202 B**	**43.0 ***	**1.8**	**2790**	**627 B**	**29.1 ***	**275**	**284 B**	**33.0**	**98.1 ***	**16200 ***

Table 5.5.2-4
Crude Phosphorus Data - Radionuclides
SWMU 2
Rhodia Silver Bow Plant

[concentrations in pCi/g]

		Chemical Name	Gross Alpha (radiation)	Gross Beta (radiation)
Location ID	**Sample Date**	**Sample Type**		
ESI-CLW-1	07/15/2003	N	**720 +/- 20**	**570 +/- 8.9**

Table 5.5.2-5
Clarifier Water Cap Data - General and Site-Specific Parameters
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name	Fluoride	Phosphate as P	Phosphorus, elemental (white)	Phosphorus, total
Location ID	**Sample Date**	**Sample Type**				
ESI-CLWC-1	07/15/2003	N	**1.7**	**1.6**	**0.0452**	**4.9**

Table 5.5.2-6
Clarifier Water Cap Data - Metals
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

		Chemical Name Analysis Location	Aluminum Lab	Antimony Lab	Arsenic Lab	Barium Lab	Beryllium Lab	Cadmium Lab	Calcium Lab	Chromium Lab	Cobalt Lab	Copper Lab	Iron Lab	Lead Lab	Magnesium Lab	Manganese Lab	Mercury Lab	Nickel Lab	Potassium Lab	Selenium Lab	Silver Lab	Sodium Lab	Thallium Lab	Vanadium Lab	Zinc Lab
Location ID	**Sample Date**	**Sample Type**																							
ESI-CLWC-1	07/15/2003	N	< 0.0278	< 0.0314	**0.0058 B**	**0.0151 B**	< 0.00033	**0.0010 B**	**136**	< 0.0034	< 0.0080	**0.0087 B**	**0.0676 B**	< 0.0029	**25.7**	**0.0116 B**	< 0.00010	< 0.0108	**16**	**0.0043 B**	< 0.0043 *	**50.7**	**0.0050 BQQ**	**0.0050 B**	**0.0344**

Table 5.5.2-7
Clarifier Water Cap Data - Radionuclides
SWMU 2
Rhodia Silver Bow Plant

[concentrations in pCi/l]

		Chemical Name	Cesium 137	Gross Alpha (radiation)	Gross Beta (radiation)	Radium 226
Location ID	Sample Date	Sample Type				
ESI-CLWC-1	07/15/2003	N	< 60.1	< 3.44	**13.5 +/- 38.0**	< 1.45

Table 5.5.2-8
Groundwater Quality - General and Site Specific Parameters
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

Location ID	Sample Date	Sample Type	2-Ethylhexanoic acid	Alkalinity, bicarbonate, as CaCO3	Alkalinity, carbonate, as CaCO3	Chloride	Fluoride	Nitrate + Nitrite, as N	Nitrogen, ammonia (NH3), as N	Orthophosphate, as PO4	Phosphate, as P	Phosphorus, elemental (white)	Phosphorus, total	Sulfate
MW-01-2	10/9/2001	N	--	--	--	**107**	**4.06**	**1.61**	**1.20**	**24.3 h**	--	< 0.000004	**25.3**	**403**
MW-01-2	1/16/2002	N	--	--	--	**115**	**3.74**	--	--	**29.8**	--	< 0.0000040	**26.0 h**	**417**
		SPLIT	--	--	--	--	**4.09**	**3.02**	**1.3**	**23**	--	< 0.00050	**32**	**473**
MW-01-2	9/4/2002	N	--	--	--	--	**5.56**	--	--	**15.8**	--	< 0.0005	**16.3**	**342**
MW-01-2	7/22/2003	N	--	--	--	--	**6.7**	--	--	--	**22**	< 0.0001	**13**	--
		FD	--	--	--	--	**6.7**	--	--	--	**23**	< 0.0001	**12**	--
MW-01-2	5/19/2008	N	--	**44**	< 2	**82**	**10.5**	**1.89**	**0.43**	--	--	< 0.0000234	**18.7**	**257**
MW-01-2	9/22/2008	N	--	**53**	< 2	**112**	**7.8**	**1.95**	**0.31**	--	--	**0.000441 R**	**17.0**	**238**
MW-01-2	12/16/2008	N	--	--	--	--	--	--	--	--	--	< 0.0000234	--	--
MW-01-3	10/9/2001	N	--	--	--	**126**	**0.75**	< 0.01	**1.01**	**97.4 h**	--	**0.403**	**128**	**486**
MW-01-3	1/22/2002	N	--	--	--	**133**	**0.98**	< 0.05	**1.0**	**66.3**	--	**0.250**	**54 h**	**489**
		FD	--	--	--	**131**	**0.98**	< 0.05	**1.0**	**64.3**	--	**0.3710**	**58 h**	**490**
		SPLIT	--	--	--	--	**1.09**	--	--	**36**	--	**1.600**	**71**	**524**
		FD SPLIT	--	--	--	--	**1.00**	--	--	**36**	--	**1.610**	**70**	**520**
		FDD SPLIT	**523**	--	--	--	**1.14**	--	--	**36**	--	--	**84**	--
MW-01-3	9/5/2002	N	--	--	--	--	**0.90**	--	--	**55.0**	--	**1.21**	**59**	**412**
		FD	--	--	--	--	**0.90**	--	--	**55.7**	--	**1.3**	**61**	**411**
MW-01-3	5/19/2008	N	--	**28**	< 2	**68**	**1.1**	**0.74**	**0.70**	--	--	**0.513**	**94.5**	**227**
MW-01-3	9/19/2008	N	--	**28**	< 2	**69.2**	**1.2**	**0.82**	**0.74**	--	--	**0.290**	**68.6**	**246**
MW-01-3	12/16/2008	N	--	--	--	--	--	--	--	--	--	**0.366**	--	--
MW-01-6	10/9/2001	N	--	--	--	**126**	**0.73**	< 0.01	**3.79**	**84.5 h**	--	**0.00250**	**234**	**482**
MW-01-6	1/17/2002	N	--	--	--	**134**	**1.32**	< 0.05	**3.8**	**134**	--	< 0.000660	**271 h**	**443**
		SPLIT	--	--	--	--	**1.59**	--	--	**120**	--	**0.00272**	**420**	**503**
MW-01-6	9/5/2002	N	--	--	--	--	**1.64**	--	--	**131**	--	**0.00413**	**238**	**450**
MW-01-6	5/19/2008	N	--	< 2	< 2	**77**	< 10	< 0.05	**2.85**	--	--	**0.00121**	**169**	**249**
MW-01-6	9/18/2008	N	--	**2**	< 2	**78.7**	**2.2**	< 0.05	**2.71**	--	--	< 0.0000234	**91.4**	**271**
MW-02-2	9/5/2002	N	--	--	--	--	**5.14**	--	--	**32.5**	--	**0.00019 J**	**36.0**	**392**
MW-02-2	5/19/2008	N	--	**21**	< 2	**76**	**7.9**	**1.29**	**0.06**	--	--	< 0.0000234	**42.1**	**240**
MW-02-2	9/22/2008	N	--	**21**	< 2	**83**	**7.6**	**1.48**	< 0.05	--	--	**0.000382 R**	**54.5**	**240**
MW-02-2	12/15/2008	N	--	--	--	--	--	--	--	--	--	< 0.0000234	--	--
MW-02-1	1/17/2002	N	--	--	--	**237**	**0.19**	**0.06**	< 0.1	**28.5**	--	< 0.0000040	**17.6 h**	**984**
		SPLIT	--	--	--	--	**0.24**	--	--	**17**	--	< 0.00050	**19**	**1030**
MW-02-1	9/4/2002	N	--	--	--	--	**0.20**	--	--	**17.4**	--	**0.00045 J**	**19.2**	**1020**
MW-02-1	7/22/2003	N	--	--	--	--	< 1.0	--	--	--	**4.1**	< 0.0001	**7.9**	--
MW-02-1	5/29/2008	N	--	**222**	< 2	**251**	< 1.0	< 0.05	< 0.05	--	--	< 0.0000234	**4.56**	**1200**
		FD	--	**223**	< 2	**251**	< 1.0	< 0.05	**0.05**	--	--	< 0.0000234	**4.41**	**1210**
MW-02-1	9/26/2008	N	--	**218**	< 2	**308**	< 1.0	< 0.05	< 0.05	--	--	< 0.0000234	**1.30**	**1350**

Table 5.5.2-9
Groundwater Quality - Metals
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name Analysis	Aluminum Dissolved	Aluminum Total	Antimony Dissolved	Antimony Total	Arsenic Dissolved	Arsenic Total	Barium Dissolved	Barium Total	Beryllium Dissolved	Beryllium Total	Cadmium Dissolved	Cadmium Total	Calcium Dissolved	Calcium Total	Chromium Dissolved	Chromium Total	Cobalt Dissolved	Cobalt Total	Copper Dissolved	Copper Total	Iron Dissolved	Iron Total
Location ID	**Sample Date**	**Sample Type**																						
MW-01-2	10/9/2001	N	--	--	< 0.003	< 0.003	**0.019**	**0.019**	**0.026**	**0.030**	< 0.001	< 0.001	**0.0009**	**0.0014**	**134**	**152**	**0.001**	**0.002**	< 0.01	< 0.01	**0.004**	**0.005**	< 0.01	< 0.01
MW-01-2	10/10/2001	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-01-2	1/16/2002	N	--	--	< 0.003	--	**0.023**	--	**0.032**	--	< 0.001	--	< 0.001	--	**148**	--	< 0.001	--	< 0.01	--	**0.003**	--	< 0.03	--
		SPLIT	--	--	< 0.003	--	**0.021**	--	**0.029**	--	< 0.001	--	**0.0007**	--	--	--	< 0.001	--	< 0.01	--	< 0.001	--	< 0.01	--
MW-01-2	9/4/2002	N	--	--	--	--	**0.015**	--	< 0.1	--	--	--	< 0.001	--	--	--	--	--	--	--	--	--	< 0.03	--
MW-01-2	7/22/2003	N	**0.419 BQQ**	**0.64**	**0.00044 J**	< 0.0020	**0.0137 BQQ**	**0.0136**	**0.0204 BQQ**	**0.0256**	**0.00049 J**	**0.00062 J**	**0.0011 BQQJ**	**0.0010**	--	--	< 0.0020	**0.0014 J**	**0.0037 BQQ**	**0.0034**	**0.0026 BQQJ**	**0.0030 J**	--	--
		FD	**0.418 BQQ**	**0.715**	**0.00039 J**	< 0.0020	**0.0134 BQQ**	**0.0123**	**0.0202 BQQ**	**0.0259**	**0.00057 J**	**0.00047 J**	**0.00094 J**	**0.00081 J**	--	--	< 0.0020	**0.00062 J**	**0.0035 BQQ**	**0.0033**	**0.0026 BQQJ**	**0.0052 J**	--	--
MW-01-2	5/19/2008	N	--	--	--	**0.00036**	--	**0.0206**	--	**0.0145**	--	**0.00061**	--	**0.00101**	--	**104**	--	< 0.0002	--	**0.00261**	--	**0.0030 J**	--	**0.02**
MW-01-2	9/22/2008	N	--	--	--	**0.00026**	--	**0.0191**	--	**0.01892**	--	**0.00036**	--	**0.00138**	--	**103**	--	**0.0003**	--	**0.00217**	--	**0.0026**	--	**0.320**
MW-01-3	10/9/2001	N	--	--	< 0.003	< 0.003	**0.030**	**0.037**	**0.073**	**0.100**	**0.002**	**0.003**	**0.0009**	**0.0010**	**185**	**192**	**0.005**	**0.008**	**0.08**	**0.10**	**0.002**	**0.010**	**7.61**	**10.0**
MW-01-3	1/22/2002	N	--	--	< 0.003	--	**0.016**	--	**0.064**	--	< 0.001	--	**0.0006**	--	**174**	--	< 0.001	--	**0.05**	--	**0.001**	--	**3.30**	--
MW-01-3	1/22/2002	FD	--	--	< 0.003	--	**0.016**	--	**0.065**	--	< 0.001	--	**0.0005**	--	**173**	--	< 0.001	--	**0.05**	--	**0.001**	--	**3.34**	--
		SPLIT	--	--	< 0.003	--	**0.014**	--	**0.053**	--	< 0.001	--	**0.0005**	--	--	--	< 0.001	--	**0.04**	--	< 0.001	--	**3.08**	--
		FD SPLIT	--	--	< 0.003	--	**0.014**	--	**0.055**	--	< 0.001	--	**0.0011**	--	--	--	< 0.001	--	**0.04**	--	< 0.001	--	**3.02**	--
		FDD SPLIT	--	--	< 0.003	--	**0.014**	--	**0.054**	--	< 0.001	--	**0.0006**	--	--	--	< 0.001	--	**0.04**	--	< 0.001	--	**3.03**	--
MW-01-3	9/5/2002	N	--	--	--	--	**0.015**	--	< 0.1	--	--	--	< 0.001	--	--	--	--	--	--	--	--	--	**1.97**	--
		FD	--	--	--	--	**0.015**	--	< 0.1	--	--	--	< 0.001	--	--	--	--	--	--	--	--	--	**1.96**	--
MW-01-3	5/19/2008	N	--	--	--	**0.00014**	--	**0.0166**	--	**0.0339**	--	**0.00006**	--	**0.00020**	--	**107**	--	**0.0002**	--	**0.0188**	--	**0.0034 J**	--	**1.02**
MW-01-3	9/19/2008	N	--	--	--	**0.00017**	--	**0.0177**	--	**0.0305**	--	**0.000099**	--	**0.00018**	--	**103**	--	< 0.00020	--	**0.0154**	--	**0.015536**	--	**0.67**
MW-01-6	10/9/2001	N	--	--	< 0.003	< 0.003	**0.009**	**0.009**	**0.009**	**0.017**	< 0.001	< 0.001	< 0.0006	< 0.0006	**212**	**229**	< 0.001	**0.001**	**0.04**	**0.04**	**0.004**	**0.005**	**15.9**	**18.0**
MW-01-6	10/10/2001	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-01-6	1/17/2002	N	--	--	< 0.003	--	**0.012**	--	**0.008**	--	< 0.001	--	< 0.001	--	**231**	--	< 0.001	--	**0.02**	--	< 0.001	--	**33.7**	--
		SPLIT	--	--	< 0.003	--	**0.011**	--	**0.007**	--	< 0.001	--	< 0.0001	--	--	--	< 0.001	--	**0.02**	--	< 0.001	--	**36.6**	--
MW-01-6	9/5/2002	N	--	--	--	--	**0.009**	--	< 0.1	--	--	--	< 0.001	--	--	--	--	--	--	--	--	--	**36.0**	--
MW-01-6	5/19/2008	N	--	--	--	< 0.00005	--	**0.0112**	--	**0.00980**	--	**0.00006**	--	< 0.00002	--	**134**	--	< 0.0002	--	**0.0116**	--	**0.0086 J**	--	**23.2**
MW-01-6	9/18/2008	N	--	--	--	**0.00005**	--	**0.0115**	--	**0.0166**	--	**0.000176**	--	**0.00002**	--	**127**	--	< 0.00031	--	**0.0087**	--	**0.061445**	--	**23.4**
MW-02-2	9/5/2002	N	--	--	--	--	**0.031**	--	< 0.1	--	--	--	**0.005**	--	--	--	--	--	--	--	--	--	< 0.03	--
MW-02-2	5/19/2008	N	--	--	--	**0.00013**	--	**0.0453**	--	**0.0186**	--	**0.00039**	--	**0.00371**	--	**102**	--	**0.0003**	--	**0.00753**	--	**0.0016 J**	--	**0.527**
MW-02-2	9/22/2008	N	--	--	--	**0.00012**	--	**0.0515**	--	**0.02268**	--	**0.00034**	--	**0.00353**	--	**111**	--	**0.0003**	--	**0.00705**	--	**0.0021**	--	**0.91**
MW-02-1	1/17/2002	N	--	--	< 0.003	--	**0.008**	--	**0.082**	--	< 0.001	--	< 0.001	--	**265**	--	**0.003**	--	< 0.01	--	< 0.001	--	**0.16**	--
		SPLIT	--	--	< 0.003	--	**0.008**	--	**0.075**	--	< 0.001	--	< 0.0001	--	--	--	**0.002**	--	< 0.01	--	< 0.001	--	**0.13**	--
MW-02-1	9/4/2002	N	--	--	--	--	**0.007**	--	< 0.1	--	--	--	< 0.001	--	--	--	--	--	--	--	--	--	**0.80**	--
MW-02-1	7/22/2003	N	< 0.0300	**0.0162 J**	**0.00016 J**	< 0.0020	**0.0025 BQQ**	**0.0039**	**0.0403 BQQ**	**0.0425**	< 0.0010	< 0.0010	< 0.0010	**0.00012 J**	--	--	< 0.0020	**0.00063 J**	**0.0076 BQQ**	**0.0066**	**0.0046 BQQJ**	**0.0059 J**	--	--
MW-02-1	5/29/2008	N	--	--	--	< 0.00005	--	**0.0044**	--	**0.0293**	--	**0.00004**	--	**0.00003**	--	**324**	--	< 0.0002	--	**0.00185**	--	< 0.0030	--	**2.29**
		FD	--	--	--	**0.00005**	--	**0.0047**	--	**0.0286**	--	**0.00005**	--	< 0.00002	--	**325**	--	< 0.0002	--	**0.00194**	--	< 0.0026	--	**2.41**
MW-02-1	9/26/2008	N	--	--	--	< 0.00025	--	**0.0055**	--	**0.0339**	--	< 0.00010	--	< 0.00010	--	**376**	--	< 0.0010	--	**0.0025**	--	**0.0087**	--	**9.51**

Table 5.5.2-9
Groundwater Quality - Metals
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

Chemical Name Analysis			Lead Dissolved	Lead Total	Magnesium Dissolved	Magnesium Total	Manganese Dissolved	Manganese Total	Mercury Dissolved	Mercury Total	Nickel Dissolved	Nickel Total	Potassium Dissolved	Potassium Total	Selenium Dissolved	Selenium Total	Silver Dissolved	Silver Total	Sodium Dissolved	Sodium Total	Strontium Lab	Thallium Dissolved	Thallium Total
Location ID	**Sample Date**	**Sample Type**																					
MW-01-2	10/9/2001	N	< 0.002	< 0.002	**25**	**28**	**2.73**	**3.06**	< 0.0006	< 0.0006	< 0.01	< 0.01	**29**	**35**	**0.006**	**0.007**	< 0.003	< 0.003	**43**	**47**	--	< 0.002	< 0.002
MW-01-2	10/10/2001	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-01-2	1/16/2002	N	< 0.002	--	**27**	--	**3.37**	--	< 0.0001	--	**0.007**	--	**34**	--	**0.006**	--	< 0.003	--	**44**	--	--	< 0.001	--
		SPLIT	< 0.002	--	--	--	**3.37**	--	< 0.0006	--	**0.01**	--	--	--	**0.007**	--	< 0.003	--	--	--	--	< 0.002	--
MW-01-2	9/4/2002	N	--	--	--	--	**2.67**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-01-2	7/22/2003	N	< 0.0010	**0.00027 J**	--	--	**2.01 BQQ**	**2.000**	< 0.00020	< 0.00020	**0.0231 BQQ**	**0.0219**	--	--	**0.0073 BQQ**	**0.0060**	**0.000020 J**	< 0.0010	--	--	--	**0.000048 J**	**0.00012 J**
		FD	< 0.0010 J	**0.00037 J**	--	--	**1.97 BQQ**	**2.01**	< 0.00020	< 0.00020	**0.0225 BQQ**	**0.0222**	--	--	**0.0059 BQQ**	**0.0058**	**0.000020 J**	< 0.0010	--	--	--	**0.000070 J**	**0.00012 J**
MW-01-2	5/19/2008	N	--	**0.00014**	--	**19 R**	--	**1.55**	--	< 0.0002	--	**0.0044**	--	**23.9**	--	**0.0121**	--	**0.00003**	--	**46.9**	--	--	**0.00004**
MW-01-2	9/22/2008	N	--	**0.00028**	--	**19.2**	--	**1.18**	--	< 0.0002	--	**0.0032**	--	**25.9**	--	**0.010**	--	< 0.00002	--	**51.8**	--	--	**0.00004**
MW-01-3	10/9/2001	N	< 0.002	< 0.002	**41**	**44**	**11.6**	**13.1**	< 0.0006	< 0.0006	**0.02**	**0.03**	**36**	**40**	**0.003**	**0.003**	< 0.003	< 0.003	**50**	**53**	--	< 0.002	< 0.002
MW-01-3	1/22/2002	N	< 0.002	--	**44**	--	**12.2**	--	< 0.0001	--	**0.012**	--	**39**	--	**0.002**	--	< 0.003	--	**51**	--	--	< 0.003	--
MW-01-3	1/22/2002	FD	< 0.002	--	**44**	--	**12.4**	--	< 0.0001	--	**0.012**	--	**39**	--	**0.002**	--	< 0.003	--	**51**	--	**0.9**	< 0.003	--
		SPLIT	< 0.002	--	--	--	**12.0**	--	< 0.0006	--	**0.01**	--	--	--	**0.004**	--	< 0.003	--	--	--	**0.9**	< 0.002	--
		FD SPLIT	**0.003**	--	--	--	**12.5**	--	< 0.0006	--	**0.01**	--	--	--	**0.004**	--	< 0.003	--	--	--	--	< 0.002	--
		FDD SPLIT	< 0.002	--	--	--	**11.4**	--	< 0.0006	--	**0.01**	--	--	--	**0.004**	--	< 0.003	--	--	--	--	< 0.002	--
MW-01-3	9/5/2002	N	--	--	--	--	**10.1**	--	--	--	--	--	--	--	< 0.005	--	--	--	--	--	--	--	--
		FD	--	--	--	--	**10.6**	--	--	--	--	--	--	--	< 0.005	--	--	--	--	--	--	--	--
MW-01-3	5/19/2008	N	--	**0.00013**	--	**29.1 R**	--	**8.47**	--	< 0.0002	--	**0.0057**	--	**33.7**	--	**0.0015**	--	< 0.00002	--	**42.7**	--	--	**0.00005**
MW-01-3	9/19/2008	N	--	**0.000423**	--	**28.3**	--	**8.36**	--	< 0.00020	--	**0.0049**	--	**34.2**	--	**0.0020**	--	< 0.000020	--	**44.0**	--	--	**0.000060**
MW-01-6	10/9/2001	N	< 0.002	< 0.002	**43**	**47**	**4.83**	**5.36**	< 0.0006	< 0.0006	**0.01**	**0.02**	**55**	**60**	**0.002**	**0.002**	< 0.003	< 0.003	**69**	**76**	--	< 0.002	< 0.002
MW-01-6	10/10/2001	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-01-6	1/17/2002	N	< 0.002	--	**42**	--	**3.17**	--	< 0.0001	--	**0.012**	--	**54**	--	**0.003**	--	< 0.003	--	**66**	--	--	< 0.001	--
		SPLIT	< 0.002	--	--	--	**3.10**	--	< 0.0006	--	**0.02**	--	--	--	**0.005**	--	< 0.003	--	--	--	--	< 0.002	--
MW-01-6	9/5/2002	N	--	--	--	--	**2.39**	--	--	--	--	--	--	--	< 0.005	--	--	--	--	--	--	--	--
MW-01-6	5/19/2008	N	--	**0.00011**	--	**22.5 R**	--	**1.24**	--	< 0.0002	--	**0.0063**	--	**42.2**	--	**0.0012**	--	< 0.00002	--	**52.2**	--	--	**0.00010**
MW-01-6	9/18/2008	N	--	**0.000707**	--	**21.0**	--	**0.965**	--	< 0.00020	--	**0.0053**	--	**41.6**	--	**0.0029**	--	< 0.000020	--	**53.9**	--	--	**0.000098**
MW-02-2	9/5/2002	N	--	--	--	--	**1.97**	--	--	--	--	--	--	--	**0.009**	--	--	--	--	--	--	--	--
MW-02-2	5/19/2008	N	--	**0.00042**	--	**18.8 R**	--	**1.03**	--	< 0.0002	--	**0.0271**	--	**18.3**	--	**0.0149**	--	**0.00010**	--	**44.6**	--	--	**0.00003**
MW-02-2	9/22/2008	N	--	**0.00075**	--	**20.9**	--	**1.14**	--	< 0.0002	--	**0.0239**	--	**19.6**	--	**0.015**	--	**0.00005**	--	**47.8**	--	--	**0.00003**
MW-02-1	1/17/2002	N	< 0.002	--	**53**	--	**2.92**	--	< 0.0001	--	**0.008**	--	**23**	--	**0.005**	--	< 0.003	--	**236**	--	--	< 0.001	--
		SPLIT	< 0.002	--	--	--	**2.72**	--	< 0.0006	--	**0.01**	--	--	--	**0.006**	--	< 0.003	--	--	--	--	< 0.002	--
MW-02-1	9/4/2002	N	--	--	--	--	**3.17**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-02-1	7/22/2003	N	**0.000030 J**	**0.00028 J**	--	--	**1.85 BQQ**	**1.76**	< 0.00020	< 0.00020	**0.0436 BQQ**	**0.0420**	--	--	**0.00087 J**	**0.0026 J**	**0.000020 J**	< 0.0010	--	--	--	< 0.0010	**0.00044 J**
MW-02-1	5/29/2008	N	--	< 0.00030	--	**62.7**	--	**2.15**	--	< 0.0002	--	**0.0048**	--	**28.8**	--	**0.0045**	--	**0.00002**	--	**306**	--	--	< 0.00002
		FD	--	< 0.00033	--	**63.4**	--	**2.1**	--	< 0.0002	--	**0.0050**	--	**28.9**	--	**0.0054**	--	**0.00002**	--	**308**	--	--	< 0.00002
MW-02-1	9/26/2008	N	--	**0.00082**	--	**71.5**	--	**2.14000**	--	< 0.0002	--	**0.0057**	--	**30.1**	--	**0.0070**	--	< 0.00010	--	**338**	--	--	< 0.00010

Table 5.5.2-9
Groundwater Quality - Metals
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name Analysis	Uranium Dissolved	Uranium Total	Vanadium Dissolved	Vanadium Total	Zinc Dissolved	Zinc Total
Location ID	Sample Date	Sample Type						
MW-01-2	10/9/2001	N	--	< 0.0003	< 0.1	< 0.1	**0.20**	**0.28**
MW-01-2	10/10/2001	N	--	--	--	--	--	--
MW-01-2	1/16/2002	N	< 0.0002	--	< 0.01	--	**0.091**	--
		SPLIT	< 0.0003	--	< 0.1	--	**0.10**	--
MW-01-2	9/4/2002	N	--	--	--	--	**0.25**	--
MW-01-2	7/22/2003	N	--	--	**0.0045 BQQ**	**0.0045**	**0.388 BQQ**	**0.327**
		FD	--	--	**0.0045 BQQ**	**0.0050**	**0.399 BQQ**	**0.321**
MW-01-2	5/19/2008	N	--	**0.000022**	--	**0.0064**	--	**0.222**
MW-01-2	9/22/2008	N	--	**0.00004**	--	**0.0062**	--	**0.2124**
MW-01-3	10/9/2001	N	--	**0.0007**	< 0.1	< 0.1	**0.47**	**0.60**
MW-01-3	1/22/2002	N	< 0.001	--	< 0.1	--	**0.09**	--
MW-01-3	1/22/2002	FD	< 0.001	--	< 0.1	--	**0.10**	--
		SPLIT	< 0.0003	--	< 0.1	--	**0.09**	--
		FD SPLIT	< 0.0003	--	< 0.1	--	**0.09**	--
		FDD SPLIT	< 0.0003	--	< 0.1	--	**0.09**	--
MW-01-3	9/5/2002	N	--	--	--	--	**0.23**	--
		FD	--	--	--	--	**0.23**	--
MW-01-3	5/19/2008	N	--	**0.000027**	--	**0.0011**	--	**0.0080**
MW-01-3	9/19/2008	N	--	**0.000036**	--	**0.000903**	--	**0.0129**
MW-01-6	10/9/2001	N	--	< 0.0003	< 0.1	< 0.1	**0.320**	**0.350**
MW-01-6	10/10/2001	N	--	--	--	--	--	--
MW-01-6	1/17/2002	N	< 0.0002	--	< 0.01	--	**0.873**	--
		SPLIT	< 0.0003	--	< 0.1	--	**0.97**	--
MW-01-6	9/5/2002	N	--	--	--	--	**0.99**	--
MW-01-6	5/19/2008	N	--	< 0.000020	--	< 0.0002	--	**0.902**
MW-01-6	9/18/2008	N	--	**0.000096**	--	**0.000500**	--	**0.6957**
MW-02-2	9/5/2002	N	--	--	--	--	**1.34**	--
MW-02-2	5/19/2008	N	--	**0.000059**	--	**0.0045**	--	**0.524**
MW-02-2	9/22/2008	N	--	**0.00008**	--	**0.0042**	--	**0.4973**
MW-02-1	1/17/2002	N	**0.0047**	--	< 0.01	--	**0.004**	--
		SPLIT	**0.0022**	--	< 0.1	--	< 0.01	--
MW-02-1	9/4/2002	N	--	--	--	--	**0.01**	--
MW-02-1	7/22/2003	N	--	--	< 0.0010	< 0.0010	**0.0030 BQQJ**	**0.0032 J**
MW-02-1	5/29/2008	N	--	**0.0035**	--	< 0.0004	--	< 0.0016
		FD	--	**0.0034**	--	< 0.0003	--	< 0.0020
MW-02-1	9/26/2008	N	--	**0.00455**	--	< 0.0010	--	**0.0143**

Table 5.5.2-10
Groundwater Quality - SVOCs
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

		Chemical Name	1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1-Methylnaphthalene	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene
Location ID	**Sample Date**	**Sample Type**														
MW-01-2	10/9/2001	N	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01
MW-01-2	5/19/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017	< 0.000018	< 0.000033	< 0.000041
MW-01-2	9/22/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017 R	< 0.000018	< 0.000033	< 0.000041
MW-01-3	10/9/2001	N	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01
MW-01-3	5/19/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017	< 0.000018	< 0.000033	< 0.000041
MW-01-3	9/19/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017 R	< 0.000018	< 0.000033	< 0.000041
MW-01-6	10/9/2001	N	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01
MW-01-6	5/19/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017	< 0.000018	< 0.000033	< 0.000041
MW-01-6	9/18/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017 R	< 0.000018	< 0.000033	< 0.000041
MW-02-2	5/19/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017	< 0.000018	< 0.000033	< 0.000041
MW-02-2	9/22/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022	< 0.00017 R	< 0.000018	< 0.000033	< 0.000041
MW-02-1	1/17/2002	N	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01
		SPLIT	--	< 0.011	< 0.011	< 0.011	< 0.011	--	< 0.021	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
MW-02-1	5/29/2008	N	--	< 0.00016	< 0.00022	< 0.00021	< 0.00029	--	< 0.00031	< 0.00058	< 0.00047	< 0.022 R	< 0.0017	< 0.00018	< 0.00033	< 0.00041
		FD	--	< 0.00032	< 0.00044	< 0.00042	< 0.00058	--	< 0.00062	< 0.0012	< 0.00094	< 0.044 R	< 0.0034	< 0.00036	< 0.00066	< 0.00082
MW-02-1	9/26/2008	N	--	< 0.000016	< 0.000022	< 0.000021	< 0.000029	--	< 0.000031	< 0.000058	< 0.000047	< 0.0022 R	< 0.00017	< 0.000018	< 0.000033	< 0.000041

Table 5.5.2-10
Groundwater Quality - SVOCs
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

		Chemical Name	2-Chlorophenol	2-Methyl-4,6-dinitrophenol	2-Methylnaphthalene	2-Nitroaniline	2-Nitrophenol	3,3`-Dichlorobenzidine	3-Nitroaniline	4-Bromophenyl phenyl ether	4-Chloro-3-methylphenol	4-Chloroaniline	4-Chlorophenol	4-Chlorophenyl phenyl ether	4-Nitroaniline	4-Nitrophenol	Acenaphthene	Acenaphthylene
Location ID	**Sample Date**	**Sample Type**																
MW-01-2	10/9/2001	N	< 0.01	< 0.05	< 0.01	--	< 0.01	< 0.02	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.05	< 0.01	< 0.01
MW-01-2	5/19/2008	N	< 0.000054	< 0.000025	< 0.000026	< 0.000024	< 0.000063	< 0.00043 R	< 0.000029	< 0.000026	< 0.000037	< 0.000025 R	--	< 0.000027	< 0.000019	< 0.00028	< 0.000026	< 0.000015
MW-01-2	9/22/2008	N	< 0.000054	< 0.000025	< 0.000026	< 0.000024	< 0.000063	< 0.00043	< 0.000029	< 0.000026	< 0.000037	< 0.000025	--	< 0.000027	< 0.000019	< 0.00028	< 0.0000044	< 0.0000034
MW-01-3	10/9/2001	N	< 0.01	< 0.05	< 0.01	--	< 0.01	< 0.02	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.05	< 0.01	< 0.01
MW-01-3	5/19/2008	N	< 0.000054	< 0.000025	< 0.000026	< 0.000024	< 0.000063	< 0.00043 R	< 0.000029	< 0.000026	< 0.000037	< 0.000025 R	--	< 0.000027	< 0.000019	< 0.00028	**0.000032 J**	**0.000018 J**
MW-01-3	9/19/2008	N	< 0.000054	< 0.000025	< 0.000026	< 0.000024	< 0.000063	< 0.00043	< 0.000029	< 0.000026	< 0.000037	< 0.000025	--	< 0.000027	< 0.000019	< 0.00028	**0.000075**	< 0.0000035
MW-01-6	10/9/2001	N	< 0.01	< 0.05	< 0.01	--	< 0.01	< 0.02	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.05	**0.0057 J**	< 0.01
MW-01-6	5/19/2008	N	< 0.000054	< 0.000025	**0.000082 J**	< 0.000024	< 0.000063	< 0.00043 R	< 0.000029	< 0.000026	< 0.000037	< 0.000025 R	--	< 0.000027	< 0.000019	< 0.00028	**0.00036**	**0.000045 J**
MW-01-6	9/18/2008	N	< 0.000054	< 0.000025	**0.000095 J**	< 0.000024	< 0.000063	< 0.00043	< 0.000029	< 0.000026	< 0.000037	< 0.000025	--	< 0.000027	< 0.000019	< 0.00028	**0.00062**	**0.000010 J**
MW-02-2	5/19/2008	N	< 0.000054	< 0.000025	< 0.000026	< 0.000024	< 0.000063	< 0.00043 R	< 0.000029	< 0.000026	< 0.000037	< 0.000025 R	--	< 0.000027	< 0.000019	< 0.00028	< 0.000026	< 0.000015
MW-02-2	9/22/2008	N	< 0.000054	< 0.000025	< 0.000026	< 0.000024	< 0.000063	< 0.00043	< 0.000029	< 0.000026	< 0.000037	< 0.000025	--	< 0.000027	< 0.000019	< 0.00028	< 0.000026	< 0.000015
MW-02-1	1/17/2002	N	< 0.01	< 0.05	< 0.01	--	< 0.01	< 0.02	--	< 0.01	< 0.01	--	< 0.01	< 0.01	--	< 0.05	< 0.01	< 0.01
		SPLIT	< 0.011	< 0.021	< 0.011	< 0.011	< 0.011	< 0.021	< 0.011	< 0.011	< 0.011	< 0.021	--	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
MW-02-1	5/29/2008	N	< 0.00054	< 0.00025	< 0.00026	< 0.00024	< 0.00063	< 0.0043	< 0.00029	< 0.00026	< 0.00037	< 0.00025	--	< 0.00027	< 0.00019	< 0.0028	< 0.00026	< 0.00015
		FD	< 0.0011	< 0.00050	< 0.00052	< 0.00048	< 0.0013	< 0.0086	< 0.00058	< 0.00052	< 0.00074	< 0.00050	--	< 0.00054	< 0.00038	< 0.0056	< 0.00052	< 0.00030
MW-02-1	9/26/2008	N	< 0.000054	< 0.000025	< 0.00022	< 0.000024	< 0.000063	< 0.00043	< 0.000029	< 0.000026	< 0.000037	< 0.000025	--	< 0.000027	< 0.000019	< 0.00028	**0.00046**	< 0.000015

Table 5.5.2-10
Groundwater Quality - SVOCs
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

		Chemical Name	Anthracene	Azobenzene	Benzidine	Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Benzo(g,h,i) perylene	Benzo(k) fluoranthene	Benzoic acid	Benzyl alcohol	Bis(2-chloroethoxy) methane	Bis(2-chloroethyl)ether	Bis(2-chloroisopropyl) ether	Bis(2-ethylhexyl) phthalate	Butyl benzyl phthalate	Carbazole	Chrysene
Location ID	**Sample Date**	**Sample Type**																	
MW-01-2	10/9/2001	N	< 0.01	--	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01
MW-01-2	5/19/2008	N	< 0.000024	< 0.000021	--	< 0.000018	< 0.000031	< 0.000017	< 0.000019	< 0.000024	< 0.0011 R	< 0.000073	< 0.000024	< 0.000035	< 0.000026	**0.00052 J**	< 0.000018	< 0.000018	< 0.000028
MW-01-2	9/22/2008	N	< 0.0000036	< 0.000021	--	< 0.0000026	< 0.0000043	< 0.0000023	< 0.0000029	< 0.0000025	**0.0016 R**	< 0.000073	< 0.000024	< 0.000035	< 0.000026	< 0.00018	< 0.000056	< 0.000018	< 0.0000034
MW-01-3	10/9/2001	N	< 0.01	--	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01
MW-01-3	5/19/2008	N	**0.000025 J**	< 0.000021	--	**0.000026 J**	< 0.000031	< 0.000017	< 0.000019	< 0.000024	< 0.0011 R	< 0.000073	< 0.000024	< 0.000035	< 0.000026	**0.00079 J**	< 0.000018	**0.000019 J**	**0.000032 J**
MW-01-3	9/19/2008	N	**0.000018 J**	< 0.000021	--	**0.000021 J**	< 0.0000044	**0.0000027 J**	< 0.0000030	< 0.0000026	**0.0015 R**	< 0.000073	< 0.000024	< 0.000035	< 0.000026	< 0.00021	< 0.000037	**0.000029 J**	**0.000033**
MW-01-6	10/9/2001	N	< 0.01	--	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01
MW-01-6	5/19/2008	N	**0.000084 J**	< 0.000021	--	< 0.000018	< 0.000031	< 0.000017	< 0.000019	< 0.000024	**0.0011 R**	< 0.000073	< 0.000024	< 0.000035	< 0.000026	**0.0026**	< 0.000018	**0.00031**	< 0.000028
MW-01-6	9/18/2008	N	**0.000025**	< 0.000021	--	**0.0000049 J**	< 0.0000043	< 0.0000023	< 0.0000029	< 0.0000025	< 0.0011 R	< 0.000073	< 0.000024	< 0.000035	< 0.000026	< 0.00025	< 0.000062	**0.00061**	< 0.0000034
MW-02-2	5/19/2008	N	< 0.000024	< 0.000021	--	< 0.000018	< 0.000031	< 0.000017	< 0.000019	< 0.000024	< 0.0011 R	< 0.000073	< 0.000024	< 0.000035	< 0.000026	**0.0019**	< 0.000018	< 0.000018	< 0.000028
MW-02-2	9/22/2008	N	< 0.000024	< 0.000021	--	< 0.000018	< 0.000031	< 0.000017	< 0.000019	< 0.000024	**0.0022 R**	< 0.000073	< 0.000024	< 0.000035	< 0.000026	< 0.00025	< 0.000018	< 0.000018	< 0.000028
MW-02-1	1/17/2002	N	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01
		SPLIT	< 0.011	--	--	< 0.011	< 0.021	< 0.011	< 0.011	< 0.011	< 0.053	< 0.021	< 0.011	< 0.021 *	< 0.011	< 0.021	< 0.011	< 0.032	< 0.011
MW-02-1	5/29/2008	N	< 0.00024	< 0.00021	--	< 0.00018	< 0.00031	< 0.00017	< 0.00019	< 0.00024	< 0.011 R	< 0.00073	< 0.00024	< 0.00035	< 0.00026	**1.4 J**	< 0.00018	< 0.00018	< 0.00028
		FD	< 0.00048	< 0.00042	--	< 0.00036	< 0.00062	< 0.00034	< 0.00038	< 0.00048	< 0.022 R	< 0.0015	< 0.00048	< 0.00070	< 0.00052	**22 J**	< 0.00036	< 0.00036	< 0.00056
MW-02-1	9/26/2008	N	< 0.000024	< 0.000021	--	< 0.000018	< 0.000031	< 0.000017	< 0.000019	< 0.000024	< 0.0011	< 0.000073	< 0.000024	< 0.000035	< 0.000026	< 0.16	< 0.000018	< 0.000018	< 0.000028

Table 5.5.2-10
Groundwater Quality - SVOCs
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name	Dibenz(a,h) anthracene	Dibenzofuran	Diethyl phthalate	Dimethyl phthalate	Di-n-butyl phthalate	Di-n-octyl phthalate	Fluoranthene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachlorocyclopentadiene	Hexachloroethane	Indeno(1,2,3-cd) pyrene	Isophorone	m,p-cresols	Naphthalene
Location ID	**Sample Date**	**Sample Type**																
MW-01-2	10/9/2001	N	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MW-01-2	5/19/2008	N	< 0.000017	< 0.000018	< 0.000033	< 0.000021	< 0.000044	< 0.000018	< 0.000020	< 0.000027	< 0.000022	< 0.000027 R	< 0.00019 R	< 0.000024	< 0.000021	< 0.000016	--	**0.000069 J**
MW-01-2	9/22/2008	N	< 0.0000025	< 0.000018	< 0.000042	< 0.000021	< 0.000088	< 0.000018	< 0.0000044	< 0.0000038	< 0.000022	< 0.000027	< 0.00019 R	< 0.000024	< 0.0000026	< 0.000016	--	< 0.000011
MW-01-3	10/9/2001	N	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	**0.015**
MW-01-3	5/19/2008	N	< 0.000017	< 0.000018	< 0.000055	< 0.000021	< 0.000053	< 0.000018	**0.00031**	< 0.000027	< 0.000022	< 0.000027 R	< 0.00019 R	< 0.000024	< 0.000021	< 0.000016	--	**0.000024 J**
MW-01-3	9/19/2008	N	< 0.0000026	**0.000031 J**	< 0.000069	< 0.000021	< 0.000083	< 0.000018	**0.00049**	**0.0000085 J**	< 0.000022	< 0.000027 R	< 0.00019 R	< 0.000024 R	< 0.0000027	< 0.000016	--	< 0.000036
MW-01-6	10/9/2001	N	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	**0.015**
MW-01-6	5/19/2008	N	< 0.000017	**0.00014 J**	**0.00020**	< 0.000021	< 0.000043	< 0.000018	**0.00019 J**	**0.00014 J**	< 0.000022	< 0.000027 R	< 0.00019 R	< 0.000024	< 0.000021	< 0.000016	--	**0.00032**
MW-01-6	9/18/2008	N	< 0.0000025	**0.00030**	< 0.00015	< 0.000021	< 0.000080	< 0.000018	**0.00031**	**0.00017**	< 0.000022	< 0.000027 R	< 0.00019 R	< 0.000024 R	< 0.0000026	< 0.000016	--	< 0.00030
MW-02-2	5/19/2008	N	< 0.000017	< 0.000018	< 0.000023	< 0.000021	< 0.000043	< 0.000018	< 0.000020	< 0.000027	< 0.000022	< 0.000027 R	< 0.00019 R	< 0.000024	< 0.000021	< 0.000016	--	< 0.000022
MW-02-2	9/22/2008	N	< 0.000017	< 0.000018	< 0.000039	< 0.000021	< 0.000090	< 0.000018	< 0.000020	< 0.000027	< 0.000022	< 0.000027	< 0.00019 R	< 0.000024	< 0.000021	< 0.000016	--	< 0.000022
MW-02-1	1/17/2002	N	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
		SPLIT	< 0.021	< 0.011	< 0.032	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	--	< 0.011
MW-02-1	5/29/2008	N	< 0.00017	< 0.00018	< 0.00012	< 0.00021	< 0.00023	< 0.00018	< 0.00020	< 0.00027	< 0.00022	< 0.00027 R	< 0.0019 R	< 0.00024 R	< 0.00021	< 0.00016	--	< 0.00022
		FD	< 0.00034	< 0.00036	< 0.00024	< 0.00042	< 0.00046	< 0.00036	< 0.00040	< 0.00054	< 0.00044	< 0.00054 R	< 0.0038 R	< 0.00048 R	< 0.00042	< 0.00032	--	< 0.00044
MW-02-1	9/26/2008	N	< 0.000017	**0.00070**	< 0.000012	< 0.000021	< 0.000023	< 0.000018	< 0.000020	**0.00064**	< 0.000022	< 0.000027	< 0.00019 R	< 0.000024	< 0.000021	< 0.000016	--	< 0.000022

Table 5.5.2-10
Groundwater Quality - SVOCs
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name	Nitrobenzene	N-Nitrosodimethylamine	N-Nitrosodi-n-propylamine	N-Nitrosodiphenylamine	N-Nitrosopyrrolidine	o-Cresol	p-cresol	Pentachlorobenzene	Pentachlorophenol	Phenanthrene	Phenol	Pyrene	Pyridine
Location ID	**Sample Date**	**Sample Type**													
MW-01-2	10/9/2001	N	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01	< 0.02
MW-01-2	5/19/2008	N	**0.000099 J**	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	< 0.00034	< 0.000022	**0.0017**	< 0.000019	--
MW-01-2	9/22/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	< 0.00034	< 0.0000050	**0.00019 J**	< 0.0000035	< 0.0014 R
MW-01-3	10/9/2001	N	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01	< 0.02
MW-01-3	5/19/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	< 0.00034	**0.000072 J**	**0.0018**	**0.00021**	--
MW-01-3	9/19/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	< 0.00034	**0.000074**	< 0.000063	**0.00033**	< 0.0014 R
MW-01-6	10/9/2001	N	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.05	< 0.01	< 0.01	< 0.01	< 0.02
MW-01-6	5/19/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	**0.00020 J**	**0.00039 J**	--	< 0.00034	**0.00037**	**0.0062**	**0.00012 J**	--
MW-01-6	9/18/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	**0.00011 J**	< 0.00012	--	< 0.00034	**0.00051**	< 0.000063	**0.00020**	< 0.0014 R
MW-02-2	5/19/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	< 0.00034	< 0.000022	**0.0014**	< 0.000019	--
MW-02-2	9/22/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	**0.00080 J**	< 0.000022	< 0.000063	< 0.000019	< 0.0014 R
MW-02-1	1/17/2002	N	< 0.01	< 0.01	< 0.01	< 0.01	--	< 0.01	--	--	< 0.05	< 0.01	< 0.01	< 0.01	< 0.02
		SPLIT	< 0.011	< 0.011 *	< 0.011	< 0.011	--	< 0.011	< 0.011	--	< 0.011	< 0.011	< 0.011 *	< 0.011	< 0.011
MW-02-1	5/29/2008	N	< 0.00028	< 0.0042	< 0.00037	< 0.00048	--	< 0.0011	< 0.0012	--	< 0.0034	< 0.00022	< 0.013	< 0.00019	--
		FD	< 0.00056	< 0.0084	< 0.00074	< 0.00096	--	< 0.0022	< 0.0024	--	< 0.0068	< 0.00044	< 0.015	< 0.00038	--
MW-02-1	9/26/2008	N	< 0.000028	< 0.00042	< 0.000037	< 0.000048	--	< 0.00011	< 0.00012	--	< 0.00034	**0.00056**	**0.0020**	< 0.000019	< 0.0014 R

Table 5.5.2-11
Groundwater Quality - VOCs
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

Chemical Name			1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloro-1-propene	1,1-Dichloroethane	1,1-Dichloroethylene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane	1,2-Dibromoethane	1,2-Dichlorobenzene
Location ID	**Sample Date**	**Sample Type**														
MW-01-2	10/9/2001	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.0010	< 0.0010	--	< 0.0010	--	--	< 0.0010	< 0.0010	--
MW-01-2	5/19/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022	< 0.000084	< 0.000044
MW-01-2	9/22/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022 J	< 0.000084	< 0.000044
MW-01-3	10/9/2001	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.0010	< 0.0010	--	< 0.0010	--	--	< 0.0010	< 0.0010	--
MW-01-3	5/19/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022	< 0.000084	< 0.000044
MW-01-3	9/19/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022 J	< 0.000084	< 0.000044
MW-01-6	10/9/2001	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.0010	< 0.0010	--	< 0.0010	--	--	< 0.0010	< 0.0010	--
MW-01-6	5/19/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	**0.00010 J**	< 0.00022	< 0.000084	< 0.000044
MW-01-6	9/18/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	**0.000090 J**	< 0.00022	< 0.000084	< 0.000044
MW-02-2	5/19/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022	< 0.000084	< 0.000044
MW-02-2	9/22/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022 J	< 0.000084	< 0.000044
MW-02-1	1/17/2002	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	**0.012**	< 0.0010	< 0.0010	< 0.0010
		SPLIT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	**0.014**	< 0.005	< 0.001	< 0.001
MW-02-1	5/29/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022	< 0.000084	< 0.000044
		FD	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022	< 0.000084	< 0.000044
MW-02-1	9/26/2008	N	< 0.000047	< 0.000050	< 0.000064	< 0.000061	< 0.000051	< 0.000042	< 0.00010	< 0.00010	< 0.00014	< 0.00013	< 0.000037	< 0.00022 J	< 0.000084	< 0.000044

Table 5.5.2-11
Groundwater Quality - VOCs
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name	1,2-Dichloroethane	1,2-Dichloroethylene, cis	1,2-Dichloroethylene, trans	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichloro-1-propene, cis	1,3-Dichloro-1-propene, trans	1,3-Dichlorobenzene	1,3-Dichloropropane	1,4-Dichlorobenzene	2,2-Dichloropropane	2-Chloroethyl vinyl ether	2-Hexanone	Acetone	Acrolein
Location ID	**Sample Date**	**Sample Type**															
MW-01-2	10/9/2001	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.0010	< 0.0010	--	--	--	--	--	< 0.02	< 0.02	--
MW-01-2	5/19/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0025	< 0.0020
MW-01-2	9/22/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0051	< 0.0020
MW-01-3	10/9/2001	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.0010	< 0.0010	--	--	--	--	--	< 0.02	**0.012 J**	--
MW-01-3	5/19/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	**0.0084 J**	< 0.0020
MW-01-3	9/19/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.023	< 0.0020
MW-01-6	10/9/2001	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.0010	< 0.0010	--	--	--	--	--	< 0.02	< 0.02	--
MW-01-6	5/19/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0025	< 0.0020
MW-01-6	9/18/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.017	< 0.0020
MW-02-2	5/19/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0025	< 0.0020
MW-02-2	9/22/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	< 0.000042	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0046	< 0.0020
MW-02-1	1/17/2002	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	**0.0058**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.02	< 0.02	< 0.02
		SPLIT	< 0.001	< 0.001	< 0.001	< 0.001	**0.007**	--	--	< 0.001	< 0.001	< 0.001	< 0.001	--	--	--	--
MW-02-1	5/29/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	**0.00078**	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0025	< 0.0020 J
		FD	< 0.000073	< 0.000045	< 0.000048	< 0.000042	**0.00032 J**	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0025	< 0.0020 J
MW-02-1	9/26/2008	N	< 0.000073	< 0.000045	< 0.000048	< 0.000042	**0.00031 J**	< 0.000038	< 0.000041	< 0.000041	< 0.000032	< 0.000054	< 0.000050	< 0.00019 R	< 0.0029	< 0.0025	< 0.0020

Table 5.5.2-11
Groundwater Quality - VOCs
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

		Chemical Name	Acrylonitrile	Benzene	Bromobenzene	Bromochloromethane	Bromodichloromethane	Bromoform	Bromomethane	Butyl benzene	Butylbenzene, sec	Butylbenzene, tert	Carbon disulfide	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane
Location ID	**Sample Date**	**Sample Type**															
MW-01-2	10/9/2001	N	--	< 0.0010	--	--	< 0.0010	< 0.0010	< 0.0010	--	--	--	**0.00030 J***	< 0.0010	< 0.0010	< 0.0010	< 0.0010
MW-01-2	5/19/2008	N	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000080	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-01-2	9/22/2008	N	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080 J	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-01-3	10/9/2001	N	--	< 0.0010	--	--	< 0.0010	< 0.0010	< 0.0010	--	--	--	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
MW-01-3	5/19/2008	N	< 0.00031	**0.00027 J**	< 0.000027	< 0.000091	< 0.000036	< 0.000080	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-01-3	9/19/2008	N	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080 J	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-01-6	10/9/2001	N	--	**0.00070 J**	--	--	< 0.0010	< 0.0010	< 0.0010	--	--	--	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
MW-01-6	5/19/2008	N	< 0.00031	**0.00060**	< 0.000027	< 0.000091	< 0.000036	< 0.000080	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-01-6	9/18/2008	N	< 0.00031	**0.00048 J**	< 0.000027	< 0.000091	< 0.000036	< 0.000080 J	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-02-2	5/19/2008	N	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000060	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-02-2	9/22/2008	N	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080 J	< 0.000072	< 0.000056	< 0.000036	< 0.000038	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
MW-02-1	1/17/2002	N	< 0.02	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	**0.0047**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
		SPLIT	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	**0.002**	**0.005**	**0.004**	--	< 0.001	< 0.001	< 0.001	< 0.001
MW-02-1	5/29/2008	N	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080	< 0.000072	< 0.00072	**0.0029**	**0.00013 J**	< 0.000045	< 0.000068	< 0.000045	< 0.000057	< 0.00013
		FD	< 0.00031	< 0.000045	< 0.000027	< 0.000091	< 0.000036	< 0.000080	< 0.000072	< 0.000056	**0.00069 J**	**0.000050 J**	< 0.000045	< 0.000068	< 0.000045	< 0.000057	**0.00022 J**
MW-02-1	9/26/2008	N	< 0.00031	**0.00012 J**	< 0.000027	< 0.000091	< 0.000036	< 0.000080 J	< 0.000072	**0.00035 J**	**0.0016 J**	**0.000060 J**	< 0.00028	< 0.000068	< 0.000045	< 0.000057	< 0.00013

Table 5.5.2-11
Groundwater Quality - VOCs
SWMU 2
Rhodia Silver Bow Plant
[concentrations in mg/l]

Chemical Name			Chloroform	Chloromethane	Chlorotoluene o-	Chlorotoluene p-	Cumene (isopropyl benzene)	Cymene p- (Toluene isopropyl p-)	Dibromomethane (methylene bromide)	Dichlorodifluoromethane (CFC-12)	Ethyl benzene	Hexachlorobutadiene	Iodomethane	Isopropyl toluene	Methyl ethyl ketone	Methyl isobutyl ketone
Location ID	**Sample Date**	**Sample Type**														
MW-01-2	10/9/2001	N	< 0.0010	< 0.0010	--	--	--	--	--	< 0.0010	< 0.0010	--	< 0.0010	--	< 0.02	< 0.02
MW-01-2	5/19/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-01-2	9/22/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-01-3	10/9/2001	N	< 0.0010	< 0.0010	--	--	--	--	--	< 0.0010	< 0.0010	--	< 0.0010	--	< 0.02	< 0.02
MW-01-3	5/19/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-01-3	9/19/2008	N	< 0.000042	**0.00016 J**	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-01-6	10/9/2001	N	< 0.0010	< 0.0010	--	--	--	--	--	< 0.0010	< 0.0010	--	< 0.0010	--	< 0.02	< 0.02
MW-01-6	5/19/2008	N	< 0.000042	**0.000090 J**	< 0.000035	< 0.000025	**0.000040 J**	< 0.000044	< 0.000089	< 0.000083	**0.000070 J**	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-01-6	9/18/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	**0.000060 J**	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-02-2	5/19/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-02-2	9/22/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	< 0.000031	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-02-1	1/17/2002	N	< 0.0010	< 0.0010	< 0.0010	< 0.0010	**0.0016**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	--	< 0.02	< 0.02
		SPLIT	< 0.001	< 0.001	< 0.001	< 0.001	**0.002**	--	< 0.001	< 0.001	< 0.001	< 0.001	--	< 0.001	--	--
MW-02-1	5/29/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	**0.00034 J**	**0.0014 J**	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
		FD	< 0.000042	< 0.000053	< 0.000035	< 0.000025	**0.00016 J**	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030
MW-02-1	9/26/2008	N	< 0.000042	< 0.000053	< 0.000035	< 0.000025	**0.00017 J**	< 0.000044	< 0.000089	< 0.000083	< 0.000042	< 0.00019	< 0.00027	--	< 0.0038	< 0.0030

Table 5.5.2-11
Groundwater Quality - VOCs
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

Chemical Name			Methyl tertiary butyl ether (MTBE)	Methylene chloride	Naphthalene	Propylbenzene	Styrene	Tetrachloroethylene	Toluene	Trichloroethylene	Trichlorofluoromethane	Vinyl acetate	Vinyl chloride	Xylene, m & p	Xylene, o	Xylenes, total
Location ID	**Sample Date**	**Sample Type**														
MW-01-2	10/9/2001	N	--	< 0.0010	--	--	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
MW-01-2	5/19/2008	N	< 0.000070	< 0.00023	< 0.00010	< 0.000037	< 0.000039	**0.00030 J**	< 0.00023	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-01-2	9/22/2008	N	< 0.000070	< 0.00023	< 0.00010	< 0.000037	< 0.000039	**0.00030 J**	< 0.00050	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-01-3	10/9/2001	N	--	< 0.0010	--	--	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
MW-01-3	5/19/2008	N	< 0.000070	< 0.00023	< 0.00010	< 0.000037	< 0.000039	< 0.000077	< 0.000060	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-01-3	9/19/2008	N	< 0.000070	< 0.00023	< 0.00010	< 0.000037	< 0.000039	< 0.000077	< 0.00046	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-01-6	10/9/2001	N	--	< 0.0010	--	--	< 0.0010	< 0.0010	**0.00020 J**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	**0.00024 J**	< 0.0010	**0.00024 J**
MW-01-6	5/19/2008	N	< 0.000070	< 0.00023	< 0.00031	< 0.000037	< 0.000039	< 0.000077	**0.00041 J**	< 0.000061	< 0.000086	< 0.00091	< 0.000071	**0.00027 J**	**0.00011 J**	--
MW-01-6	9/18/2008	N	< 0.000070	< 0.00023	**0.00023 J**	< 0.000037	**0.000050 J**	< 0.000077	< 0.00011	< 0.000061	< 0.000086	< 0.00091	< 0.000071	**0.00015 J**	**0.000090 J**	--
MW-02-2	5/19/2008	N	< 0.000070	< 0.00023	< 0.00010	< 0.000037	< 0.000039	< 0.000077	< 0.00012	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-02-2	9/22/2008	N	< 0.000070	< 0.00023	< 0.00010	< 0.000037	< 0.000039	< 0.000077	< 0.000090	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-02-1	1/17/2002	N	< 0.0010	< 0.0010	< 0.0010	**0.00086 J**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
		SPLIT	< 0.001	< 0.005	< 0.005	**0.001**	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	--	< 0.001	--	--	< 0.002
MW-02-1	5/29/2008	N	< 0.000070	< 0.00023	< 0.00053	**0.00018 J**	< 0.000039	< 0.000077	< 0.000060	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
		FD	< 0.000070	< 0.00023	< 0.00038	**0.000070 J**	< 0.000039	< 0.000077	< 0.00020	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--
MW-02-1	9/26/2008	N	< 0.000070	< 0.00023	< 0.00010	**0.000080 J**	**0.000060 J**	< 0.000077	< 0.00015	< 0.000061	< 0.000086	< 0.00091	< 0.000071	< 0.000078	< 0.000037	--

Table 5.5.2-12
Groundwater Quality - Radionuclides
SWMU 2
Rhodia Silver Bow Plant
[concentrations in pCi/l]

		Chemical Name	Cesium 137	Gross Alpha (radiation)	Gross Beta (radiation)	Radium 226	Radium 228	Radium, total	Strontium 90
Location ID	Sample Date	Sample Type							
MW-01-2	10/9/2001	N	--	< 1	**31 +/- 5.0**	**0.30 +/- 0.2**	< 1	--	< 10
MW-01-2	1/16/2002	N	--	< 1.0	**33 +/- 4.5**	< 0.20	**1.5 +/- 1**	--	< 10
		SPLIT	--	**0.7**	**32**	--	**0.5**	--	--
MW-01-2	9/4/2002	N	--	**1.4 +/- 1.2**	**17.6 +/- 2.7**	< 0.2	< 1.0	< 0.2	--
MW-01-2	7/22/2003	N	< 49.1	**5.68 +/- 2.34 J**	**23.8 +/- 9.41**	< 1.56	--	--	--
		FD	< 40.1	< 3.55	**27.3 +/- 19.8**	< 1.76	--	--	--
MW-01-2	5/19/2008	N	--	< 2.3	**24 +/- 4.3**	< 0.32	< 0.71	--	--
MW-01-2	9/22/2008	N	--	**2.1 +/- 2.4**	**27 +/- 4.5**	< 0.3	**0.82 +/- 0.26**	--	--
MW-01-3	10/9/2001	N	--	**6.5 +/- 1.9**	**50 +/- 5.0**	**1.0 +/- 0.20**	< 1	--	< 10
MW-01-3	1/22/2002	N	--	**3.1 +/- 2.5**	**46 +/- 4.9**	< 0.20	< 1.0	--	< 10
		FD	--	< 1.0	**45 +/- 4.9**	< 0.20	< 1.0	--	< 10
		SPLIT	--	**4.8**	**32**	**0.2**	--	--	--
		FD SPLIT	--	**8.1**	**29**	**0.5**	--	--	--
MW-01-3	9/5/2002	N	--	< 1.0	**42.2 +/- 4.1**	< 0.2	< 1.0	< 0.2	--
		FD	--	< 1.0	**41.3 +/- 4.1**	< 0.2	< 1.0	< 0.2	--
MW-01-3	5/19/2008	N	--	**2.7 +/- 2.6**	**35 +/- 4.9**	< 0.32	< 0.73	--	--
MW-01-3	9/19/2008	N	--	< 2.1	**33 +/- 4.6**	< 0.35	< 0.72	--	--
MW-01-6	10/9/2001	N	--	**2.2 +/- 2.3**	**63 +/- 6.3**	**0.70 +/- 0.2**	< 1	--	< 10
MW-01-6	1/17/2002	N	--	< 1.0	**67 +/- 5.6**	< 0.20	**3.4 +/- 3**	--	< 10
		SPLIT	--	**5**	**29**	--	**0.5**	--	--
MW-01-6	9/5/2002	N	--	< 1.0	**49.2 +/- 6.1**	< 0.2	**2.2 +/- 1.1**	**2.2 +/- 1.1**	--
MW-01-6	5/19/2008	N	--	< 3.3	**41 +/- 6.4**	< 0.2	< 0.72	--	--
MW-01-6	9/16/2008	N	--	< 2.7	**39 +/- 5.6**	< 0.21	**2.5 +/- 0.7**	--	--
MW-02-2	9/5/2002	N	--	< 1.0	**23.5 +/- 3.5**	< 0.2	< 1.0	< 0.2	--
MW-02-2	5/19/2008	N	--	< 2	**25 +/- 4.2**	< 0.59	< 4	--	--
MW-02-2	9/22/2008	N	--	**4.9 +/- 2.9**	**21 +/- 3.9**	< 0.31	< 0.7	--	--
MW-02-1	1/17/2002	N	--	< 1.0	**22 +/- 7.5**	**0.80 +/- 0**	**1.9 +/- 1**	--	< 10
		SPLIT	--	**4**	**5**	**0.4**	**1.2**	--	**0.1**
MW-02-1	9/4/2002	N	--	**7.1 +/- 3.6**	< 2.0	**0.5**	< 1.0	**0.5 +/- 0.3**	--
MW-02-1	7/22/2003	N	< 56.5	< 9.40	**21.9 +/- 77.9**	< 1.82	--	--	--
MW-02-1	5/29/2008	N	--	< 6.3	**24 +/- 11**	< 0.17	**1.1 +/- 0.32**	--	--
		FD	--	< 6.9	**27 +/- 11**	< 0.35	**1.2 +/- 0.32**	--	--
MW-02-1	9/26/2008	N	--	< 7.6	**37 +/- 12**	**0.6 +/- 0.16**	< 1.4	--	--

Table 5.5.2-13
Groundwater Quality - PCBs
SWMU 2
Rhodia Silver Bow Plant

[concentrations in mg/l]

		Chemical Name	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Aroclor 1262	Aroclor 1268
Location ID	Sample Date	Sample Type									
MW-01-2	05/19/2008	N	< 0.0000094	< 0.000020	< 0.000023	< 0.000013	< 0.0000054	< 0.0000070	< 0.0000031	< 0.0000048	< 0.0000065
MW-01-3	05/19/2008	N	< 0.000016	< 0.000020	< 0.000047	< 0.000040	< 0.0000054	< 0.0000070	< 0.0000031	< 0.0000048	< 0.0000065
MW-01-6	05/19/2008	N	< 0.000033	< 0.000020	< 0.000023	< 0.000013	< 0.0000054	< 0.0000070	< 0.0000031	< 0.0000048	< 0.0000065
MW-02-2	05/19/2008	N	< 0.000012	< 0.000020	< 0.000023	< 0.000013	< 0.0000054	< 0.0000070	< 0.0000031	< 0.0000048	< 0.0000065
MW-02-1	01/17/2002	N	< 0.00050	< 0.0010	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
		SPLIT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	--	--
		FD SPLIT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	--	--
MW-02-1	05/29/2008	N	< 0.0000094	< 0.000020	< 0.000023	< 0.000013	< 0.0000054	< 0.0000070	< 0.0000031	< 0.0000048	< 0.0000065
		FD	< 0.0000094	< 0.000020	< 0.000023	< 0.000013	< 0.0000054	< 0.0000070	< 0.0000031	< 0.0000048	< 0.0000065

Figures

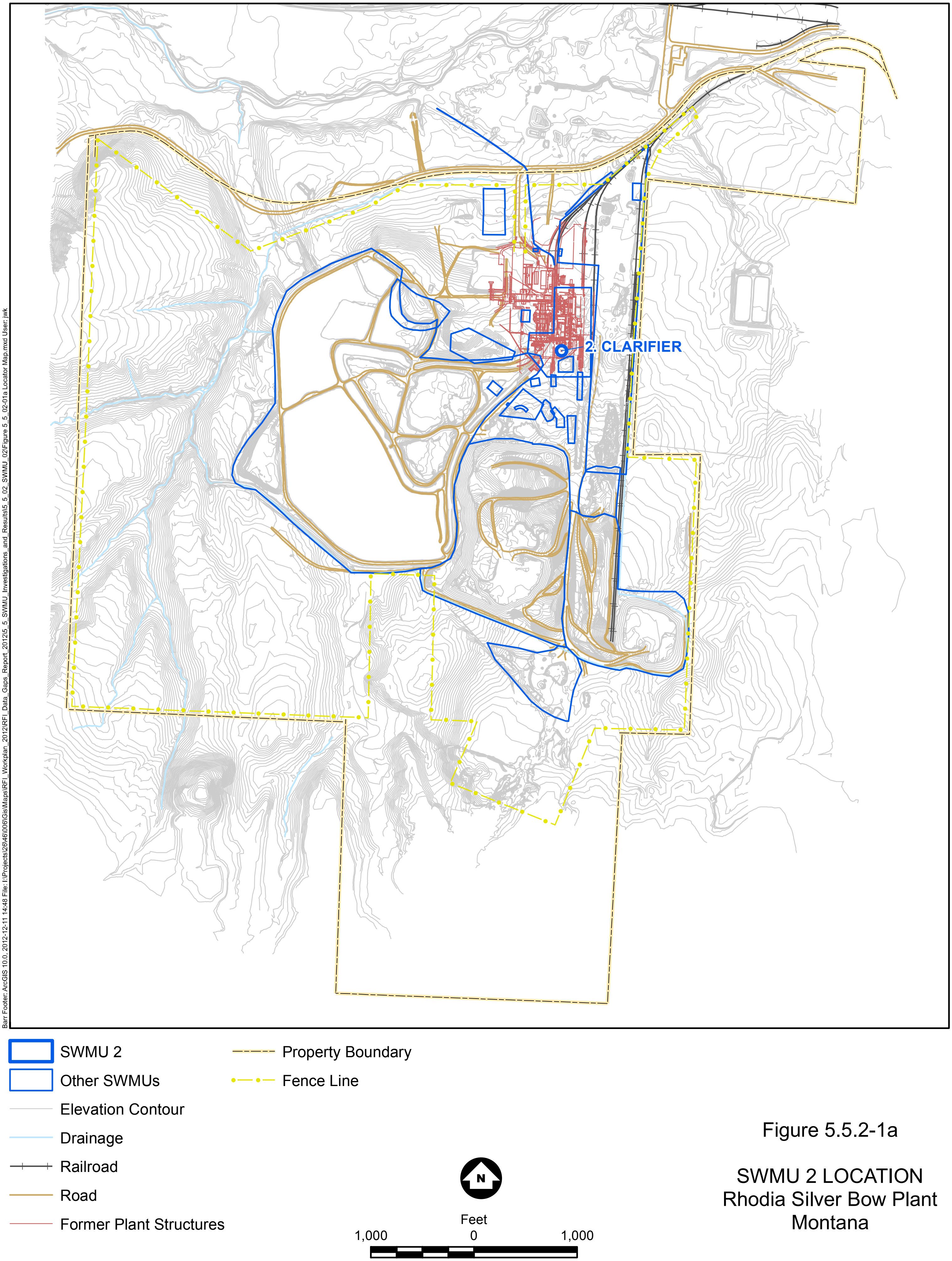


Figure 5.5.2-1a

SWMU 2 LOCATION
Rhodia Silver Bow Plant
Montana

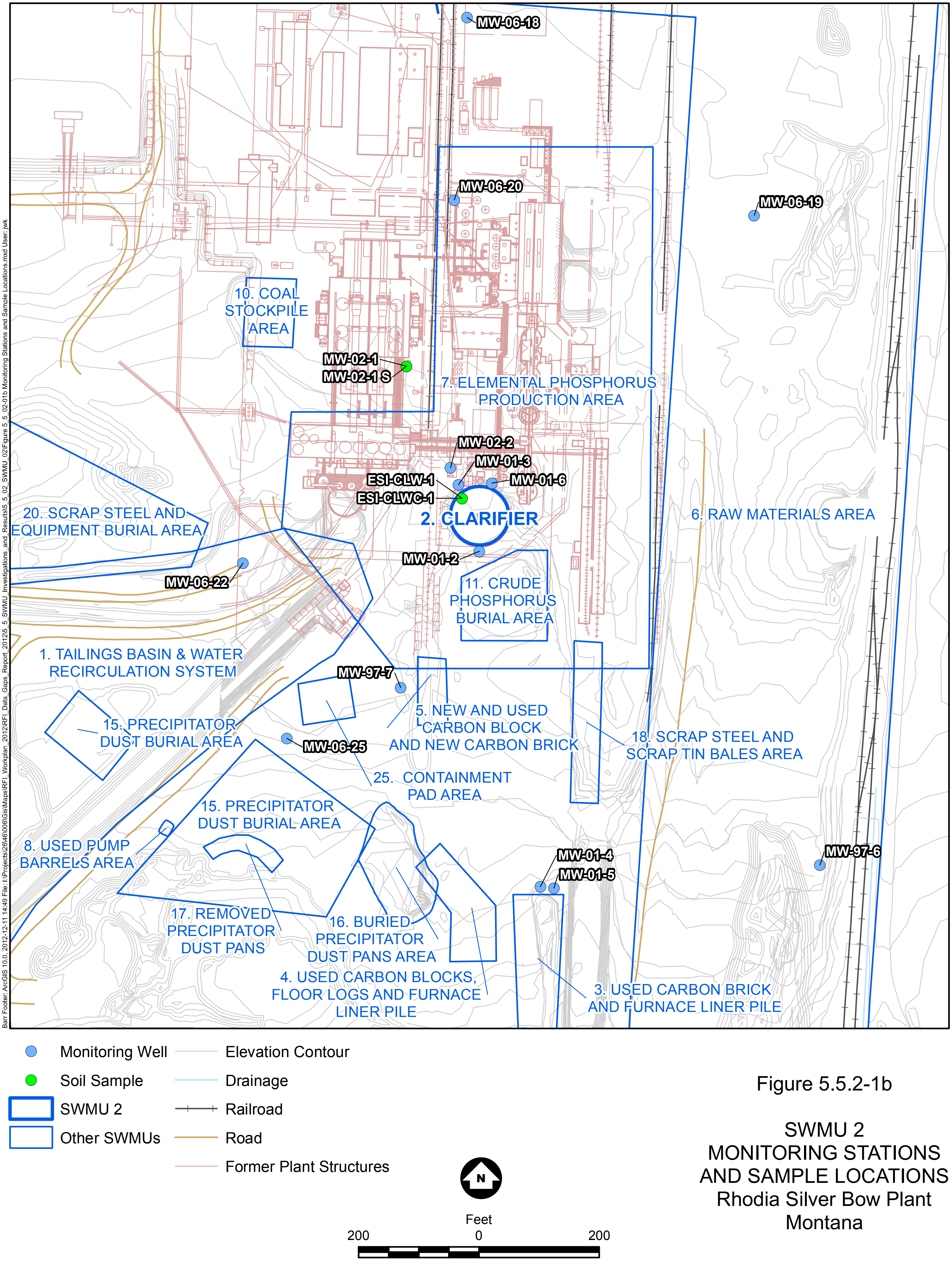
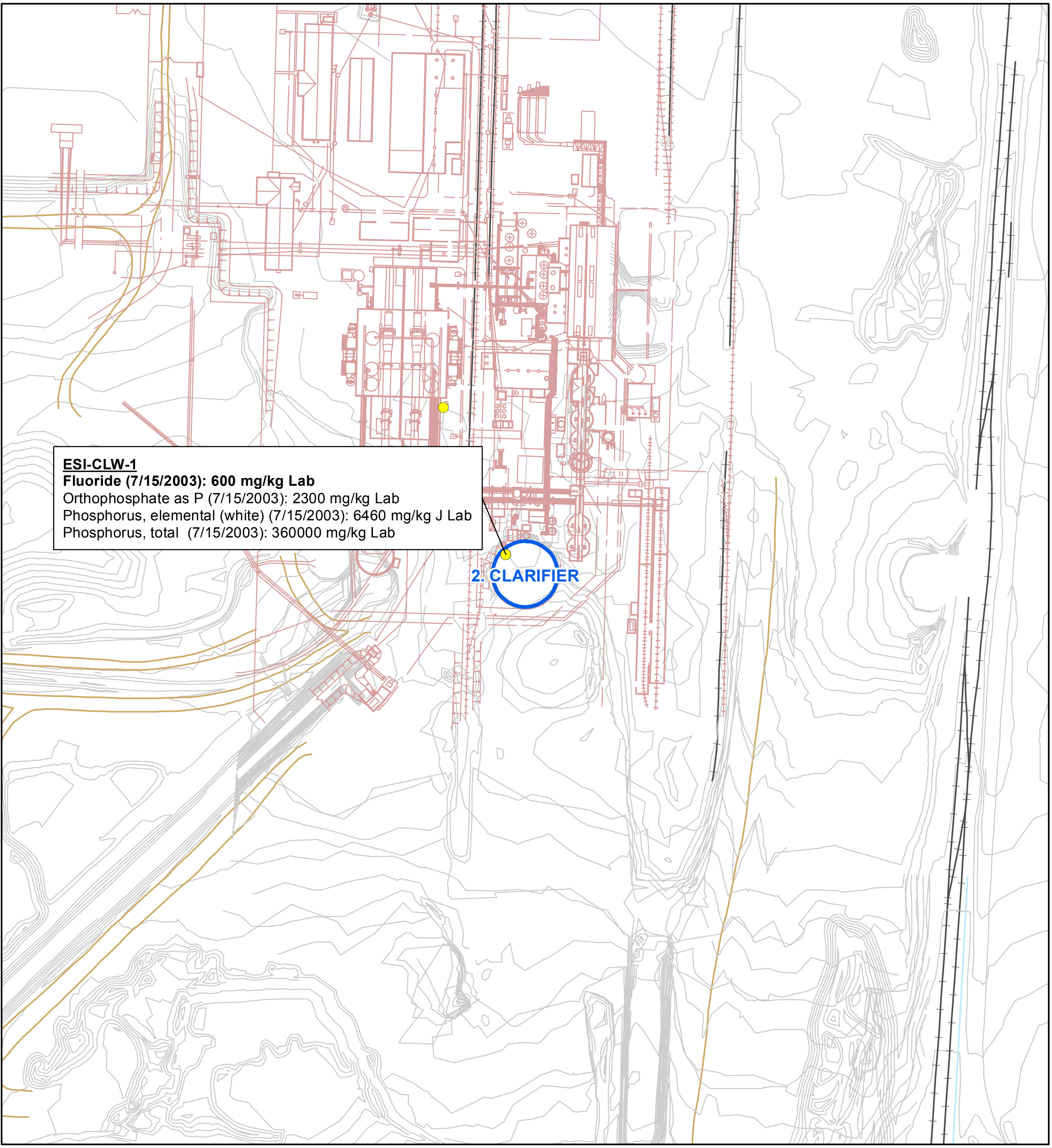


Figure 5.5.2-1b

SWMU 2
MONITORING STATIONS
AND SAMPLE LOCATIONS
Rhodia Silver Bow Plant
Montana



ESI-CLW-1
Fluoride (7/15/2003): 600 mg/kg Lab
Orthophosphate as P (7/15/2003): 2300 mg/kg Lab
Phosphorus, elemental (white) (7/15/2003): 6460 mg/kg J Lab
Phosphorus, total (7/15/2003): 360000 mg/kg Lab

●	Sample Location
▭	SWMU 2
—	Elevation Contour
—	Drainage
—+—	Railroad
—	Road
—	Former Plant Structures

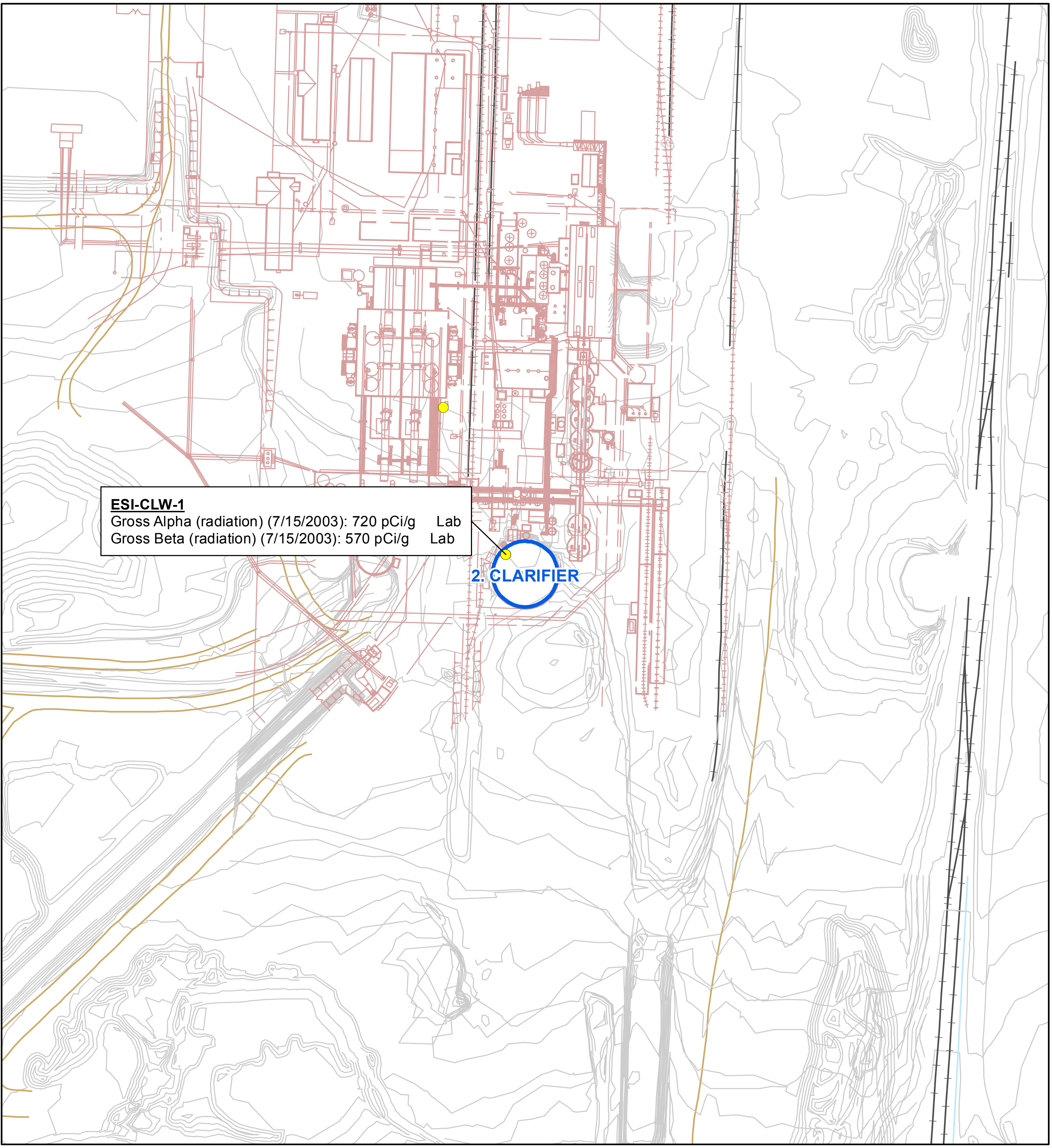
Bold font indicates that sample concentration is greater than the 95% UCL of mean Reference Area Concentration.

N

Feet
200 0 200

Figure 5.5.2-2

SWMU 2
GENERAL PARAMETERS
Rhodia Silver Bow Plant
Montana



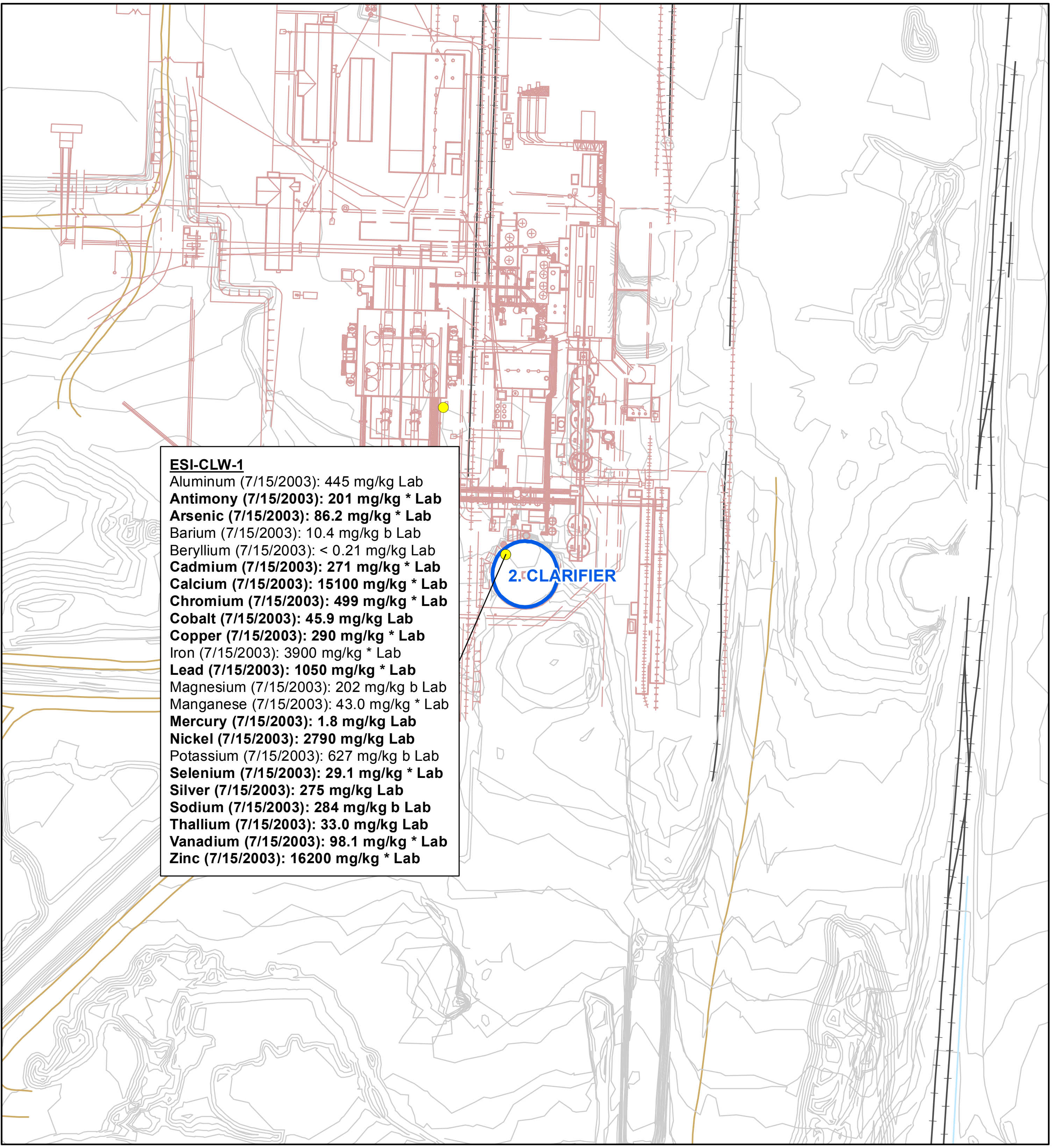
ESI-CLW-1
Gross Alpha (radiation) (7/15/2003): 720 pCi/g Lab
Gross Beta (radiation) (7/15/2003): 570 pCi/g Lab

● Sample Location
▭ SWMU 2
— Elevation Contour
— Drainage
—+— Railroad
— Road
— Former Plant Structures

Bold font indicates that sample concentration is greater than the 95% UCL of mean Reference Area Concentration.

Figure 5.5.2-3

SWMU 2
RADIONUCLIDES
Rhodia Silver Bow Plant
Montana



ESI-CLW-1
Aluminum (7/15/2003): 445 mg/kg Lab
Antimony (7/15/2003): 201 mg/kg * Lab
Arsenic (7/15/2003): 86.2 mg/kg * Lab
Barium (7/15/2003): 10.4 mg/kg b Lab
Beryllium (7/15/2003): < 0.21 mg/kg Lab
Cadmium (7/15/2003): 271 mg/kg * Lab
Calcium (7/15/2003): 15100 mg/kg * Lab
Chromium (7/15/2003): 499 mg/kg * Lab
Cobalt (7/15/2003): 45.9 mg/kg Lab
Copper (7/15/2003): 290 mg/kg * Lab
Iron (7/15/2003): 3900 mg/kg * Lab
Lead (7/15/2003): 1050 mg/kg * Lab
Magnesium (7/15/2003): 202 mg/kg b Lab
Manganese (7/15/2003): 43.0 mg/kg * Lab
Mercury (7/15/2003): 1.8 mg/kg Lab
Nickel (7/15/2003): 2790 mg/kg Lab
Potassium (7/15/2003): 627 mg/kg b Lab
Selenium (7/15/2003): 29.1 mg/kg * Lab
Silver (7/15/2003): 275 mg/kg Lab
Sodium (7/15/2003): 284 mg/kg b Lab
Thallium (7/15/2003): 33.0 mg/kg Lab
Vanadium (7/15/2003): 98.1 mg/kg * Lab
Zinc (7/15/2003): 16200 mg/kg * Lab

● Sample Location
▭ SWMU 2
— Elevation Contour
— Drainage
┼ Railroad
— Road
— Former Plant Structures

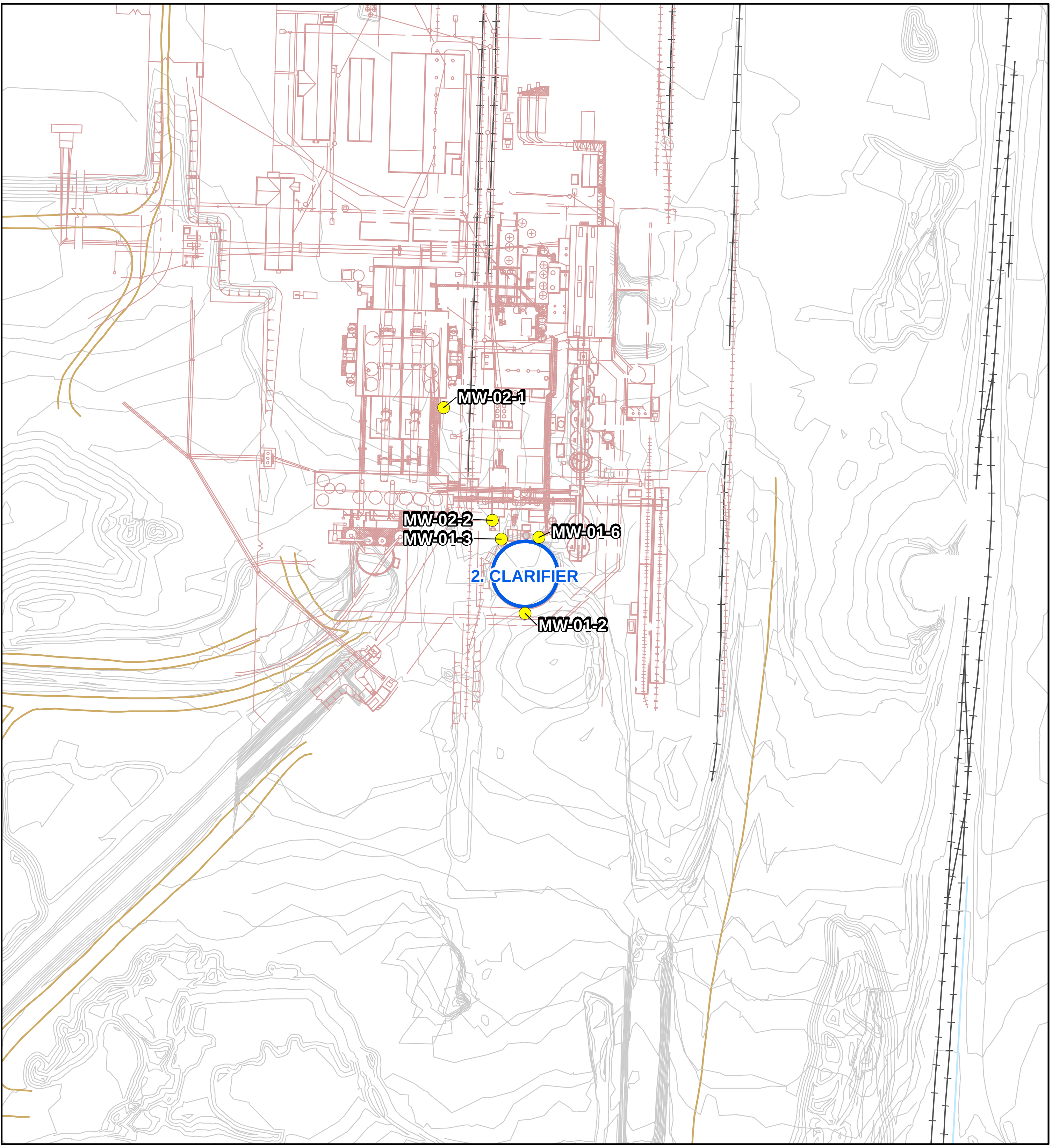
Bold font indicates that sample concentration is greater than the 95% UCL of mean Reference Area Concentration.

N

Feet
200 0 200

Figure 5.5.2-4

SWMU 2
METALS
Rhodia Silver Bow Plant
Montana



- ● Monitoring Well
- ☐ SWMU 2
- Elevation Contour
- Drainage
- Railroad
- Road
- Former Plant Structures

Figure 5.5.2-5

SWMU 2
MONITORING WELL
LOCATIONS
Rhodia Silver Bow Plant
Montana

Figures 5.5.2-6 - 5.5.2-9
Groundwater Quality - General and Site Specific Parameters
SWMU 2

Figure 5.5.2-6
Groundwater Quality Time Series - Fluoride

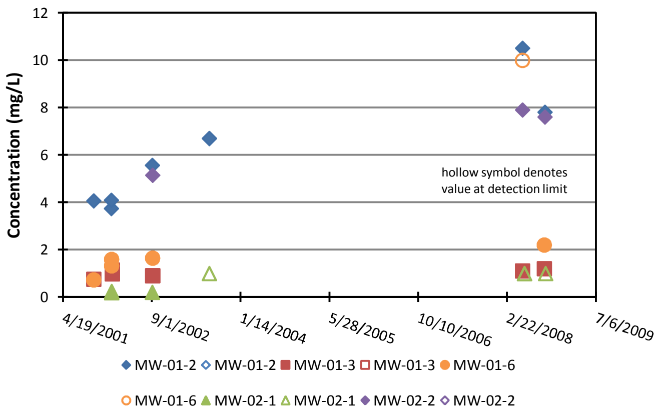


Figure 5.5.2-7
Groundwater Quality Time Series - Elemental Phosphorous

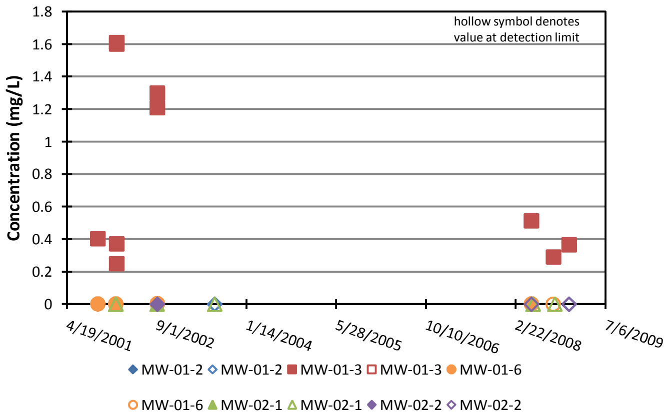


Figure 5.5.2-8
Groundwater Quality Time Series - Total Phosphorous

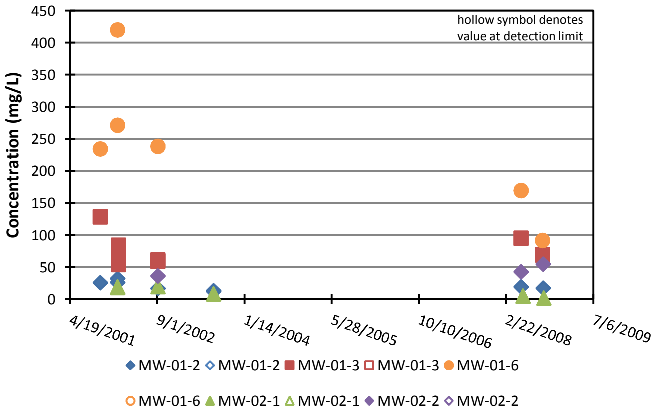
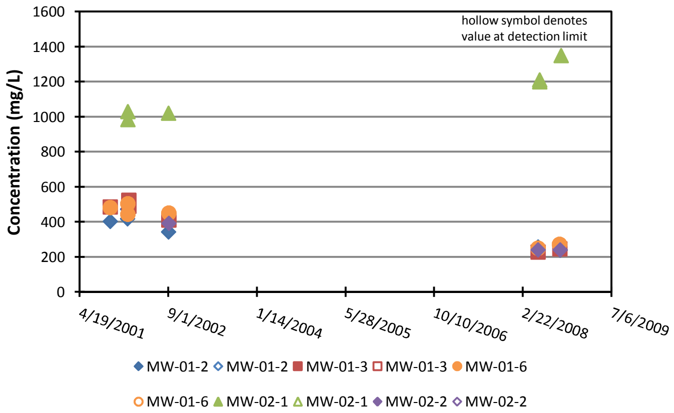


Figure 5.5.2-9
Groundwater Quality Time Series - Sulfate



Figures 5.5.2-10 - 5.5.2-39
Groundwater Quality - Metals
SWMU 2

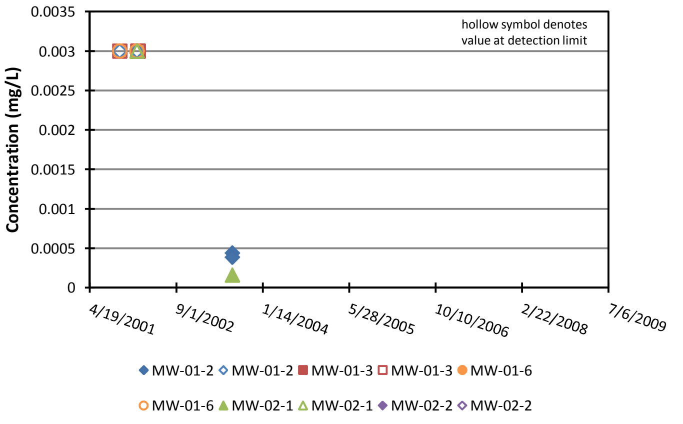


Figure 5.5.2-10
Groundwater Quality Time Series - Dissolved Antimony

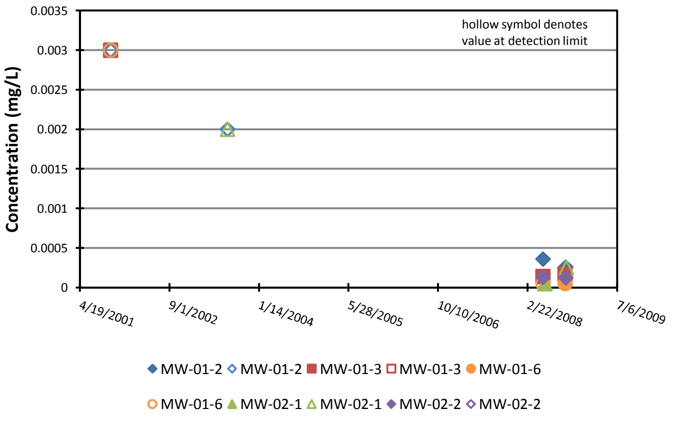


Figure 5.5.2-11
Groundwater Quality Time Series - Total Antimony

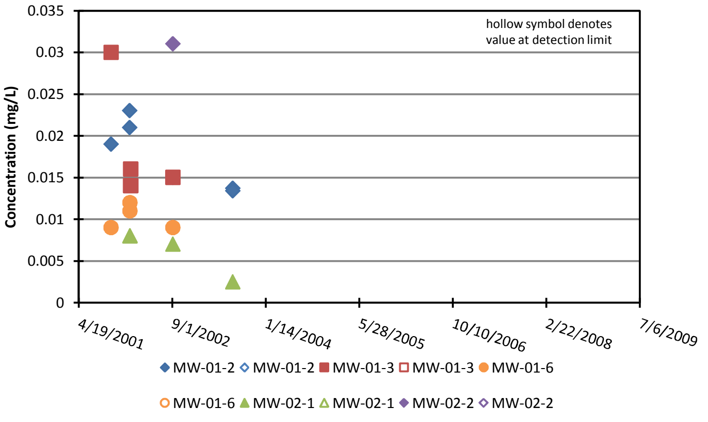


Figure 5.5.2-12
Groundwater Quality Time Series - Dissolved Arsenic

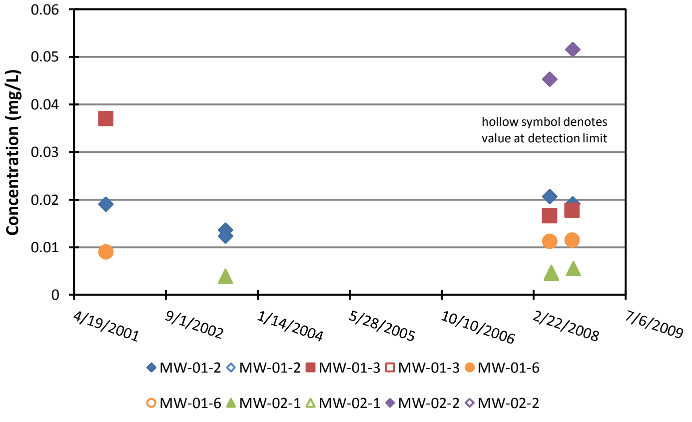


Figure 5.5.2-13
Groundwater Quality Time Series - Total Arsenic

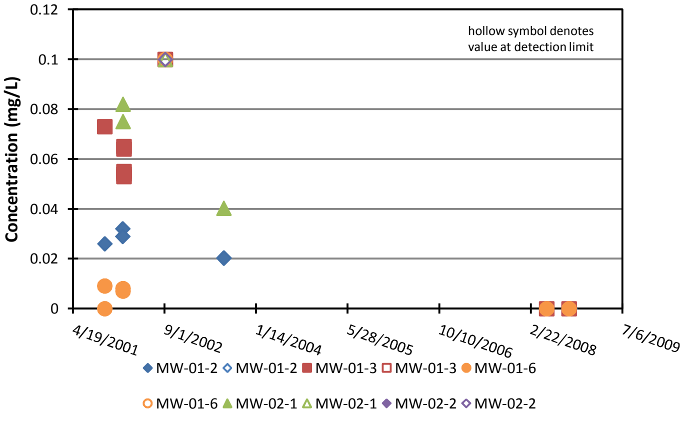


Figure 5.5.2-14
Groundwater Quality Time Series - Dissolved Barium

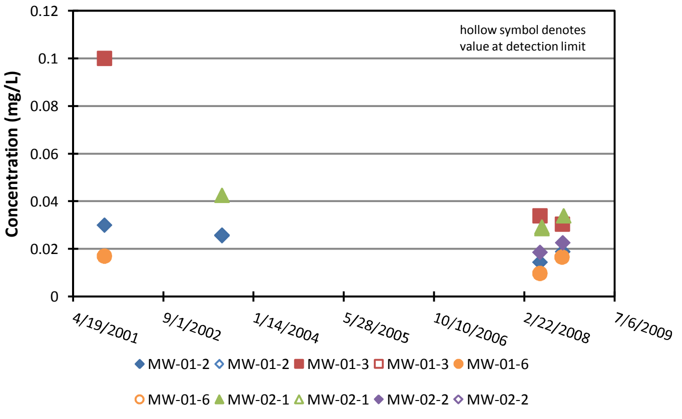


Figure 5.5.2-15
Groundwater Quality Time Series - Total Barium

Figures 5.5.2-10 - 5.5.2-39
Groundwater Quality - Metals
SWMU 2

Figure 5.5.2-16
Groundwater Quality Time Series - Dissolved Beryllium

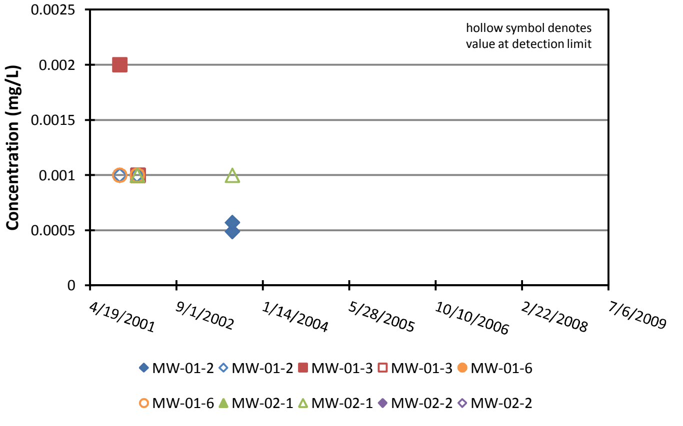


Figure 5.5.2-17
Groundwater Quality Time Series - Total Beryllium

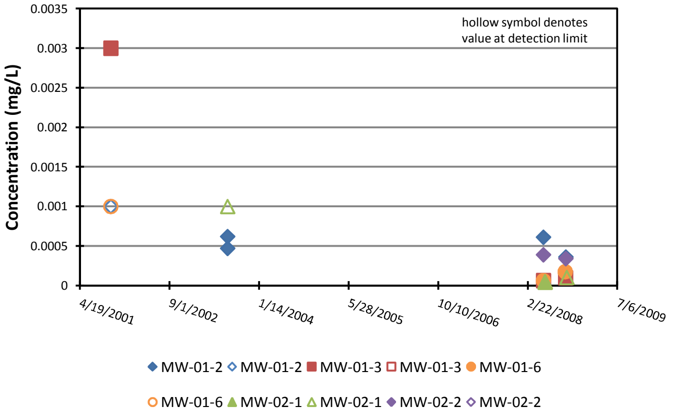


Figure 5.5.2-18
Groundwater Quality Time Series - Dissolved Cadmium

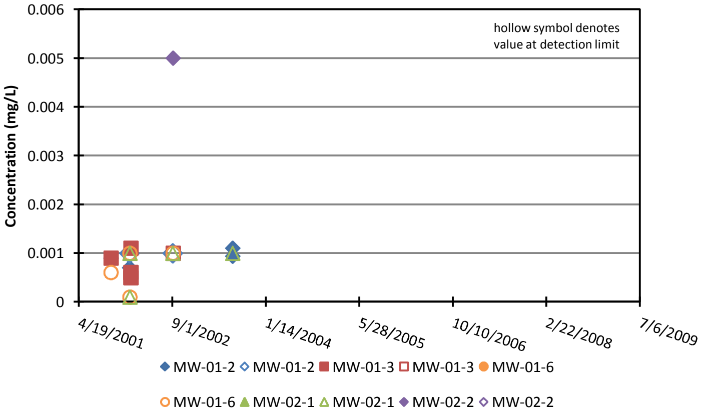


Figure 5.5.2-19
Groundwater Quality Time Series - Total Cadmium

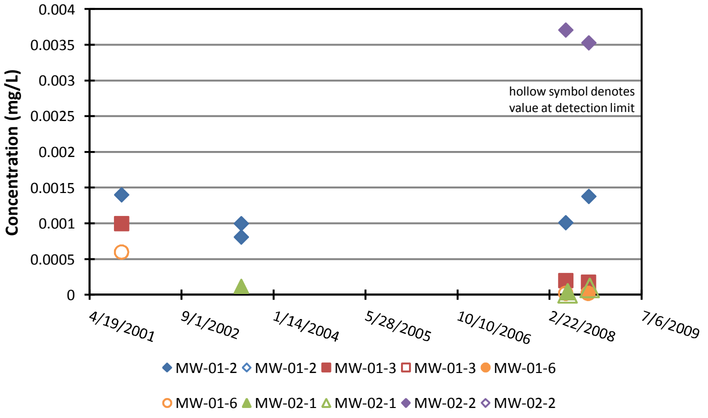


Figure 5.5.2-20
Groundwater Quality Time Series - Dissolved Chromium

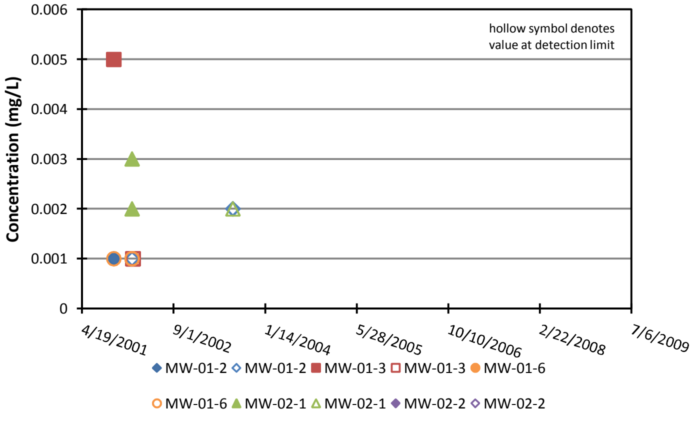
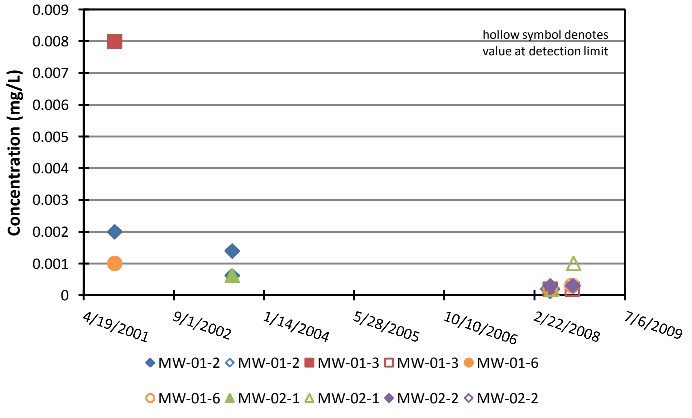


Figure 5.5.2-21
Groundwater Quality Time Series - Total Chromium



Figures 5.5.2-10 - 5.5.2-39
Groundwater Quality - Metals
SWMU 2

Figure 5.5.2-22
Groundwater Quality Time Series - Dissolved Cobalt

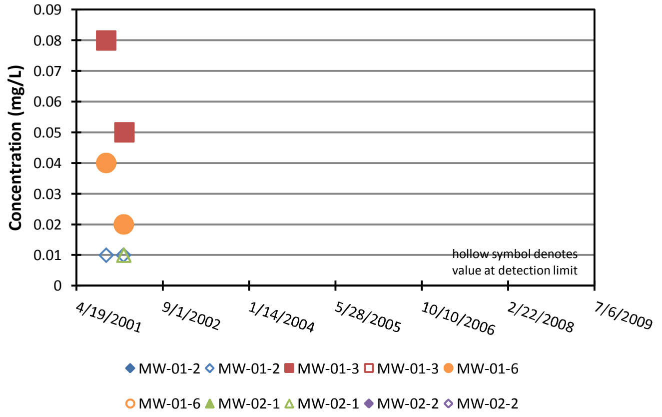


Figure 5.5.2-23
Groundwater Quality Time Series - Total Cobalt

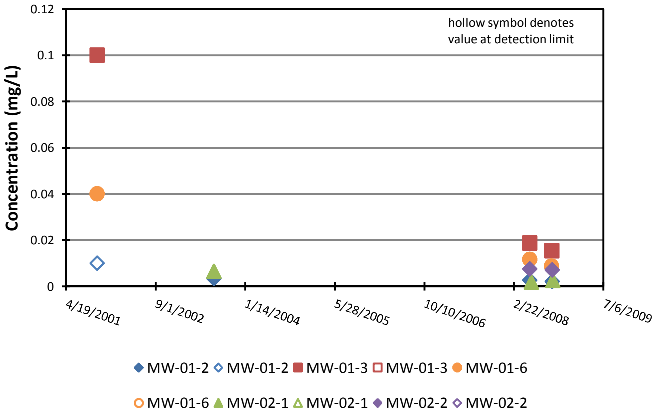


Figure 5.5.2-24
Groundwater Quality Time Series - Dissolved Manganese

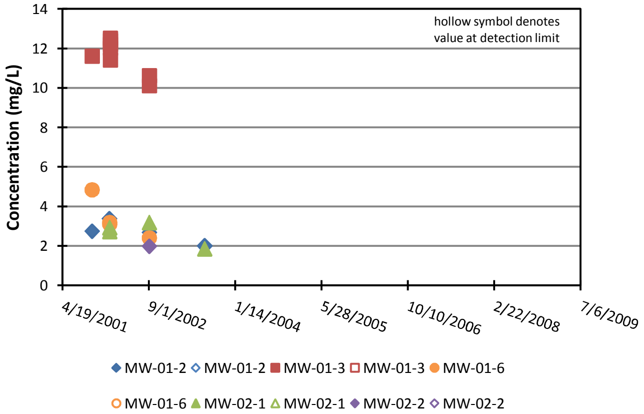


Figure 5.5.2-25
Groundwater Quality Time Series - Total Manganese

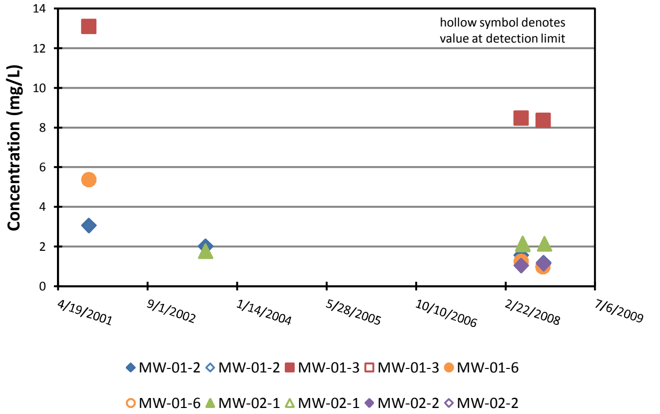


Figure 5.5.2-26
Groundwater Quality Time Series - Dissolved Nickel

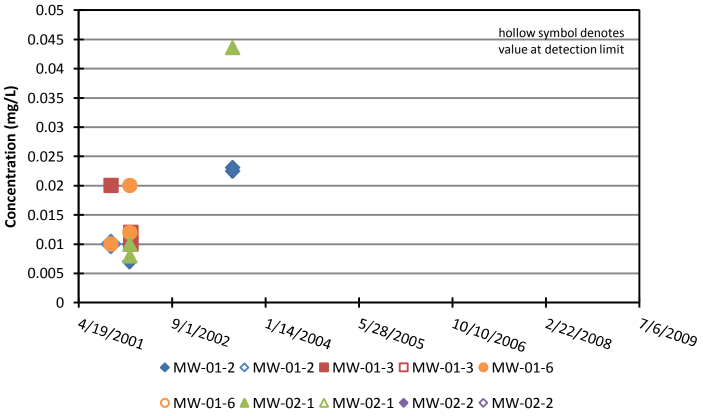
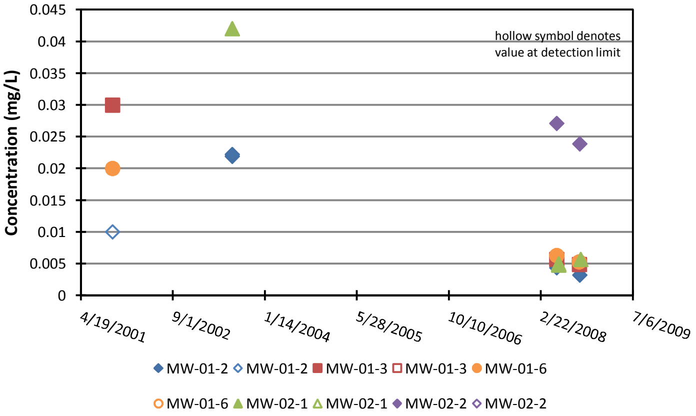


Figure 5.5.2-27
Groundwater Quality Time Series - Total Nickel



Figures 5.5.2-10 - 5.5.2-39
Groundwater Quality - Metals
SWMU 2

Figure 5.5.2-28
Groundwater Quality Time Series - Dissolved Selenium

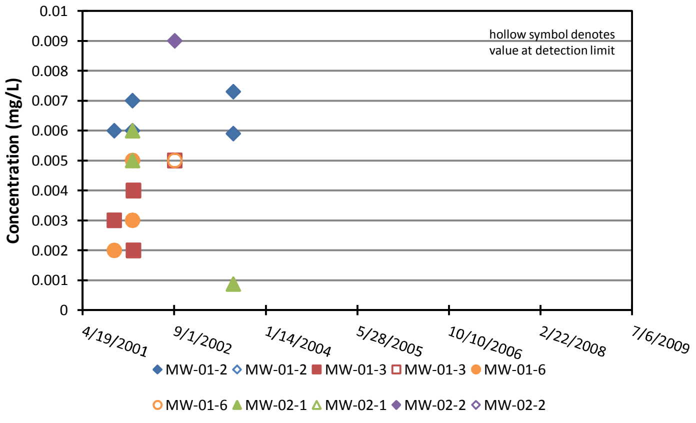


Figure 5.5.2-29
Groundwater Quality Time Series - Total Selenium

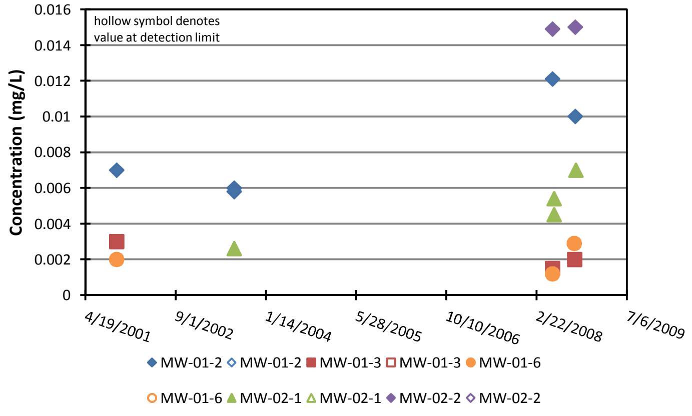


Figure 5.5.2-30
Groundwater Quality Time Series - Dissolved Silver

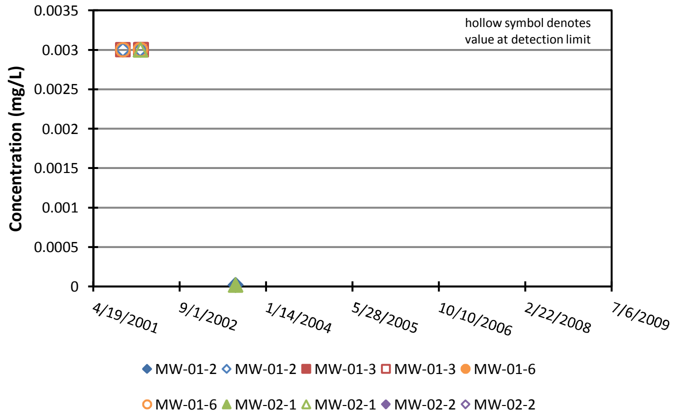


Figure 5.5.2-31
Groundwater Quality Time Series - Total Silver

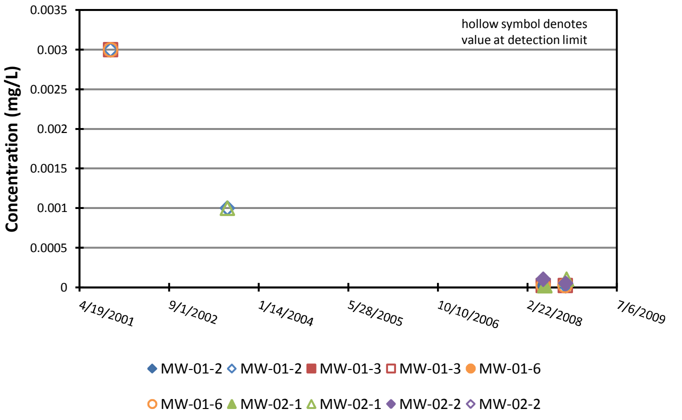


Figure 5.5.2-32
Groundwater Quality Time Series - Dissolved Thallium

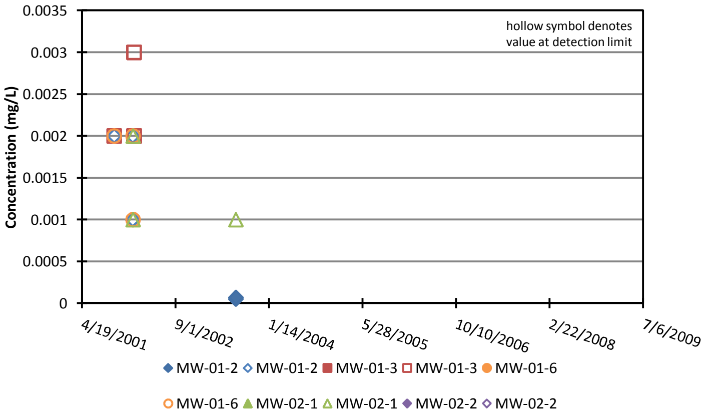
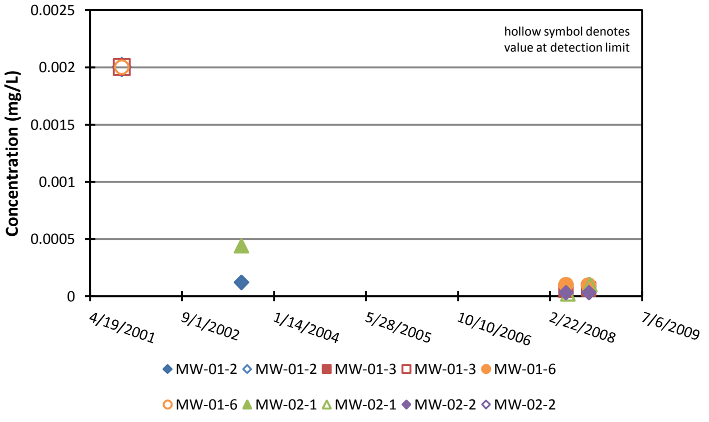


Figure 5.5.2-33
Groundwater Quality Time Series - Total Thallium



Figures 5.5.2-10 - 5.5.2-39
Groundwater Quality - Metals
SWMU 2

Figure 5.5.2-34
Groundwater Quality Time Series - Dissolved Uranium

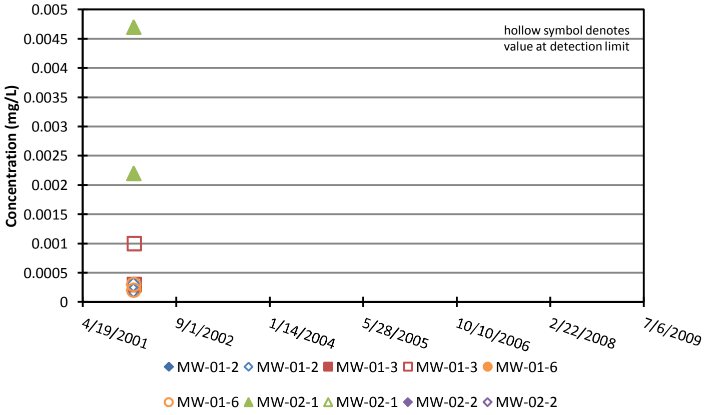


Figure 5.5.2-35
Groundwater Quality Time Series - Total Uranium

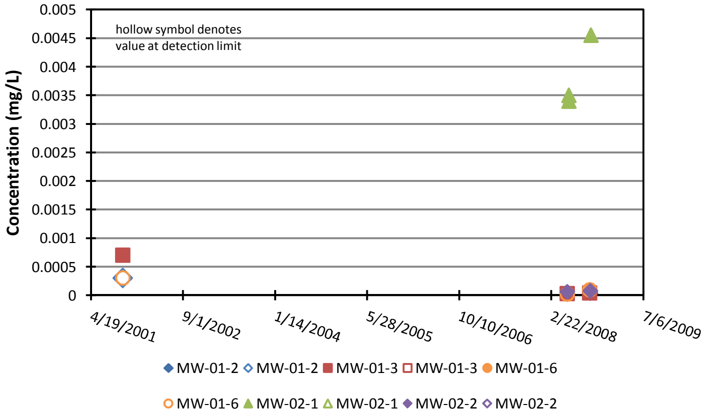


Figure 5.5.2-36
Groundwater Quality Time Series - Dissolved Vanadium

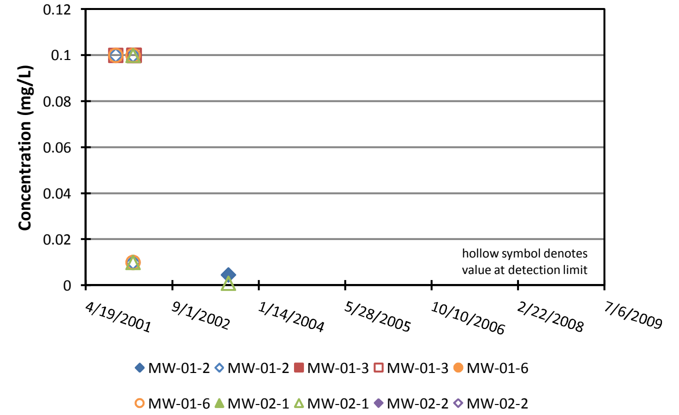


Figure 5.5.2-37
Groundwater Quality Time Series - Total Vanadium

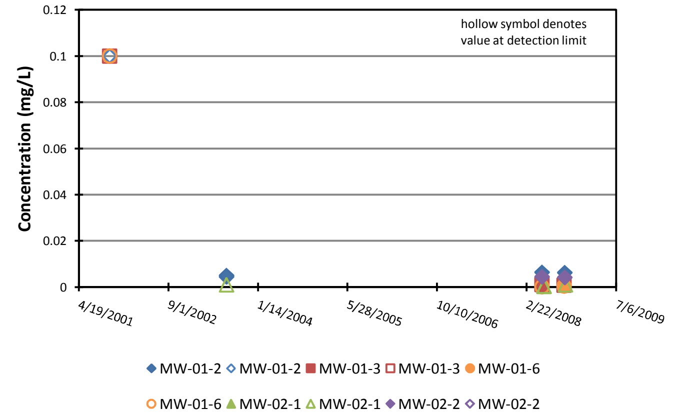


Figure 5.5.2-38
Groundwater Quality Time Series - Dissolved Zinc

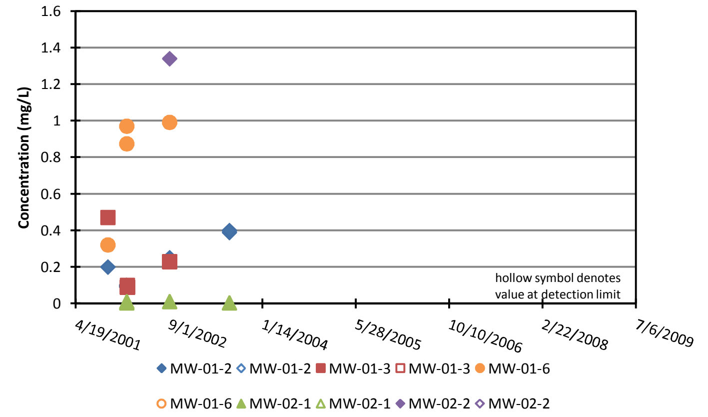
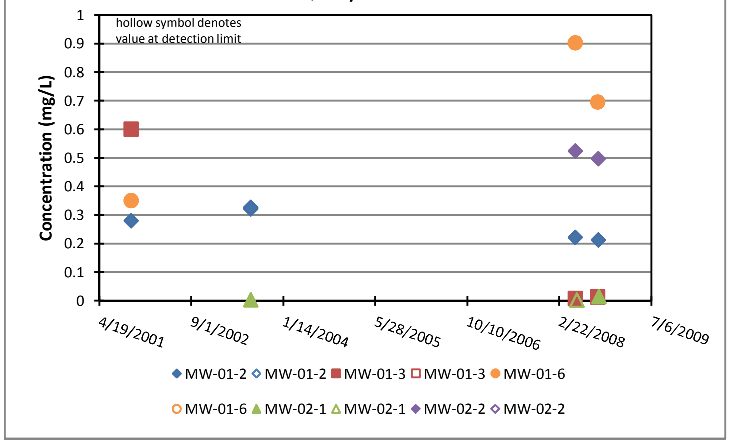
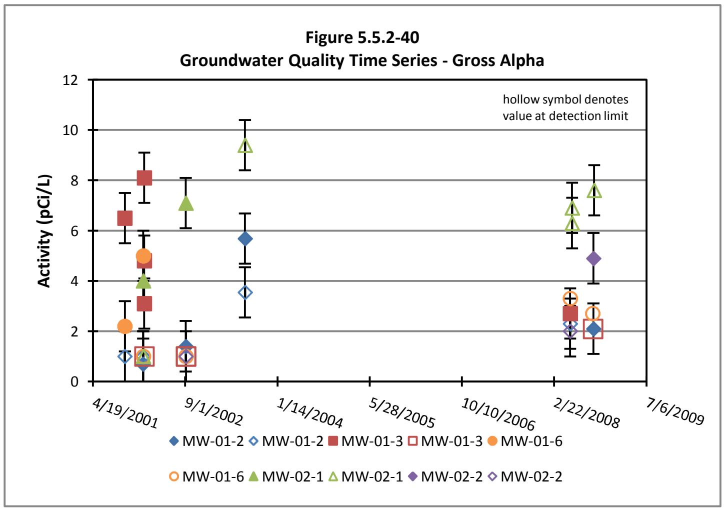
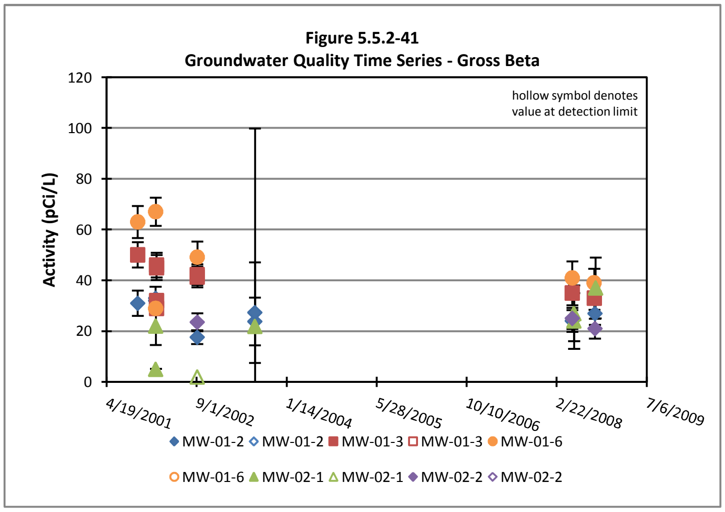


Figure 5.5.2-39
Groundwater Quality Time Series - Total Zinc



Figures 5.5.2-40 - 5.5.2-41
Groundwater Quality - Radionuclides
SWMU 2





Appendices

Appendix 5.5.2-A

Boring/Monitoring Well Logs

Barr Engineering Company | **Ref. Boring # n/a** | **Well # MW-01-2**

Project: Pre-Closure Groundwater Monitoring Program

Project Number:	26/25/001-JSL-021
Boring Location:	Rhodia Silver Bow Plant - Butte, Montana
Drilling Contractor:	O'Keefe Drilling
Drilling Method:	Hollow Stemmed Auger
Driller:	Steve Malkovich
Geologist:	Sheryl Filby
Total Drilled Depth (ft):	43.4
Ground Surface Elevation (ft):	5361.3
Depth to Groundwater (ft):	36.59
Riser Elevation (ft):	5363.47
Date Started:	9/18/01
Date Completed:	9/18/01

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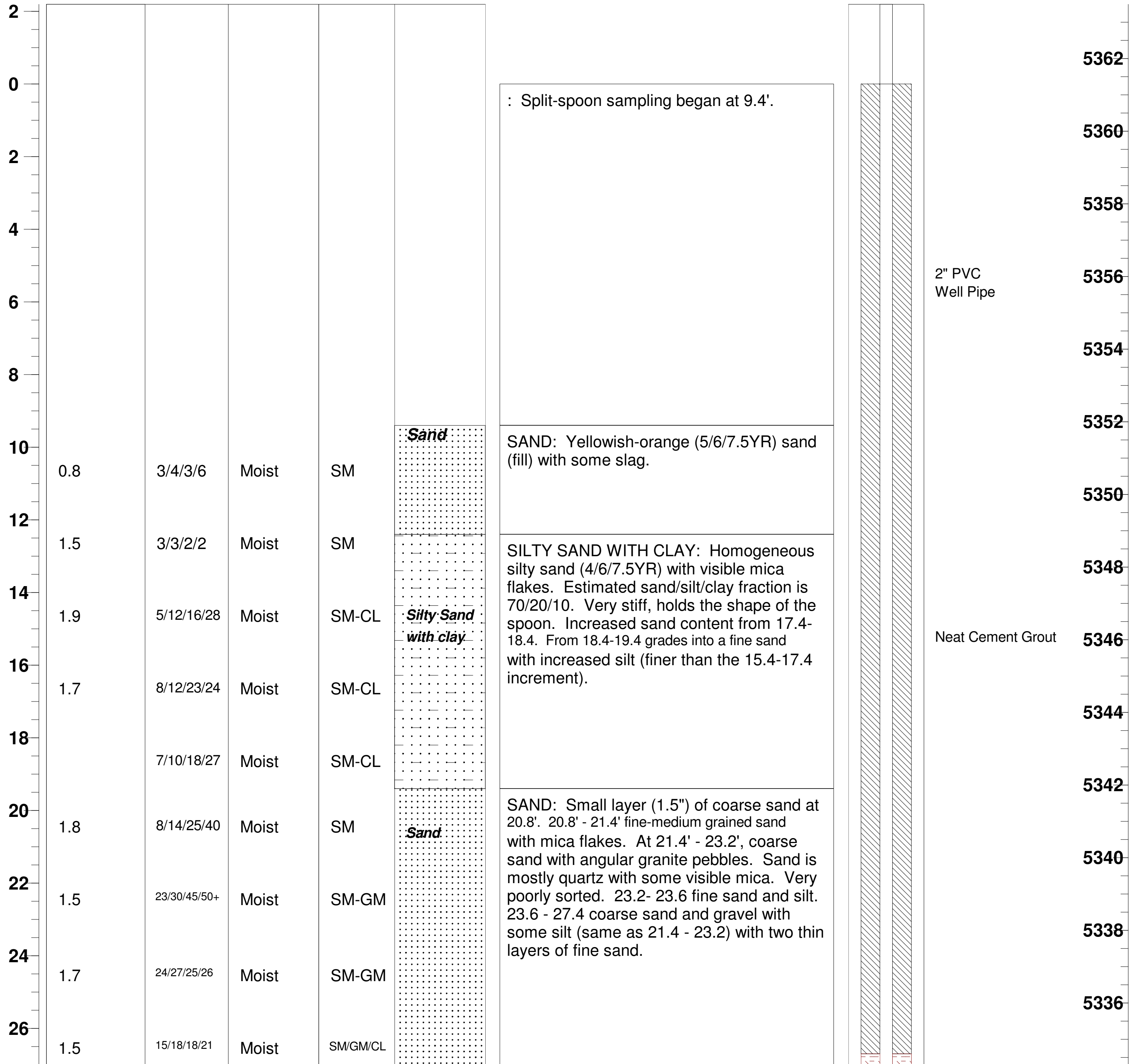
Page 1 of 2



Split spoon Recovery (ft)	Blow Count	Moisture/W.L.	ASTM	Lithologic Unit	Material Descriptions and Remarks	Well Construction/ Comments
					: Split-spoon sampling began at 9.4'.	2" PVC Well Pipe
0.8	3/4/3/6	Moist	SM	Sand	SAND: Yellowish-orange (5/6/7.5YR) sand (fill) with some slag.	
1.5	3/3/2/2	Moist	SM	Silty Sand with clay	SILTY SAND WITH CLAY: Homogeneous silty sand (4/6/7.5YR) with visible mica flakes. Estimated sand/silt/clay fraction is 70/20/10. Very stiff, holds the shape of the spoon. Increased sand content from 17.4-18.4. From 18.4-19.4 grades into a fine sand with increased silt (finer than the 15.4-17.4 increment).	
1.9	5/12/16/28	Moist	SM-CL			Neat Cement Grout
1.7	8/12/23/24	Moist	SM-CL			
	7/10/18/27	Moist	SM-CL			
1.8	8/14/25/40	Moist	SM	Sand	SAND: Small layer (1.5") of coarse sand at 20.8'. 20.8' - 21.4' fine-medium grained sand with mica flakes. At 21.4' - 23.2', coarse sand with angular granite pebbles. Sand is mostly quartz with some visible mica. Very poorly sorted. 23.2- 23.6 fine sand and silt. 23.6 - 27.4 coarse sand and gravel with some silt (same as 21.4 - 23.2) with two thin layers of fine sand.	
1.5	23/30/45/50+	Moist	SM-GM			
1.7	24/27/25/26	Moist	SM-GM			
1.5	15/18/18/21	Moist	SM/GM/CL			

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Barr Engineering Company

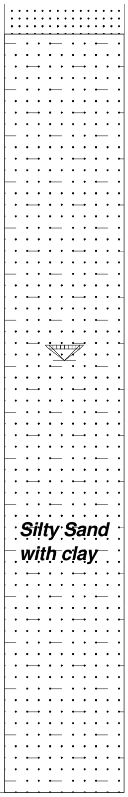
Ref. Boring # n/a

Well # MW-01-2

Page 2 of 2

Depth (ft. bgs)	Sample Type/ Recovery (ft.)	Blow Count	Moisture\W.L.	ASTM
28	1.7	12/18/33/48	Moist	SM
30	1.8	12/18/28/34	Moist	SM
32	1.7	8/10/18/28	Moist	SM
34	1.6	8/16/25/22	Moist	SM
36	2.0	7/14/26/47	Moist/Sat.	SM
38	1.2	8/30/50+	Sat.	SM-ML
40	1.2	17/50+	Sat.	SM-ML
42	2.0	15/15/33/50+	Sat.	SM-ML

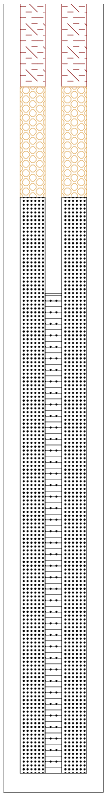
Lithologic Unit



Material Descriptions and Remarks

SILTY SAND WITH CLAY: Homogeneous silty sand. Fine grained with mica (4.6/7.5YR). Slight increase fines at 33.7. At 35.0', 1.5" layer of coarse sand. Increased clay content at 37.4 that maintains until depth.

Well Construction/ Comments



Hole Plug

100-mesh Sand

#6-slot 2" PVC Screen

Specified Sand Pack

Elevation

5334

5332

5330

5328

5326

5324

5322

5320

5318

Barr Engineering Company

Ref. Boring # n/a

Well # MW-01-3

Project: Pre-Closure Groundwater Monitoring Program

Project Number: 26/25/001-JSL-021
Boring Location: Rhodia Silver Bow Plant - Butte, Montana
Drilling Contractor: O'Keefe Drilling
Drilling Method: Hollow Stemmed Auger
Driller: Steve Malkovich
Geologist: Sheryl Filby

Total Drilled Depth (ft): 40.3
Ground Surface Elevation (ft): 5357.0
Depth to Groundwater (ft): 32.74
Riser Elevation (ft): 5358.99
Date Started: 9/19/01
Date Completed: 9/21/01

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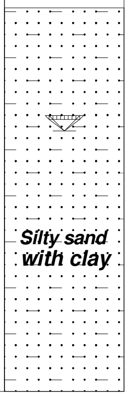
Page 1 of 1

Depth (ft. bgs)	Split spoon Recovery (ft)	Blow Count	Moisture/W.L.	ASTM
0				
2				
4				
6				
8				
10				
12				
14				
16				
18				
20				
22				
24				
26				
28	1.5	31/19/29/30	moist	SM-GM
30	2.0	20/22/28/50+	moist-sat.	SM-SC
32	1.8	14/44/50+	moist	SM/CL
34	2.0	13/28/38/50	sat.	SM/CL
36	2.0	15/16/18/40	sat.	SM/CL
38	1.8	12/28/23/50+	sat.	SM/CL
40	1.2	15/20/50+	sat.	SM/CL

Lithologic Unit

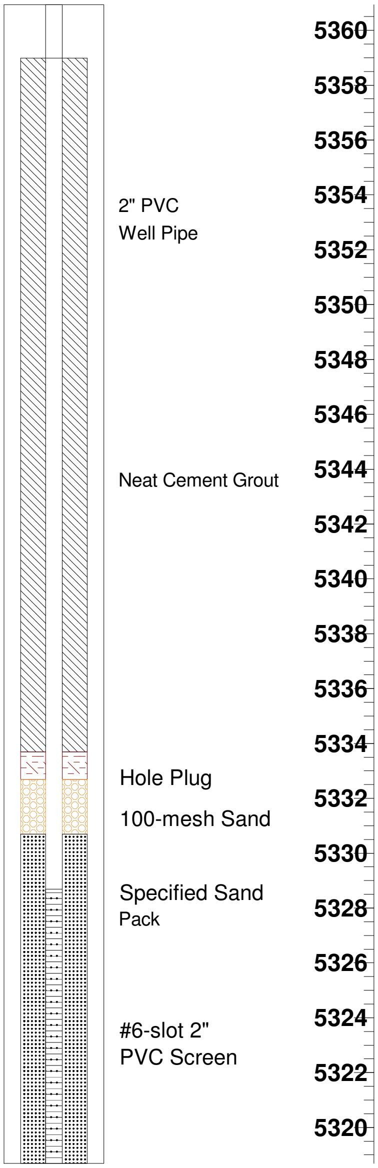


Material Descriptions and Remarks

: Split-spoon sampling began at 26.3'.

SILTY SAND WITH CLAY: 26.3-27.3 Clayey fine sand. 27.3-28.3 Coarse grained sand with mica. Sample smoking. Phosphorus odor. At 28.3', silty sand with some clay. From 28.3 - 28.5 saturated. 29.8-30.3 increased fines- moist but not saturated. 30.3- 38.3 homogenous siltysand with clay with mica. 38.3-40.3 coarse grained sand and gravel with subangular pebbles. Samples smoking throughout. Phosphorus odor throughout.

Well Construction/ Comments **Elevation**



Barr Engineering Company

Ref. Boring # n/a

Well # MW-01-6

Project:	**Pre-Closure Groundwater Monitoring Program**	**Total Drilled Depth (ft):**	40.3
Project Number:	26/25/001-JSL-021	**Ground Surface Elevation (ft):**	5356.0
Boring Location:	Rhodia Silver Bow Plant - Butte, Montana	**Depth to Groundwater (ft):**	31.56
Drilling Contractor:	O'Keefe Drilling	**Riser Elevation (ft):**	5357.75
Drilling Method:	Hollow Stemmed Auger	**Date Started:**	9/21/01
Driller:	Steve Malkovich	**Date Completed:**	9/21/01
Geologist:	Sheryl Filby		

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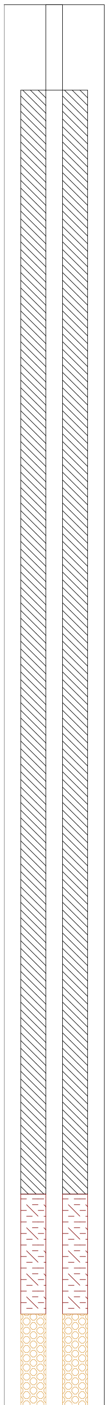
Page 1 of 2

Depth (ft. bgs)	Split spoon Recovery (ft)	Blow Count	Moisture/W.L.	ASTM	Lithologic Unit	Material Descriptions and Remarks	Well Construction/ Comments	Elevation
0						: Split-spoon sampling began at 29.0'.		5356
2								5354
4								5352
6							2" PVC Well Pipe	5350
8								5348
10								5346
12								5344
14								5342
16							Neat Cement Grout	5340
18								5338
20								5336
22								5334
24							Hole Plug	5332
26							100-mesh Sand	5330



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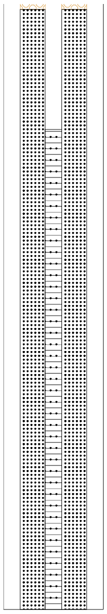
Barr Engineering Company

Ref. Boring # n/a

Well # MW-01-6

Page 2 of 2

Depth (ft. bgs)	Sample Type/ Recovery (ft.)	Blow Count	Moisture\W.L.	ASTM	Lithologic Unit	Material Descriptions and Remarks	Well Construction/ Comments	Elevation
28								5328
						SILTY SAND WITH CLAY: Fine sand with silt and clay. Very tight. Some weathered quartz granite pebbles. Mica Flakes. 4/6/7.5YR. Some coarse grained saturated sand in lenses.		
30	1.8	11/18/32/50+	moist	SM/CL/ML			Specified Sand Pack	5326
32	1.8	12/19/32/42	moist	SM/CL/ML				5324
34	2.0	13/18/32/50+	sat.	SM/CL/ML				5322
					Silty sand with clay.		#6-slot 2" PVC Screen	
36	2.0	14/25/35/45	sat.	SM/CL/ML				5320
38	1.8	17/27/31/50+	sat.	SM/CL/ML	Coarse sand.	SAND AND GRAVEL: Coarse sand and gravel.		5318
					Medium sand.	SAND: Dark brown medium grained sand with mica.		
40								5316



Barr Engineering Company

Ref. Boring # n/a

Well # MW-02-2

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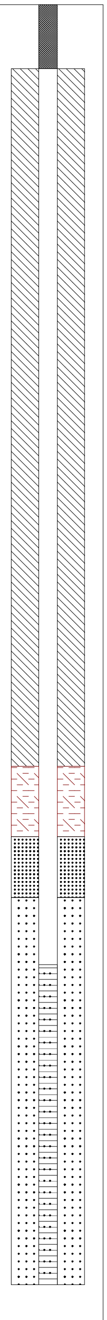
Project: 2002 Requested Services

Project Number:	26/25/001-JSL-035	**Total Drilled Depth (ft):**	38.0 (bgs)
Boring Location:	Rhodia Silver Bow Plant - Butte, Montana	**Ground Surface Elevation (ft):**	5357.10
Drilling Contractor:	O'Keefe Drilling	**Depth to Groundwater (ft):**	34.94 (bgs)
Drilling Method:	Hollow Stem Auger	**Riser Elevation (ft):**	5358.81
Driller:	Steve Malkovich	**Date Started:**	8/19/02
Geologist:	Karma Geiger	**Date Completed:**	8/20/02

Page 1 of 1

Depth (ft. bgs)	Split spoon Recovery (ft)	Blow Count	Moisture/W.L.	ASTM	Odor/PH3 Reading	Lithologic Unit	Material Descriptions and Remarks	Well Construction/ Comments
2								
0						Fill	FILL: Concrete and fill.	
2	1.6	156	dry	SM	No/0.00		SILTY SAND: Yellowish-brown (7.5YR5/4), homogenous, very dense, silty sand. Sand is mostly fine grained but includes medium to coarse sand as well as trace fine gravel. Sand is predominantly golden-colored mica and subrounded to subangular quartz. Silt fraction is 30%.	
4	1.6	18/26/30/31	dry	SM	No/0.00			
6	1.9	15/24/34/38	dry	SM	No/0.00			2" PVC Well Pipe
8	1.6	12/24/32/41	dry	SM	No/0.00	Silty Sand		
10	1.6	16/27/41/49	dry	SM	No/0.00			
12	1.6	21/32/34/36	dry	SP	No/0.00	Sand	SAND: Light gray (10YR7/2), loose fine to coarse sand with trace silt.	
14	1.6	13/20/33/40	dry	SM	No/0.00		SILTY SAND: Homogenous, dark yellowish brown (10YR4/4), very dense silty fine sand with trace gravel. Sand includes 20% medium to coarse grained sand with fine gravel. Silt fraction is approximately 40%. Sand is golden-colored mica (possible iron pyrite), quartz and igneous.	Neat Cement Grout
16	1.7	11/15/22/29	moist	SM	No/0.00			
18	1.9	10/19/30/50	moist	SM	No/0.00	Silty Sand with Gravel		
20	1.8	10/21/33/54	dry	SM	No/0.00			
22	1.8	11/17/36/48	dry	SM	No/0.00			Hole Plug
24	1.8	8/22/37/38	dry	SM-ML	No/0.00	Silty Sand to Silt	SILTY SAND TO SILT: Dark yellowish brown silty very fine sand.	100 Sieve Sand
26	1.8	8/21/38/45	moist	SM	No/0.00		SILTY SAND: Homogenous, dark yellowish brown, homogenous silty sand. Sand is mostly very fine to fine grained but includes up to approximately 15% medium to coarse sand and trace fine gravel. Sand is quartz, mica and igneous-rich. Silt fraction is 35 to 40%.	
28	1.7	8/20/28/48	moist	SM	No/0.00			
30	1.8	13/42/68/91	moist	SM	No/0.00	Silty Sand with Clay		70/30 Sand Pack
32	1.8	12/24/30/52	dry moist	SM	No/0.00			
34	1.8	10/24/43/74	saturated	SM	No/0.00			#6-slot 2" PVC Screen
36	1.9	11/24/42/63	saturated	SM	No/0.00			
38								
40								



Elevation

5358
5356
5354
5352
5350
5348
5346
5344
5342
5340
5338
5336
5334
5332
5330
5328
5326
5324
5322
5320
5318

Barr Engineering Company

Ref. Boring # n/a

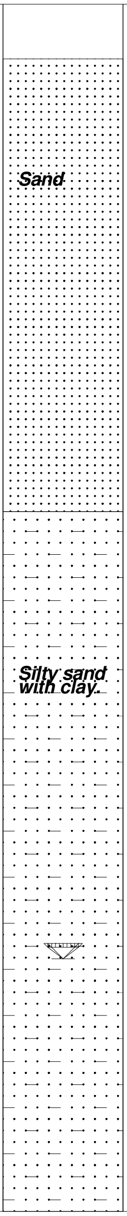
Well # MW-02-1

Project:	**Pre-Closure Groundwater Monitoring Program**
Project Number:	26/25/001-JSL-031
Boring Location:	Rhodia Silver Bow Plant - Butte, Montana
Drilling Contractor:	O'Keefe Drilling
Drilling Method:	Hollow Stemmed Auger
Driller:	Steve Malkovich
Geologist:	Sheryl Filby
Total Drilled Depth (ft):	42.0
Ground Surface Elevation (ft):	5356.54
Depth to Groundwater (ft):	32.8
Riser Elevation (ft):	5358.70
Date Started:	1/14/02
Date Completed:	1/15/02

Page 1 of 1

Depth (ft. bgs)	Split spoon Recovery (ft)	Blow Count	Moisture/W.L.	ASTM	Odor/PH3 Reading	Elevation
-2						5358
0	2.0	frozen	none	SM	N/0.0	5356
2	1.5	10/10/12/14	none	SM	N/0.0	5354
4	1.7	23/30/33/46	none	SM	N/0.0	5352
6	1.7	23/44/57/58	none	SM	N/0.0	5350
8	1.6	21/38/64/71	none	SM	N/0.0	5348
10	1.6	31/51/73/90	none	SM	N/0.0	5346
12	1.6	26/37/64/78	none	SM	N/0.0	5344
14	1.6	30/46/53/57	none	SM-ML	N/0.0	5342
16	1.7	22/31/50/61	none	SM-ML	N/0.0	5340
18	1.7	16/19/30/46	none	SM-ML	N/0.0	5338
20	1.7	22/34/54/71	none	SM-ML	N/0.0	5336
22	1.6	32/56/87/116	moist	SM-ML	N/0.0	5334
24	1.7	30/36/62/75	moist	SM-ML	N/0.0	5332
26	1.7	28/57/83/105	moist	SM-ML	N/0.0	5330
28	1.8	30/44/68/74	moist	SM-ML	N/0.0	5328
30	1.8	23/50/55/73	moist	SM-ML	N/0.0	5326
32	1.8	22/36/48/63	moist	SM-ML	N/0.0	5324
34	1.8	12/32/50/67	moist-wet	SM-ML	N/0.0	5322
36	1.8	?12/22/41/52?	moist-wet	SM-ML	N/0.0	5320
38	1.8	17/63/74/101	moist-wet	SM-ML	N/0.0	5318
40	2.0	31/49/73/112	moist-wet	SM-ML	SL/0.0	5316
42						

Lithologic Unit



Material Descriptions and Remarks

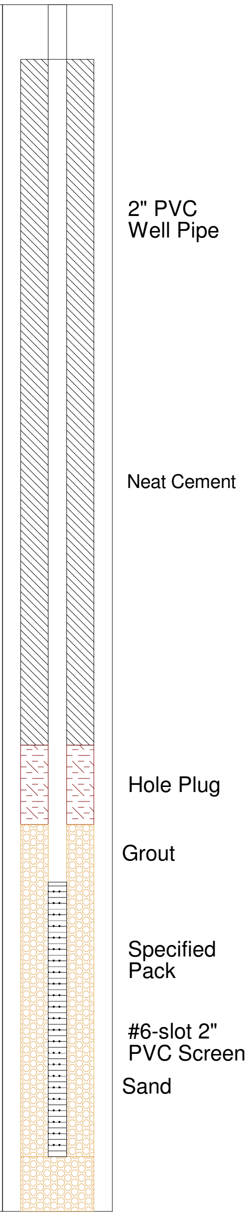
SAND: 0-0.3', sand and gravel. 0.3-0.4', slag. 0.4-0.6' brown (2.5/3 7.5YR) organic-rich soil. 0.6-4'light brown (7/4 10YR) silty sand with some small angular pebbles. At 6', color grades into 6/6 10yr. 8-12', increased fines. 12-14.5, fine grained sand with some medium grained sand, sand/silt/clay 70/30/0. 14.5-14.7', pocket of medium grained sand. 14.7-16', silty sand with mica. 16-16.5', as 14.7-16' with some medium sand.

SILTY SAND WITH CLAY: 16.5-17.8, fine grained sand and silt with some clay. Mica and small sub-angular pebbles present. Color 5/6/7.5YR. 17.8-18.4', increased silt (55/40/5). 18.4-19.3, thin layer of medium-coarse sand. 19.3-19.5, clean fine sand with some silt (8/1 10YR). 19.5-42', silty fine grained sand with clay (65/30/5). Includes mica and small sub-angular pebbles. Reddish color (5/6/7.5 YR).

37.6-37.7', thin layer of black stained soil. No noticeable odor. Sheen observed on drill bit.

41.6-41.7', thin layer of black stained soil. Slight petroleum odor.

Well Construction/ Comments



Appendix I

July 31, 2003 Letter
Enhanced RCRA Cap Alternative

July 31, 2003

Mr. John F. Wardell
Director, Montana Office
U.S. EPA, Region 8
Federal Building
10 West 15th Street, Suite 3200
Helena, MT 59626

Re: **Preliminary Decision on Draft Waste Plan**
Rhodia – Silver, Bow, Montana

Dear Mr. Wardell:

In your June 27, 2003 letter, you asked Rhodia to identify issues we would like to discuss with you regarding the Focused Feasibility Study (FFS) prepared by Booz Allen Hamilton (BAH), and EPA Region 8's preliminary conclusion that off-site incineration is the best option for management of the clarifier wastes. The main issue we would like to discuss is an alternative capping option that we will summarize below.

We have developed this alternative to address what we understand is the Region's principle concern with a capping option—that the capped material could become a hazard in the future. The new option addresses this concern by, among other things, using the advanced "Astaris-type cap" design for Ponds 8S and 15S at the FMC/Astaris plant that EPA Region 10 recently approved after our Waste Plan was submitted. This is also the cap design your consultant BAH has recommended for the clarifier material. In addition, the groundwater around the cap will be monitored. Phosphine generated under the cap will also be monitored, collected and treated, again as BAH has recommended. Institutional controls, layered in the manner suggested in EPA's guidance, will be established to prevent future disturbance of the cap and exposure to affected groundwater, and to require future owners to maintain the cap, groundwater and phosphine monitoring systems. Rhodia will also provide long-term financial assurance to inspect, monitor and maintain these systems.

This package of cap design enhancements, the institutional controls, the monitoring and maintenance of the cap, groundwater and phosphine systems, and the financial assurances exceeds by far the protections normally associated with approved caps of similar waste. This new proposal would likely cost Rhodia over 75% more than the enhanced cap that Rhodia proposed in the Waste Plan. And unlike incineration, capping is well-supported by the many other caps that have routinely and successfully been used to close elemental phosphorus units at over a dozen facilities. Indeed, as recently as January 2002, EPA Region 10 selected a capping remedy for Pond 18 Cell A at FMC's Pocatello facility.[1]

We would like to discuss this new capping option in a meeting with you in the near future. We would also be pleased to discuss at this meeting any of our over 30 comments on BAH's assumptions and conclusions in the FFS. Many of our comments on the FFS identify shortcomings in the BAH analysis that Region 8 should consider before it seeks public comment on remedial options. We ask that these comments on the FFS, which are Attachment A hereto, as well as this entire letter and all of its other attachments, be included in the administrative record for the 7003 order. We will describe and discuss the new capping option in the remainder of this letter.

I. New Cap Proposal

A. Design

Rhodia would install a cap over the clarifier material that meets or exceeds the design that EPA Region 10 recently approved for closure of Ponds 8S and 15S at the FMC/Astaris facility. See Attachments B, C, D and E. The Astaris-type cap will provide about 16 feet of cover material over the crude phosphorus in the clarifier. The cap includes a 60 mil flexible membrane liner, a geosynthetic clay liner, and a biotic protection layer. BAH recommended in its FFS that Rhodia use this Astaris-type cap.

When all phases of the cap are completed and adequately sloped to promote proper run-off, the Astaris-type cap will necessarily extend beyond the clarifier and cover other nearby production areas shown on Attachment B, including a currently-capped burial area, which contains the same type of crude phosphorus

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[1] Pond 18 Cell A has approximately 15% elemental phosphorus in the capped solids, which is comparable to the estimated 20% elemental phosphorus in the clarifier. The 15% is based on the total slurry having 0.75% elemental phosphorus content, and the slurry being 5% solids and 95% water. See Volume 2, Section 7 of the "Engineering Package Update for the LDR Waste Treatment System," Astaris, Pocatello, ID (September 2001).

material as the clarifier. As a result, this larger cap will provide additional environmental benefit beyond the clarifier material.[2]

The construction cost alone for this Astaris-type cap is estimated to be about $2.5 million, which is over $1.4 million more expensive than the enhanced cap and almost $2 million more expensive than the soil cap that Rhodia proposed in the Waste Plan.[3]

The Astaris-type cap would be inspected twice a year (after the spring snow melt and before significant snow in the fall) and after precipitation events that exceed the 25-year 24-hour storm design criteria. The cover would be maintained (e.g., mowing), and repairs would be made whenever necessary to correct the effects of settling, erosion or other relevant events. A 10 foot fence and signage, which would warn not to dig or trespass and identify the hazards and a contact telephone number, would be maintained around the cap and repaired and replaced whenever necessary. Rhodia would maintain the cap, fencing and signage for as long as it owns the property, and require its successors, through a combination of contractual obligations and institutional controls, similarly to maintain the cap, fence and signage. For purposes of cost estimates and financial assurances, Rhodia has assumed a 50 year maintenance period.

A groundwater monitoring program would be implemented around the cap that meets the substantive requirements of RCRA post-closure groundwater monitoring at 40 CFR § 265.90 through § 265.94. The approximate locations of the proposed upgradient and downgradient wells are shown on Attachment B. The groundwater monitoring wells would be maintained and repaired, as necessary.

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[2] Prior to construction of the cap, additional sampling will be conducted in the areas beyond the clarifier and the burial area that will be under the cap. The objective of this sampling is to characterize the constituents of concern in the soil in this area. After this sampling is completed, Rhodia would construct all phases of the cap, or if EPA and MDEQ prefer, we would construct the cap in phases that are consistent with timelines that may otherwise be established for remediation of other plant areas beyond the clarifier that may require a cap. For example, Rhodia could first install all of the subgrade up to the flexible membrane liner, and, at a later time, install the liner and complete the remainder of the cap when instructed to do so by the Region.

[3] See Attachment F hereto and "Representative Cost Estimate Summary," Appendix G to Waste Plan (Nov. 16, 2001).

It is expected that 30 years of groundwater monitoring will be more than adequate to establish groundwater quality trends and demonstrate the protectiveness of the cap. Current data show that elemental phosphorus in the groundwater degrades to non-toxic compounds and concentrations within 30 feet of the clarifier, as would be expected based on the chemistry of this element.[4] Modeling discussed in the Waste Plan (pages 76-78) shows that once the clarifier is capped with an enhanced cap, the incremental risk level to humans of cancer from the potential leaching from the capped clarifier is 10^{-7} (1 in 10 million) for arsenic and 10^{-9} (1 in 1 billion) or lower for other heavy metals. These risks are well below EPA's typical 10^{-4} to 10^{-6} drinking water standards. In light of this, and so as not to inflate the expected cost of this groundwater measure, Rhodia has estimated the groundwater monitoring and maintenance costs over a 30 year period. The RCRA regulations allow the Regional Administrator or state authority to require longer term groundwater monitoring, and Rhodia would undertake such longer-term monitoring, if it is determined to be necessary.

Rhodia would also monitor, and as necessary, collect and treat with a carbon system any phosphine gas that is generated from under the cap. A system of pipes will be installed under the cap to collect any gas, and it will be sealed to prevent emissions to the atmosphere and air entering the subgrade. This proposal includes BAH's recommendation to include in the cost estimate the expected costs for a carbon treatment system, which is the same type of system Region 10 approved for FMC at Pocatello. The phosphine monitoring and collection systems would also be inspected routinely and maintained as necessary. Since little phosphine generation is expected based both on the subsurface conditions (neutral pH, about 60°F, and no agitation) and FMC's experience with not seeing appreciable phosphine in the monitoring systems under its completed caps, Rhodia has estimated phosphine collection and treatment for five years to avoid overstatement of those costs. Rhodia would monitor for ten years, <u>i.e.</u>, five more years after collection and treatment, to establish that longer term collection and treatment is not necessary. If a longer period of collection and treatment is determined to be necessary, Rhodia would continue to operate and maintain the phosphine system.

The total operation, monitoring and repair costs, hereafter referred to as "post-closure" costs, are estimated to be about $1.4 million. This is based on: (1) monitoring, maintaining and repairing the cap for 50 years; (2) monitoring the groundwater and maintaining the monitoring wells for 30 years; (3) monitoring phosphine gas for 10 years, collecting and treating gas for five years, and maintaining these systems for those periods of time; and (4) related administration,

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[4] <u>See</u> Pre-Closure Groundwater Monitoring Report, page 32 (December, 2002).

inspection and reporting for up to 50 years. See Attachment F. These periods could be extended or shortened as actual events and observations unfold in the future, but these time frames were chosen to reflect reasonable worst case scenarios that do not unreasonably inflate the future expected costs of this option.

Combining both the $2.5 million construction and the $1.4 million post-closure costs, Rhodia would expect to spend a total of $3.9 million on this new Astaris-type cap option and the post-closure care. The comparable construction and 50-year post-closure cost estimates for the caps Rhodia evaluated in the Waste Plan are $1.7 million for the soil cap, and $2.2 million for the enhanced cap.[5]

B. Financial Assurances

To ensure the long-term reliability of the cap and the groundwater and phosphine systems, Rhodia would provide financial assurance for the approximate $1.4 million post-closure costs in accordance with the substantive financial assurance rules at 40 CFR § 265.145. As noted above, this cost estimate covers the inspection, maintenance and repair of the cap for 50 years, sampling and maintaining the groundwater monitoring system for 30 years, and monitoring and maintaining the phosphine collection and treatment system for 10 years. In the unexpected event that the data show a need to extend these time periods, the Regional Administrator or state authority may require an extension. In that event, Rhodia would maintain financial assurance during the extended period.

The RCRA §7003 order could obligate Rhodia and its successors to undertake the post-closure care (monitoring, maintenance, repair, inspections, reporting, etc.) and to maintain the financial assurances noted above. Since financial assurances are based on the costs of third-parties doing the work, and since the Region and/or state would be the designated beneficiaries of the financial assurance mechanism, e.g., letters of credit, trust or insurance, there will be ample money available to the Region and/or state to ensure that any necessary maintenance tasks are completed in the unlikely event that Rhodia or its successors were to become insolvent.

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[5] To compare "apples and apples," Rhodia has calculated the 50 Year Post-Closure Cost amounts for the soil and enhanced caps. This calculation is the 50-year present worth, at a zero percent interest rate, of the operation, maintenance, and repair costs shown in Appendix G "Representative" Cost Estimate tables in the November 16, 2001 Waste Plan.

C. Institutional Controls

Institutional controls would also be put into place to protect the cap from unauthorized disturbance, to ensure that groundwater associated with the capped area is not consumed, and to require cap maintenance. As discussed in EPA's institutional controls guidance documents,[6] these institutional controls would be "layered" to provide redundant assurances that the capped material will not pose a future risk. All of the institutional controls are based on Montana law authorizing the controls, and in most cases, on specific situations where the controls have been used at similar sites in Montana. The specific types of controls and the precedent for them are briefly noted below:

- Governmental Controls – Rhodia would work with the Silver Bow County and/or state authorities to develop and have adopted prohibitions on disturbance of the capped area and the drilling of drinking water wells in the upper aquifer downgradient from the clarifier up to the Streamside Tailing Operable Unit. For example, authority for adoption of such prohibitions appears at Mont. Code Ann. 85-2-506.
- Private Property Law Restrictions – Rhodia would place on the title and other land use records land use restrictions that prevent disturbance of the capped area and use of contaminated groundwater for drinking water purposes. In addition, Rhodia would ensure that the title would provide for an easement that would allow access to Rhodia, its successors, and third-parties, including governmental agencies, to conduct the monitoring and maintenance of the cap, the groundwater wells, and the phosphine system. A covenant would also be placed on the land requiring perpetual care and maintenance of the cap, fence and signage by Rhodia and future owners. Montana Code Annotated § 75-10-727 expressly authorizes the establishment of these covenants and easements in the land records, and they can be established at any time, i.e., they need not be associated with a property conveyance.

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[6] See "Institutional Controls: A Guide to Implementing, Monitoring and Enforcing Institutional Controls ...," pp. 3-4 (EPA, Draft 2003) and "Institutional Controls" A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups," OSWER 9355.0-74FS-P, p. 2 (Sept., 2000).

- Informational Devices – Rhodia would also place in the land records a notice identifying the fact that the clarifier material has been capped in place, that the cap should not be disturbed, and that groundwater downgradient from the capped area should not be consumed so long as it exceeds drinking water standards.
- Enforcement Tools – The RCRA §7003 order could require Rhodia to have included in the appropriate land records the covenants, easement, and notices noted above, and to use best efforts to obtain enactment by the County and/or the state of the governmental controls noted above. In addition, Rhodia and its successors could be ordered to provide notice to EPA Region 8 and MDEQ of any land transfer involving the capped clarifier area.

Note that similar types of institutional controls have been established at the Montana Pole and Treating Plant Superfund site in Butte (see September 3, 1993 ROD), in the Streamside Tailings Operable Unit Consent Decree (see subparagraph 40.a. and b.), and at the Anaconda Company Smelter (see 1994 ROD and Land Use Master Plan).

II. Evaluation of New Cap Proposal

A. Evaluation Criteria

As BAH notes in the FFS at page 9, Rhodia evaluated the various options using Phase I threshold criteria that are based on the requirements of the RCRA §7003 order: (1) will the alternative abate the alleged characteristics of fire and phosphine gas generation; and (2) will the alternative comply with applicable regulations under federal, state and international law. We used these criteria because the Agency's authority for all Waste Plan requirements is RCRA §7003. We evaluated the options that passed the Phase I criteria using the five criteria that are typically employed in evaluating corrective measures at RCRA sites that are subject to corrective action. BAH employed the same Phase II criteria in its evaluation of the options. See FFS, pp. 9-12.

We understand that the Region would like Rhodia in this letter to evaluate the new proposed capping option and the off-site incineration option based on the CERCLA evaluation criteria.[7] We seriously question whether the CERCLA evaluation criteria are applicable to this Waste Plan determination. CERCLA is not the underlying authority for this RCRA §7003 order. Under RCRA, it is common to

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[7] See 40 CFR § 300.430(e)(9)(iii) and (f).

allow RCRA units to be closed with waste left in place. Specifically, under 40 CFR § 264.197 and § 265.197, units may be closed by removing all waste or by leaving waste in place and conducting post-closure care. EPA has expressly relied on this in-place closure authority to support its decision in the FMC Consent Decree to cap the elemental phosphorus ponds.[8] Similarly, since the Government has insisted in the past that Rhodia's clarifier must be closed according to RCRA's substantive requirements under the assumption that it contains a hazardous waste, closure of the clarifier waste in place with a cap followed by RCRA post-closure care should be an entirely acceptable alternative for closing this alleged RCRA unit. In any event, in light of the Region's request, we will evaluate the capping options against the CERCLA criteria.

In evaluating remedies under CERCLA, one is to apply two threshold criteria: overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements (ARARs).[9] Remedies that do not provide "adequate protection" or comply with ARARs, are screened out and are not further evaluated under the "five balancing criteria."[10] The five balancing criteria are:

1. long-term effectiveness and permanence;
2. reduction of toxicity, mobility or volume;
3. short-term effectiveness;
4. implementability; and
5. cost.

As EPA explains, the "*five primary balancing criteria are used to identify major trade offs between remedial alternatives. These trade offs are ultimately balanced to identify the preferred alternative and to select a final remedy.*"[11]

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[8] See Government's "Memorandum in Support of Motion for Entry of Proposed Consent Decree," U.S. v. FMC Corporation, Civil No. 98-0406-E-BLW, page 20 (March 29, 1999).

[9] See "A Guide to Selecting Superfund Remedial Actions," Publication No. 9355.0-27FS (April 1990).

[10] Id. at Exhibit 3, page 3.

[11] Id.

B. Threshold Criteria

As noted earlier, the incremental risk level to human health from potential leaching of metals into drinking water from the clarifier material under an enhanced cap would be several orders of magnitude below EPA's safe 10^{-4} to 10^{-6} levels. The institutional controls we propose will also prevent placement of drinking water wells in any area where there might be contaminated groundwater. Potential disturbance or failure of the cap and consequent direct exposure to the phosphorus-bearing materials should be virtually eliminated by the very protective design of the Astaris-type cap, and the proposed institutional controls, post-closure care, and financial assurance. Thus, there is little question that the proposed Astaris-type cap and the post-closure care could pass the initial threshold criteria of adequately protecting human health and the environment and complying with ARARs.[12] The principle question you have raised is whether this remedy will be effective in providing such protection in the long-term. This long-term effectiveness issue is discussed below, along with the other balancing criteria.

C. Balancing Criteria

1. Long-Term Effectiveness

The Astaris-type cap is the most protective design ever approved by the Agency for capping elemental phosphorus-bearing materials. The Astaris-type cap would provide approximately 16 feet of cover, including two very low permeability synthetic layers, over the crude phosphorus solid material in the clarifier. This will prevent air and water from seeping into the phosphorus-bearing material and causing a threat of fire or significant phosphine generation. Indeed, modeling of the Astaris cap that Region 10 approved at Pocatello for Pond 18 Cell A concluded that only 0.00002 inches of rainwater per year would infiltrate the cap.[13]

This very thick cap should also provide cover even in the event of the worst earthquake ever recorded in this Earthquake Zone 3 area. The cap also has a

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[12] BAH raised one question regarding compliance with ARARs. It asks whether capping would comply with the RCRA land disposal restriction requirements and the Subtitle C prohibition against co-disposal of ignitable and reactive waste. See FFS at 15. As explained in our Comment # 35 in Attachment A, closure in place of hazardous waste does not trigger land disposal restriction requirements or other Subtitle C regulations.

[13] See Section 7.1.2 of Pond 18 Cell A Closure Plan, Astaris, Pocatello, ID, (August 2001).

self-healing geosynthetic clay liner that can tolerate differential settlement better than a simple synthetic membrane liner. The 3.5 feet of top soil is reinforced with pea gravel to resist wind erosion, and will support vegetation that will resist rain erosion. The 100-year, 24-hour rainfall for this area of 3.2 inches will not impair the integrity of this Astaris-type cap. The cap would also not be located in a floodplain. The 2.5 foot biotic protection layer of slag below the 4.5 feet of top soil and sand will protect the underlying liner from intrusion by vegetation, burrowing animals or excavation activities. The integrity of the cap will be further ensured by Rhodia's proposal to provide long-term financial assurance to pay for a third party (if Rhodia is unable) to inspect, maintain and repair the cap, the groundwater monitoring system, the phosphine monitoring, collection and treatment systems, and the fence and signage, in the event Rhodia or its successors become insolvent or refuse to do this work.

Rhodia's proposal to put into place layered institutional controls should greatly reduce the Region's concerns that someone might dig into the cap and potentially expose the clarifier material. Prospective purchasers of this property will be on notice, by virtue of several layered and enforceable institutional controls, that the cap cannot be disturbed, groundwater associated with the cap cannot be consumed, and the cap must be maintained. In sum, the Astaris-type design, as well as the institutional controls, post-closure care and financial assurance that Rhodia proposes should together provide a high degree of comfort that the capping remedy will be effective in the long-term.

Of course, the off-site incineration option also will be effective in the long-term if it can be completed as described. But it is important to recognize that even with the incineration option, your consultant BAH estimates that approximately 5,000 gallons of crude phosphorus will not be able to be removed from the clarifier, and it will have to be capped in place. (FFS, page 33). This 5,000 gallons of crude phosphorus will contain approximately 1,000 gallons of elemental phosphorus, as well as trace metals. The infiltration rate through the cap and the leachability of this residual 5,000 gallons of crude phosphorus would not be less than the infiltration rate and leachability of the 500,000 gallons of crude phosphorus that would be capped in place under Rhodia's proposal. The only theoretical difference is that the 5,000 gallons of capped material would probably be exhausted as a source for leaching contaminants in relatively less time (2,000 to 3,000 years[11]) than it would take to exhaust the source if all of the material

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[11] The duration of leaching was calculated using information published in the November 2001 Waste Plan: the soil cap infiltration rate of 0.013 inches per year, the leachate concentrations shown in Table 3-3, Partitioning Model section, and the concentrations of metals calculated by mass balance in Section 3.1.1.2 (pages 38-42).

currently in the clarifier were capped. Thus, there would be no less leachate moving through the capped clarifier and into groundwater for centuries if 5,000 gallons rather than 500,000 gallons of crude phosphorus are capped in place. Similarly, whether there are 5,000 or 500,000 gallons of phosphorus left in place, disturbance of the cap could lead to the same exposure concerns.

In reality, these exposure and leachability concerns are insignificant whether all or a portion of the clarifier material is capped. They should not drive the Region's decision at all. But whatever significance the Agency places on the long-term groundwater impacts, the concerns should be essentially the same for hundreds of years to come whether all of the crude phosphorus is capped in place or just 5,000 gallons. As such, the Region cannot legitimately point to concerns over long-term groundwater impacts as a justification for requiring incineration.

2. Reduction in Toxicity, Mobility and Volume

The cap will reduce the mobility of the waste since it will be effective in reducing the quantity of leachate that will migrate from the clarifier. Rhodia demonstrated in the Waste Plan that there would be only about 0.00002 inches of water infiltrating each year through the enhanced cap.[15] This infiltration rate was shown to result in an incremental risk level in drinking water of 10^{-7} for arsenic and 10^{-9} or below for other heavy metals. Modeling of the Astaris-type cap at the Silver Bow Plant location confirms that the infiltration rate is likely to be even less than 0.00002 inches per year.[16] Thus, the cap reduces mobility and protects groundwater.

The incineration option reduces the toxicity, mobility and volume of the crude phosphorus that is removed from the clarifier and incinerated, but that which cannot be removed will not have reduced toxicity or volume. There will still be approximately 1,000 gallons of elemental phosphorus as well as other constituents of concern under a cap after incineration.

The calculated leaching duration for most of the TCLP metals is in the 2,000 to 3,000 year range.

[15] See Waste Plan, page 73 and Attachment 3 of Appendix D.

[16] This result is consistent with the modeling of the cap for the Pocatello, Idaho area, which also showed an annual infiltration rate of 0.00002 inches per year. See Section 7.1.2 Pond 18 Cell A Closure Plan, Astaris, Pocatello, ID, August 2001.

3. Short-Term Effectiveness

The short-term risks involved in implementing the incineration option (remove, package, transport and incinerate the estimated 25,000 drums of frozen crude phosphorus) were projected in the Waste Plan to be 1.4% risk of fatality and 41% risk of serious injury. This is for a trained worker with full protective gear. While BAH brushes these estimates aside saying Rhodia has experience handling crude phosphorus materials, the fact is that these estimates were calculated based on Rhodia's actual incident experience while the plant was being operated, and the estimates are in line with other industrial safety studies. These short-term risks of serious injury and death are 29 times greater for the incineration option than are the short-term risks of constructing and maintaining the enhanced cap.[17]

These are alarmingly high risks for a remedial project. The Agency cannot justify incineration with its very high 41 in 100 risk of serious injury and 1.4 in 100 risk of death on the grounds of trying to avoid the insignificant 1 in 10 million and 1 in 1 billion long-term incremental risks of cancer from groundwater exposure.

4. Implementability

Construction of the Astaris-type cap is readily implementable, uses standard materials and construction techniques, and can be completed in one to two years. In contrast, removal, packaging and incineration of this very large volume of frozen crude phosphorus raises serious feasibility questions. Under the incineration option, several years will be required to design, build and put into effective operation the new facilities that will be needed to remove the frozen crude phosphorus from the clarifier and package it at Silver Bow. If tank trucks or railcars are used, as BAH suggests, the receiving incineration facilities will also have to design an effective removal and gas collection system for the crude phosphorus and off-gases, and they will need to obtain permits or permit modifications for these facilities. These upfront efforts are likely to take at least two to three years. The actual removal, packaging, transportation, and incineration of the clarifier material, as well as the capping of the residual 5,000 gallons of crude

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[17] <u>See</u> Waste Plan, pages 131-132. The risks for construction of the Astaris-type cap were calculated in the same manner as those risks were calculated for the enhanced cap in the Waste Plan. Since the Astaris-type cap is about twice as large as the enhanced cap, the work will take longer, and the associated risks will be roughly twice the enhanced cap construction risks. Even so, the incineration risks are still dramatically higher – more than 14 times greater than the Astaris-type cap risks.

phosphorus that cannot be effectively removed from the clarifier, will take at least another two to four years assuming both incineration facilities are available for use. Thus, Rhodia's proposed capping will likely take one to two years to complete, while the incineration option will likely take at least four to seven years to complete.

5. Cost

Rhodia has, in good faith, re-evaluated the cost for the incineration option to address BAH's questions and suggestions, and to identify a "best case" cost that assumes that the material can be fairly easily removed from the clarifier and packaged. Rhodia believes that the "best case" cost is $39.1 million.[18] This is still ten times higher and over $35 million more costly than the $3.9 million estimated cost of the proposed Astaris-type cap and its associated post-closure care.

III. Summary

Choosing incineration, with its dramatically higher cost, is not justified based on the CERCLA evaluation criteria. Although the incineration option will reduce the volume and toxicity of the waste more than Rhodia's cap proposal, the issue is whether the greater volume of crude phosphorus (about 500,000 gallons) that will remain and be capped under Rhodia's proposal or the smaller volume (5,000 gallons) that will be capped under the incineration option will be secure over the long-term. Rhodia's proposal for an Astaris-type cap over the clarifier material, coupled with the institutional controls, post-closure care and financial assurances that Rhodia will commit to, would provide a secure and effective means of closing the clarifier in an environmentally protective manner for the long-term. In reality, the long-term risks are miniscule whether capping all the material or just 5,000 gallons and incinerating the rest.

Regarding the other three balancing criteria, construction of the Astaris-type cap is far superior in terms of short-term risk. A requirement to incinerate this material runs a 41% risk of serious injury and a 1.4% risk of a fatality, which is 14 times higher than the Astaris-type cap. These are very high risks that far outweigh the long-term risks. This is precisely the type of situation that EPA regards as inappropriate for a treatment remedy since "*[i]mplementation of treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation.*"[19] The incineration option will also take at least four to

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[18] See Comment #32 and #33 in Attachment A

[19] "A Guide to Selecting Superfund Remedial Actions," Publication No. 9355.0-27FS, page 3 (April 1990).

seven years to complete, and its cost is ten times higher than capping. Further, capping has been demonstrated to be reliable at every one of the more than a dozen facilities where it has been used to cap elemental phosphorus wastes. And finally, Rhodia would agree to an Astaris-type capping requirement in the RCRA §7003 Order, and move forward constructively with the Region to implement it as soon as possible.

We look forward to an opportunity to discuss this new capping option with you, answer questions you might have about it, and attempt to resolve any concerns you might have. Please let me know when a meeting would be convenient for you and your colleagues. We will do our best to make ourselves available at your earliest convenience.

Sincerely,

Dan Bersanti

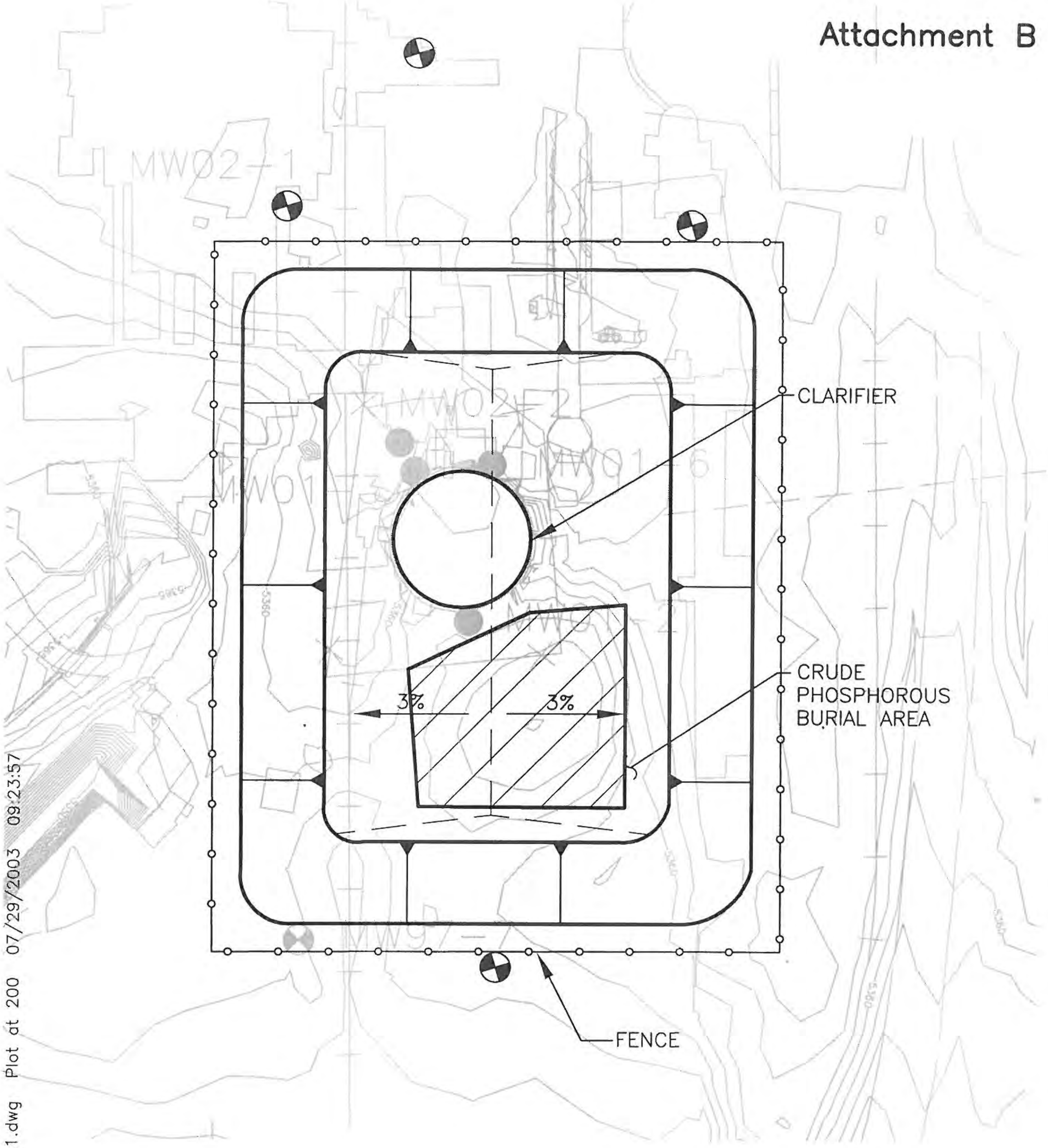
Enclosure

cc: Chuck Figur
Rebecca Holmes
Rosemary Rowe

Attachment A

REDACTED

Attachment B



LEGEND

⊕ Closure System Monitoring Well

● Monitoring Wells to be Sealed

N

0 100 200

SCALE IN FEET

Figure 1

GENERAL LOCATION
OF COVERED AREA

Rhodia, Inc., Silver Bow, Montana

Xrefs in Drawing - M:\cad\2625001\16381_1.DWG

rlg M:\CAD\2625001\18569_1.dwg Plot at 200 07/29/2003 09:23:57

Attachment C

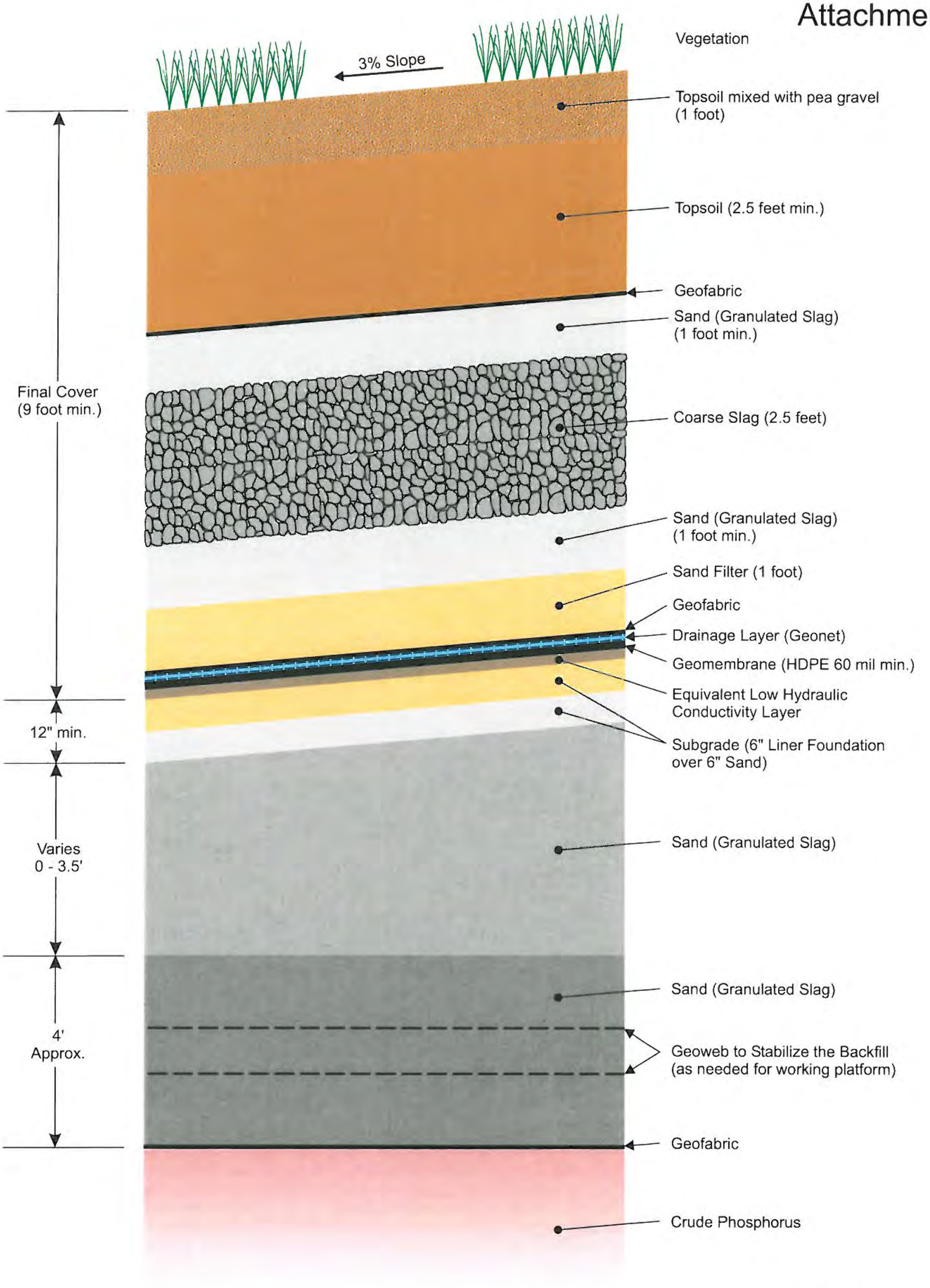
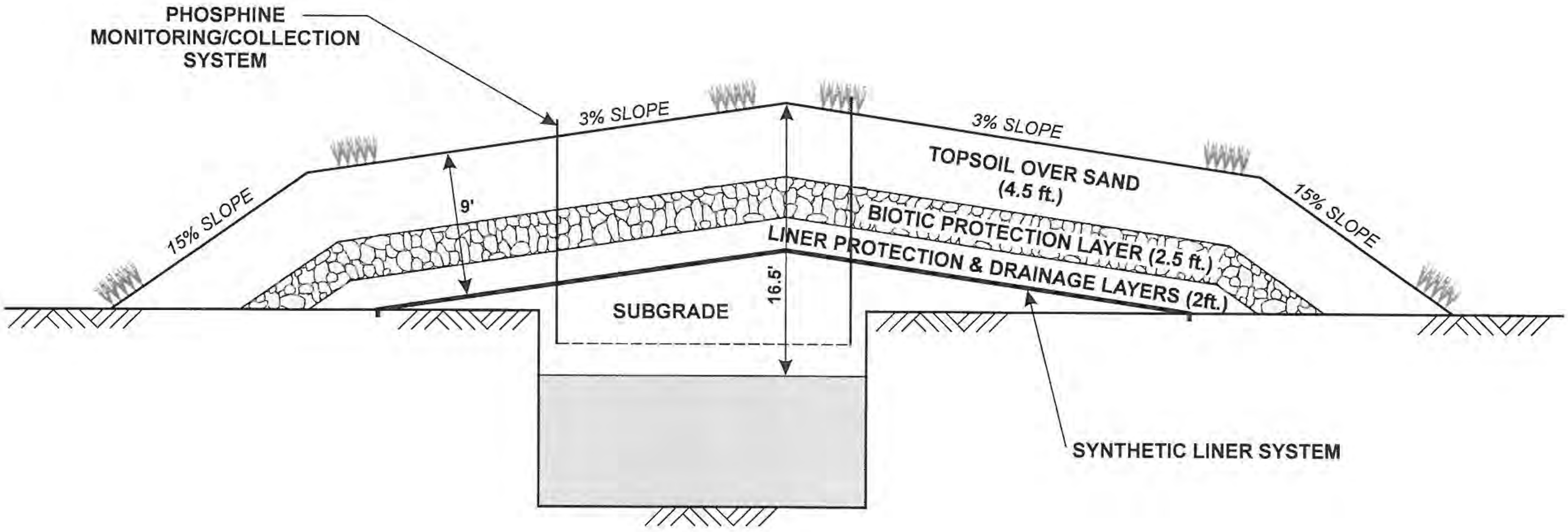


Figure 2

TYPICAL SECTION OF
ASTARIS-TYPE CAP SYSTEM
Rhodia, Inc.
Silver Bow, Montana

P:26\25\001\WastePlanNov16\April252003FFS\EnhancedCapDesign.CDR RLG 07-28-03

Attachment D



Approximate Horizontal Scale in Feet
5 x Vertical Exaggeration

See Figure 2 for detailed depiction of Cover System.

Figure 3

ASTARIS-TYPE CAP
CROSS SECTION
Rhodia, Inc.
Silver Bow, Montana

Attachment E

Comparison of Cap System Designs

Layer	Rhodia Proposed Astaris-Type Cap			Astaris Pond 18 Final Cap[1]			Difference
	Thickness	Description	Details	Thickness	Description	Details	
16	1 foot	Topsoil mixed with 15% pea gravel	Native vegetation cover (See Section 3.5.3 of Waste Plan Appendix D) over 3.5 feet of topsoil classified as SM/SC/ML/CL per ASTM D2487 with the top foot of topsoil mixed with pea gravel; poor vegetation coverage was assumed considering the site climatic conditions.	1 foot	Topsoil mixed with 15% pea gravel	Native vegetation cover over 3.5 feet of topsoil classified as ML/SM per ASTM D2487 with the top foot of topsoil mixed with pea gravel; poor vegetation coverage was assumed considering the site climatic conditions.	Rhodia's design also allows soil classified as SC or CL per ASTM D2487. These soils have a higher proportion of fines to hold soil moisture.
15	2.5 feet	Topsoil		2.5 feet	Topsoil		
14	---	Geofabric	A commercial synthetic filter fabric.	---	---	---	Rhodia's design provides an additional filter fabric to maintain separation of topsoil and underlying coarser material layers. Astaris's design uses specific particle size materials to maintain separation of topsoil layers and the underlying coarse material layers.
13	1 foot	Sand	Sand. Granulated slag classified as poorly graded sand (SP) per ASTM Standard D2487.	0.5 feet	Sand filter	Coarse sand.	
				0.5 feet	Gravel filter	4-inch minus, graded, crushed and screened slag; or gravel.	
12	2.5 feet	Coarse slag (1½ to 12 inches) Biotic Protection Layer	Coarse Slag (1½ to 12 inches in diameter) and granulated slag. The coarse slag and granulated slag will be placed in lifts such that the interstices in the coarse slag are filled with granular slag to minimize settling of overlying layers.	1.5 feet	Coarse Slag (1½ to 12 inches)	Coarse Slag (1½ to 12 inches in diameter).	Rhodia's design includes an extra 1 foot of coarse slag. Granulated slag and installation methods will be used to fill any void space between the cobbles.
11	1 foot	Sand	Sand. Granulated slag classified as SP per ASTM Standard D2487.	---	---	---	Rhodia's design provides an additional 1 foot of sand to protect the underlying flexible membrane and geosynthetic clay layers during construction.
10	1 foot	Sand Filter	Sand rounded to sub-rounded (< or = 3/8 inches in diameter) classified as SP or SW per ASTM Standard D2487.	1 foot	Sand Filter	Sand all classified as SP or GW per ASTM Standard D2487.	Same, except that Astaris allows gravel as the sand filter.
9	---	Geofabric	A commercial synthetic filter fabric.		Geofabric	A commercial synthetic filter fabric.	Same
8	---	Drainage layer	Geonet (GN) drainage layer, a commercial synthetic drainage net, having a performance equivalent to a one foot thick layer of granular material which has a hydraulic conductivity of 10^{-2} cm/sec or higher.	---	Drainage layer	Geonet (GN) drainage layer, a commercial synthetic drainage net, having a performance equivalent to a one foot thick layer of granular material which has a hydraulic conductivity of 10^{-2} cm/sec or higher.	Same

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[1] Pond 18 Closure Plan, Volume 1-Cell A. Astaris Idaho, LLC, Pocatello, Idaho, August 2001.

Attachment E

Comparison of Cap System Designs (cont.)

Layer	Rhodia Proposed Astaris-Type Cap			Astaris Pond 18 Final Cap[1]			Difference
	Thickness	Description	Details	Thickness	Description	Details	
7	60 mil	Geomembrane	Durable commercial synthetic liner, HDPE (60 mil min.).	60 mil	Geomembrane	Durable commercial synthetic liner, HDPE (60 mil min.).	Same
6	---	Equivalent Low Hydraulic Conductivity Layer	Geosynthetic Clay Liner (GCL), a commercial synthetic HDPE/Bentonite composite liner, having a hydraulic conductivity of 5 x 10^{-9} cm/sec or less, hydraulically equivalent to a 2-foot thick layer of fine clayey material with a hydraulic conductivity of 1 x 10^{-7} cm/sec.	---	Equivalent Low Hydraulic Conductivity Layer	Geosynthetic Clay Liner (GCL), a commercial synthetic HDPE/Bentonite composite liner, having a hydraulic conductivity of 5 x 10^{-9} cm/sec or less, hydraulically equivalent to a 2-foot thick layer of fine clayey material with a hydraulic conductivity of 1 x 10^{-7} cm/sec.	Same
<u>Subgrade</u>							
5	0.5 feet	Subgrade (6" Liner Foundation material)	Sand rounded to sub-rounded (< or = 3/8 inches in diameter). Sand subgrade will serve as a leveling course to provide proper bedding for the overlying geosynthetic clay liner.	0.5 feet	Subgrade (6" Liner Foundation material).	Sand subgrade will serve as a leveling course to provide proper bedding for the overlying geosynthetic clay liner.	Same, but Rhodia would use rounded sand to protect the overlying liners.
4	0.5 feet	Subgrade (6" sand)	Sand. Granulated slag classified as SP per ASTM Standard D2487.	0.5 feet	Sand Filter (6" sand).	Sand filter between overlying liner foundation and underlying slag.	Rhodia does not need the filter function because Rhodia's layer 3 is sand, not coarse slag.
3	Varies (0–3.5 feet)	Sand	Sand. Granulated slag classified as SP per ASTM Standard D2487. The thickness of this layer represents fill above the top of the clarifier wall Graded to form the shape of the cap.	Varies	Backfill, slag (12" max size).	Locally borrowed sand and slag material. Graded to form the shape of the cap.	Rhodia's design specifies granulated slag which is a superior foundation material.
2	4 feet (approx.)	Sand with Geoweb layers (to stabilize backfill for working platform, as needed)	Sand. Granulated slag classified as SP per ASTM Standard D2487. The thickness of this layer is based on filling to the top of the clarifier wall. Geoweb, a commercial synthetic fabric.	Varies	Sand with Geoweb to stabilize the backfill (as needed for working platform).	Locally borrowed sand and slag material. Geoweb, a commercial synthetic fabric.	Rhodia's design specifies granulated slag which is a superior foundation material.
1	---	Geofabric filter	A commercial synthetic filter fabric.	---	Geofabric filter	A commercial synthetic filter fabric.	Same
---	---	Crude phosphorus	---	---	Pond Material	---	---

Attachment F

Table 1
Astaris-Type Cap
Representative Cost Estimate of Cap Installation
Rhodia Silver Bow Plant

ITEM	ESTIMATED QUANTITY	UNIT	UNIT COST [1]	ITEM TOTAL COST	WORK SUBDIVISION TOTAL COST	SOURCE	COMMENTS
SOIL SAMPLING							
Sampling and Analysis	24	SAMPLE	$2,500	$60,000		Barr	12 soil borings in cap area, 2 samples per boring
Reporting	1	LS	$15,000	$15,000		Barr	Soil sampling report
SUBTOTAL SOIL SAMPLING					$75,000		
GENERAL REQUIREMENTS							
Mobilization/Demob./Submittals							The amount is shown under Estimated Subtotal Field Cost, below
Health & Safety	1	LS	$50,000	$50,000		Barr	Training and field support
Equipment and Personnel Decon. Facilities	7	MO	$10,000	$70,000		Barr	
Sitework							
Clear and Grade	5	ACRE	$2,000	$10,000		Barr	
Fence Removal	800	LF	$2	$1,600		Barr	
SUBTOTAL GENERAL REQUIREMENTS					$131,600		
CAP CONSTRUCTION							
Geofabric Filter	15,000	SF	$1.50	$22,500		Barr	Cover the clarifier contents with geotextile (higher cost for install)
Sand (Granulated Slag) Subgrade	1,500	CY	$6	$9,000		Barr/Rhodia	4 ft thick, 10,000 sq ft area; assume on-site source, careful placement
Geoweb	30,000	SF	$1.00	$30,000		Barr	2 layers in clarifier
Gas Collection System	1	LS	$4,000	$4,000		Barr	Piping and fittings within clarifier, enclosure,
Gas Treatment System	1	LS	$4,500	$4,500		Barr	Enclosure, 20 cfm blower, 3 - 55 gallon drums, piping, fittings
Placement and Grading - Coarse & Granulated Slag	14,800	CY	$3	$44,400		Barr/Rhodia	4 ft thick, 100,000 sq ft area; assume on-site source (outside clarifier)
Sand (Granulated Slag) Surcharge	15,000	CY	$5	$75,000		Barr/Rhodia	Place and remove surcharge; assume on-site source
Sand (Granulated Slag)	1,900	CY	$3	$5,700		Barr/Rhodia	0.5 ft thick, 100,000 sq ft area; assume on-site source
Sand Filter - Rounded to Subrounded	1,900	CY	$20	$38,000		Barr	0.5 ft thick, 100,000 sq ft area; assume off-site source
Geosynthetic Clay Liner (GCL)	100,000	SF	$2	$200,000		Barr	100,000 sq ft area (furnished and installed cost)
HDPE - 60 mil	100,000	SF	$1.60	$160,000		Barr	100,000 sq ft area (furnished and installed cost)
Drainage Layer - Geonet	100,000	SF	$1.00	$100,000		Barr	100,000 sq ft area (furnished and installed cost)
Geofabric Filter	100,000	SF	$0.50	$50,000		Barr	Geotextile 100,000 sq ft area
Sand Filter - Rounded to Subrounded	3,700	CY	$20	$74,000		Barr	1 ft thick, 100,000 sq ft area; assume off-site source
Sand (Granulated Slag)	6,700	CY	$3	$20,100		Barr/Rhodia	1 ft thick, 180,000 sq ft area; assume on-site source
Biotic Protection Layer - Coarse Slag	16,700	CY	$6	$100,200		Barr	2.5 ft thick, 180,000 sq ft area; assume on-site source, and screening
Sand (Granulated Slag)	6,700	CY	$3	$20,100		Barr/Rhodia	1 ft thick, 180,000 sq ft area; assume on-site source
Geofabric Filter	180,000	SF	$0.50	$90,000		Barr	Geotextile 180,000 sq ft area
Topsoil	16,700	CY	$8	$133,600		Barr/Rhodia	2.5 ft thick, 180,000 sq ft area; assume on-site source
Pea Gravel for Topsoil Mixing	1,000	CY	$20	$20,000		Barr/Rhodia	15% of 1 ft thick, 180,000 sq ft area; assume off-site source
Topsoil for Pea Gravel	5,700	CY	$12	$68,400		Barr/Rhodia	85% of 1 ft thick, 180,000 sq ft area; assume on-site source; mixing
SUBTOTAL CAP CONSTRUCTION					$1,269,500		
SITE RESTORATION							
Site Restoration/Revegetation	10	ACRE	$5,000	$50,000		Barr	Includes seeding, mulching, fertilizing, watering
Install Perimeter Fence	1,900	LF	$12	$22,800		Barr	520 ft x 420 ft
SUBTOTAL SITE RESTORATION					$72,800		
ESTIMATED SUBTOTAL FIELD COST					$1,549,000		
Mobilization/Demob./Submittals					$155,000	Barr	10% of Estimated Subtotal Field Cost
ESTIMATED TOTAL FIELD COST					$1,704,000		
Contingency (20%) [2]					$341,000		20% of Estimated Total Field Cost
Engineering/Administration	9	MO	$50,000		$450,000	Barr	2 months design, 7 months construction
ESTIMATED TOTAL CONSTRUCTION COST					$2,495,000		

NOTES:
[1] Unit cost includes labor, materials, equipment, overhead, and profit.
[2] Calculated as Contingency Multiplier times Estimated Total Field Cost.

Attachment F

Table 1 (Cont.)
Astaris-Type Cap
Representative Post-Closure Cost Estimate of Operation, Maintenance, Repair, and Administration
Rhodia Silver Bow Plant

ITEM	ESTIMATED QUANTITY	UNIT	UNIT DIRECT COST [1]	ANNUAL ITEM TOTAL DIRECT COST	NUMBER OF YEARS	POST-CLOSURE COST	COMMENTS
Admin., Inspection, Reporting (Years 1 to 5)	1	LS	$25,000	$25,000	5	$125,000	
Admin., Inspection, Reporting (Years 6 to 10)	1	LS	$15,000	$15,000	5	$75,000	
Admin., Inspection, Reporting (Years 11 to 50)	1	LS	$10,000	$10,000	40	$400,000	
Groundwater Monitoring (Years 1 to 5)	3	QTR	$5,000	$15,000	5	$75,000	1 upgradient, 3 downgradient wells
Groundwater Monitoring (Years 6 to 30)	1	QTR	$5,000	$5,000	25	$125,000	1 upgradient, 3 downgradient wells
Cap Maintenance (Years 1 to 30)	1	LS	$6,000	$6,000	30	$180,000	
Cap Maintenance (Years 31 to 50)	1	LS	$5,000	$5,000	20	$100,000	
Phosphine Monitoring (Years 1 to 10)	1	LS	$5,000	$5,000	10	$50,000	
Phosphine Collection/Treatment System Maintenance (Years 1 to 5)	1	LS	$2,500	$2,500	5	$12,500	120 lbs of Centaur Carbon per year, includes labor for change-out, piping and blower repair
SUBTOTAL OMR COSTS						$1,142,500	
Contingency (20%) [2]						$228,500	
ESTIMATED TOTAL OMR COSTS						$1,371,000	

NOTES:

[1] Lump sum costs include labor, materials, equipment, profit and overhead. Costs in 2003 dollars.

[2] Calculated as Contingency Multiplier times subtotal OMR costs.

[3] Groundwater compliance monitoring is not included in this estimate.

Attachment F

Table 1 (Cont.)
Astaris-Type Cap
Representative Cost Estimate Summary
Rhodia Silver Bow Plant

Closure			
Estimated Field Cost	Contingency	Engineering/ Administration	Total Estimated Closure Cost
$1,700,000	$341,000	$450,000	$2,500,000

Post-Closure
Financial Assurance Cost
$1,400,000

Total
Estimated Closure and Post-Closure Cost
$3,900,000

Attachment F

Table 1 (cont.)
Astaris-Type Cap
Representative Post-Closure Cost Estimate of Operation, Maintenance, Repair, and Administration
Notes
Rhodia Silver Bow Plant

Administration, Inspection, Reporting

This work includes cap inspections 2 times per year, surveying settling markers on the cap, and all reporting and project administration. The reporting includes review and reporting of cap inspection results, any maintenance performed on the cap, groundwater data, phosphine monitoring data, any changes to or problems with the phosphine treatment system, and any recommended changes to the inspection, monitoring, or maintenance programs.

The estimated cost steps down at year 6, corresponding to the change from quarterly to annual groundwater monitoring and the assumed end of gas collection activities. The cost steps down again in year 11, corresponding to the end of routine phosphine monitoring activities. There are sufficient resources, between the stated budget and contingencies, to support occasional monitoring of the groundwater and the phosphine monitoring/collection/treatment system for the period after the end of routine monitoring.

Cap Maintenance

This work includes mowing the cap, topsoil addition as needed, gully repair, seeding, and fence and signage maintenance. With the annual attention to cap repair, topsoil addition, and seeding, and this very thick 3.5 foot topsoil cap, it is not anticipated that major topsoil restoration and re-seeding will be necessary at longer-interval periods, like the 40 and 80 years BAH suggested in the FFS. The $5,000 and $6,000 annual budgets include $2,000 per year that is to be set aside for occasional capital expenses, like fence and signage replacement. The budget steps down slightly at year 31, by which time the cap vegetation and cap erosion resistance should be well established.

Appendix J

HELP Modeling for Enhanced RCRA Cap

HELP Modeling
Enhanced RCRA Cap

Introduction

The HELP (Hydrologic Evaluation of Landfill Performance) model (Version 3.07, U.S. Army Corps of Engineers, November 1997) was used to project long-term infiltration through the proposed enhanced cap system.

The HELP model tracks the water budget for the cap system. The water enters as precipitation (including snowmelt) less the runoff, and exits via evapotranspiration (ET), percolation, and drainage, or it is held in storage in the pore spaces. The amount of water percolating through the capped material is of particular interest because it can leach contaminants and may impact the underlying groundwater.

The summary model output for the proposed cap system is attached. It includes data inputs and summary results for 30 years of model simulation.

Input

The input values used were those recommended in the HELP guidance and documentation for this climate and this type of application. Site-specific parameters such as soil characteristics were used to select reasonably similar HELP soil textures. The inputs and rationales for their selection are explained below.

Climate Data: 30 years of precipitation data were synthetically generated from monthly total precipitation data from the Butte, Montana airport and the Helena, Montana coefficients. The Helena coefficients are a default data set available with the HELP model. The average annual precipitation at Helena and Butte and the monthly distribution of precipitation were nearly identical, so the Helena coefficients were considered suitable for this model. The attached table of weather information for Butte and Helena illustrate the similarities in their climates. Temperature data were generated synthetically by the HELP model using Helena coefficients and monthly averages for Butte. The latitude was adjusted to 45.8E for the solar radiation and the Helena values were used for the relative humidity. The growing season for Helena was used: 128 days.

Cover Design: The layers that comprise the cover are shown in the attached figure (Figure J-1). This multi-layer cover system is a combination of locally available soil and slag, along with multiple types of geosynthetics.

Topsoil and common fill will be obtained locally. The attached soil test data is for a borrow source available at the Silver Bow Plant property. The soil was compacted to approximately 90 percent of standard proctor maximum density for the permeability testing. The borrow soil is expected to function similarly to HELP soil Texture 12, based on the similar soil type (silty clay loam) and identical hydraulic conductivities ($4.2x10^{-5}$ cm/s). The borrow soil may have an ability to store more water than the HELP Texture 12 soil, which would only improve the effectiveness of the cap. Local sand and granulated slag available at the plant would be used for granular filter layers.

Geosynthetic layers including geofabric, geonet, geomembrane, geosynthetic clay liner (GCL), and geoweb are part of this multi-layer cover system. Geofabric is assumed to aid in filtering between soil layers. Geonet is used as a lateral drainage layer beneath a minimum 9 feet thick soil cover. Geomembrane and an underlying GCL layer are the barrier layer underlying the geonet drainage layer. Geoweb is used to stabilize the backfill above the crude phosphorus waste.

General Design and Evapotranspiration Parameters: The input and HELP-computed parameters for runoff and evapotranspiration are as follows:

Cover slope: 3%
Cover slope length: 50 feet
SCS runoff curve number: 83.50 (computed by HELP)
Evaporative zone depth: 24.0 inches
Maximum leaf area index: 2.00

Results

Summary output for the HELP model is attached.

The annual average values for the 30-year simulation are as follows:

Precipitation: 12.55 inches
Runoff: 0.469 inches
Evapotranspiration: 12.085 inches
Lateral drainage: 0.30824 inches (collected from the geonet drainage layer)
Percolation through cap: 0.00000306 inches (0.002 ft^3)

Model Sensitivity

Model sensitivity was tested on 5 parameters:

1. Evaporative zone depth
2. Leaf index
3. Pinhole density
4. Liner defects
5. Liner soil

The summary outputs for the HELP model runs are attached. The effect on average annual percolation for the sensitivity cases are summarized in the following table. The representative case using the inputs described earlier is listed first, followed by the sensitivity cases where one or more parameters were varied.

Sensitivity Case

Parameter	Representative	Deep Evap. Zone	Shallow Evap. Zone	High Leaf Area	High Liner Defects	Ineffective Liner Soil
Evaporative zone depth (in)	24	42	14	24	24	24
Maximum leaf area index	2	2	2	3	2	2
FML pinhole density (hole/acre)	1	1	1	1	2	1
FML installation	15	15	15	15	30	15

defects (holes/acre)						
Liner soil hydraulic conductivity (10^{-9} cm/s)	3	3	3	3	3	100
Acreage annual percolation through cap (10^{-6} in/yr)	3.06	3.06	3.06	3.06	3.06	6.12
Acreage annual percolation through cap (10^{-3} ft^3/yr)	2	2	2	2	2	4

The range of annual average percolation is 0.002 cubic feet to 0.004 cubic feet (3.06 x 10^{-6} in/year to 6.12 x 10^{-6} in/year) for the representative and sensitivity cases, as shown in the last line of the above table. This result strongly suggests that this form of cap is insensitive to variations in the cover vegetation, liner defects, and even the permeability of the liner material below the HDPE geomembrane. Based on these sensitivity results and the very low percolation rates through the cap system, the enhanced RCRA cap is a very robust design for this climate and this application.

Monthly Climate Summary
Butte FAA Airport, Montana: (Weather Station 241318)
Compared to HELP Helena Climate Data

Month	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Butte Average Maximum Temperature, °F	29.8	34.3	40.6	51.1	60.5	69.3	79.5	78.0	66.9	55.5	40.5	31.7	53.2
Butte Average Minimum Temperature, °F	7.4	10.9	17.7	27.0	34.9	42.0	47.1	45.3	36.9	28.7	18.2	10.0	27.2
Butte Average Total Precipitation, inches	0.61	0.56	0.81	1.03	1.89	2.27	1.30	1.11	1.12	0.80	0.62	0.59	12.71
Butte Average Total Snowfall, inches	8.6	7.7	10.3	7.5	3.7	0.5	0.0	0.1	1.1	3.6	6.6	8.3	57.9
Butte Average Snow Depth, inches	4.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0
Butte Average Wind Speed, mph **	14.9	14.1	3.6	0.8	2.3	2.6	5.1	4.3	6.5	5.9	15.5	2.5	6.3
Helena Average Mean Temperature, °F	18.1	26.0	31.6	42.3	52.2	60.1	67.9	65.9	55.6	45.1	31.4	23.5	43.3
Helena Average Total Precipitation, inches	0.66	0.44	0.69	1.01	1.72	2.01	1.04	1.18	0.83	0.65	0.54	0.60	11.4
Helena Average Wind Speed, mph													7.8

Notes: Data were based on a record period of 104 years, 1894 to 1998, for Butte FAA Airport unless noted otherwise
* Indicates data are based on a record period of 1 year, 1996, from onsite weather station

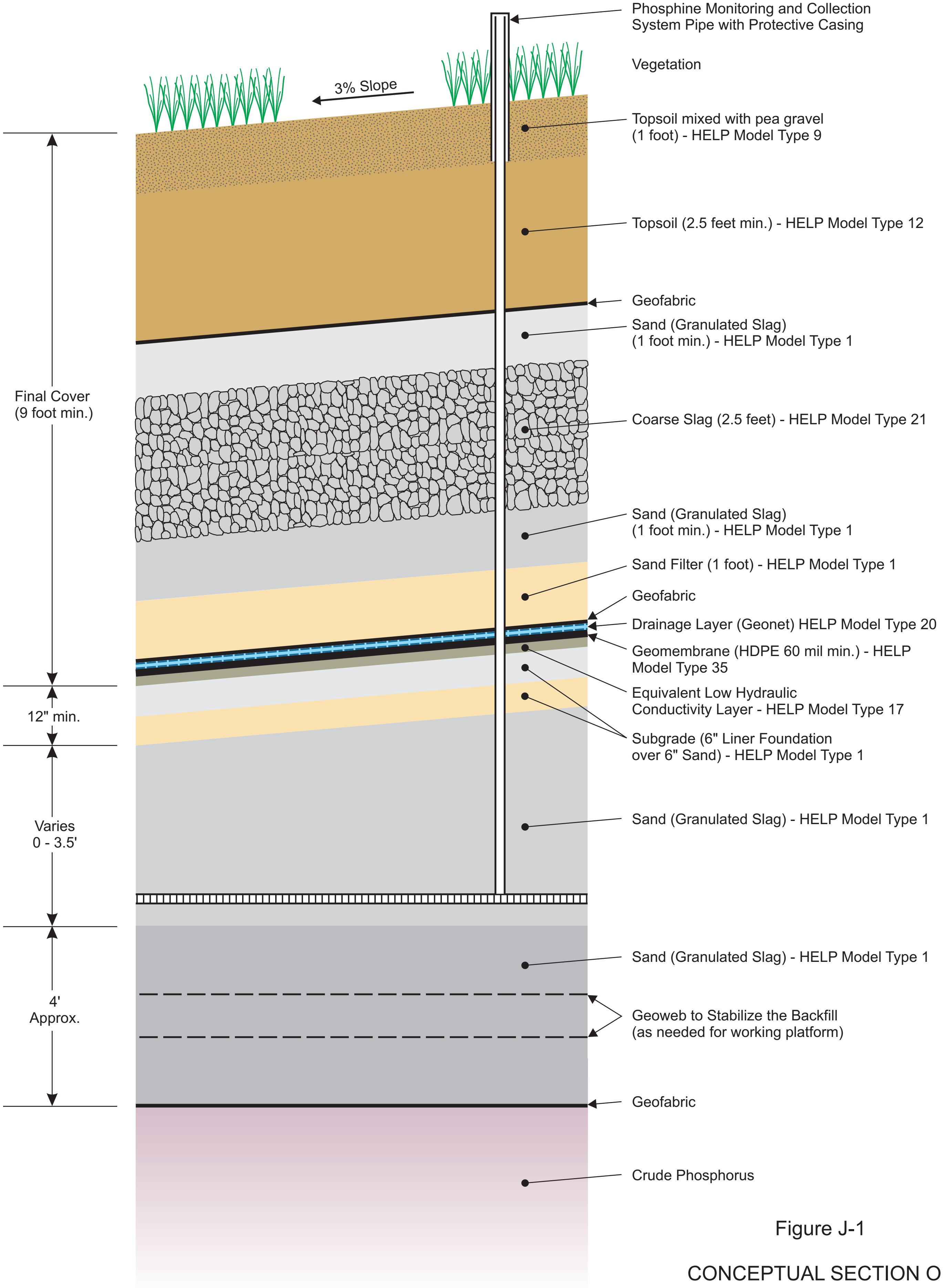


Figure J-1

CONCEPTUAL SECTION OF
ENHANCED RCRA CAP
Silver Bow Plant
Butte, Montana

P:\Mpls\26 MT\46\2646006\WorkFiles\Figures_Graphics\Typical Section of Enhanced RCRA.CDE RLG 05-08-15

Project: RHODIA SILVER BOW - # 26/46-004 JSL200 Date: 7-30-99

Reported To: BARR ENGINEERING COMPANY Job No.: 3604

Boring No.		99-10	99-10	99-10		
Sample No.						
Depth (Ft)		1/2 -6	1/2 -6	6-12		
Type of Sample		BULK	BULK	BULK		
Soil Classification (ASTM: D2487/2488)		CLAYEY SAND W/A TRACE OF GRAVEL (SC)	→			
Mechanical Analysis Dry Weight (Grams)						
Percent Passing						
Gravel	3"					
	2"					
	1"					
	3/4"					
Sand	#4					
	#10					
	#40					
	#100					
	#200					
Atterberg Limits						
Liquid Limit						
Plastic Limit						
Plasticity Index						
Moisture - Density						
Water Content (%)		3.6 *	25.8 **	33.2		
Dry Density (PCF)			100.6 #			
Unconfined Compression Maximum Load (psf)						
Hand Penetrometer (tsf)						
Organic Content (%)						
pH (Meter Method)						
cific Gravity						
Resistivity (ohm-cm)						

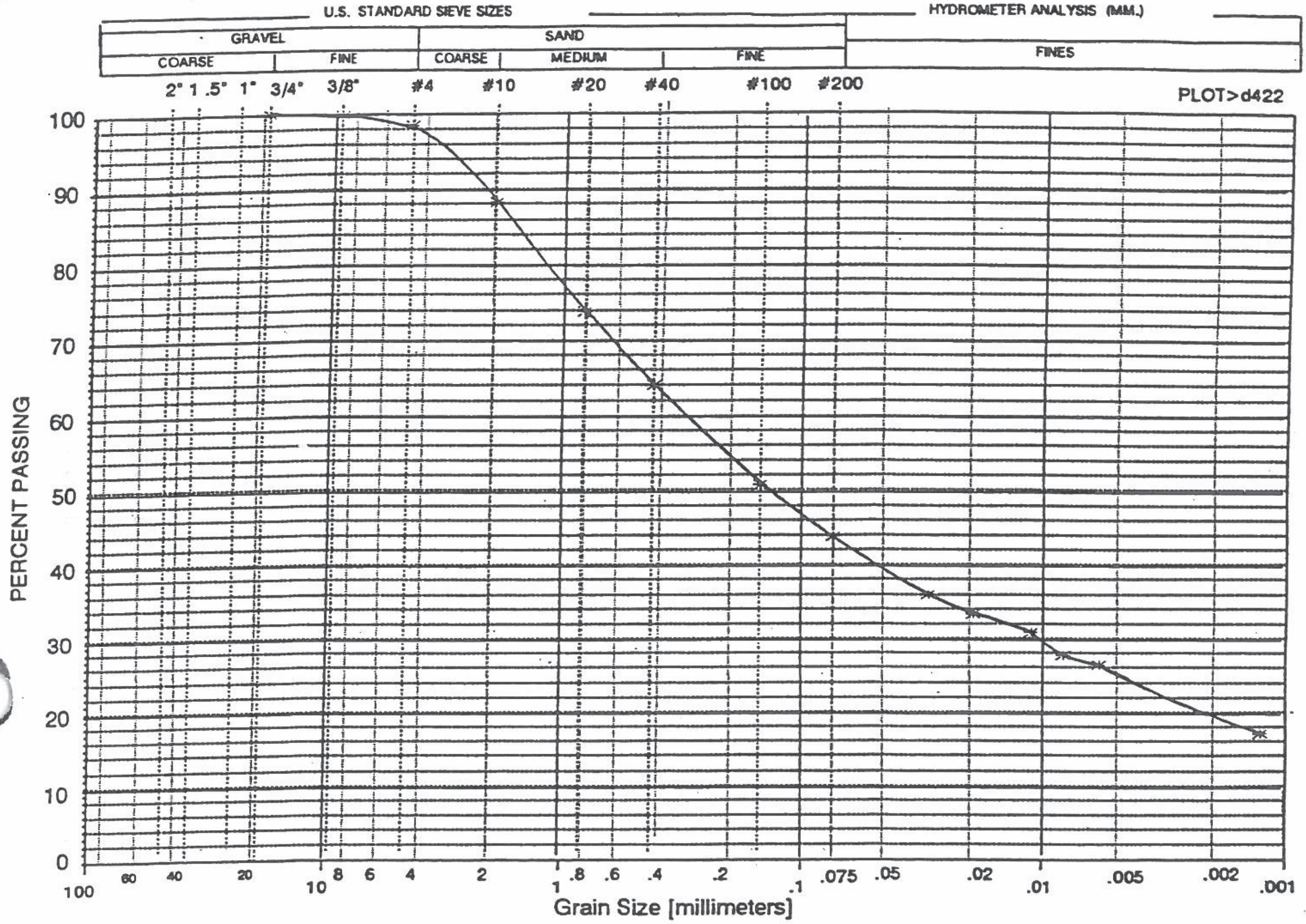
* AIR DRIED TO CONSTANT WEIGHT FOR TWO WEEKS

** WATER HOLDING CAPACITY

INITIAL DRY DENSITY AT 12.4% W.C. BEFORE SOAKING & GRAVITY DRAINING

REPORTED TO: Rhodia Silver Bow	Date: 7-19-99

	Boring Number	Sample Number	Depth (feet)	Type of Sample	Soil Classification
x	99-10		0.5-6.0	Bulk	Clayey sand w/a trace of gravel (SC)



OTHER TESTS

	x	+	▯
Liquid Limit (%)	46.5		
Plastic Limit (%)	20.1		
Plasticity Index	26.4		
Water Content (%)	12.3		
Dry Density [pcf]			
Specific Gravity (*)	2.67*		
Porosity			
Organic Content (%)			
pH			
Shrinkage Limit [SL]			
Penetrometer [tsf]			
Qu [psf]			

* Assumed Value

PERCENT PASSING

	x	+	▯
Mass [gm]			
2"			
1-1/2"			
1"			
3/4"	100.0		
3/8"	99.7		
#4	98.5		
#10	88.3		
#20	73.8		
#40	64.1		
#100	50.7		
#200	43.9		

ASTM: D422 Sieve Set

	x	+	▯
D_{60}			
D_{30}			
D_{10}			
C_u			
C_c			

Remarks:

PS'111

ARS

MOISTURE - DENSITY CURVE

Project	RHODIA SILVER BOW - #26/46-004 JSL 200	Date	7-16-99
Reported To	BARR ENGINEERING COMPANY	Job No.	3604

Boring No. 99-10 Sample No. ____ Depth (ft.) 1/2 - 6 Location ____

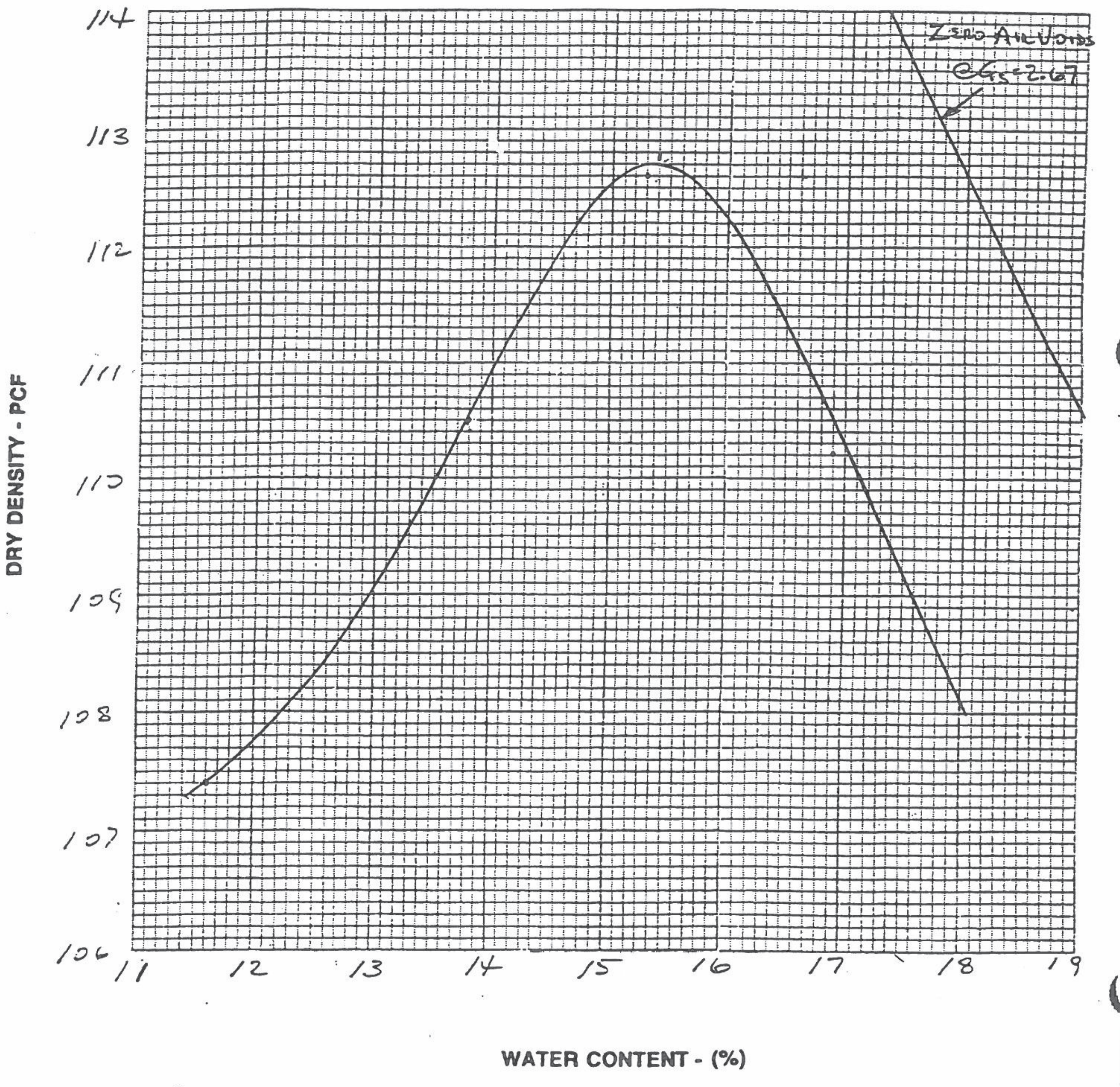
Test Method ASTM: D698, PROCEDURE B

Soil Description CLAYEY SAND W/A TRACE OF GRAVEL (SC)

AS RECEIVED WATER CONTENT: 12.3% LL=46.5%, PL=20.1%, PI=26.4

Maximum Dry Density 112.7 pcf

Optimum Water Content 15.4 %



Permeability Test Data (Compacted Specimens)

Project: RHODIA SILVER BOW - # 26/46-004 JSL200 Date: 7-23-99

ported To: BARR ENGINEERING COMPANY Job No.: 3604

Sample No./Designation	99-10					
Sample Type, Location Elevation or Depth	e½'-6'					
Soil Classification	CLAYEY SAND W/A TRACE OF GRAVEL (SC)					
In-Place Water Content (%)	12.3					
Moisture - Density Relation (ASTM: D698)						
Max Dry Density (PCF)	112.7					
Opt. Water Content (%)	15.4					
Atterberg Limits						
uid Limit	46.5					
Plastic Limit	20.1					
Plasticity Index	26.4					
Permeability Test						
% Saturation (After Test)	87.5*		* LOST WATER AFTER DISSAMBLING DUE TO GRAVITY DRAINAGE			
Specimen Height (Inches)	3.00					
Specimen Diameter (Inches)	2.86					
Dry Density (PCF)	101.9					
% of Max. Density	90.4					
Water Content (%)	12.3					
Type of Test (Head)	Falling					
Max. Head Differential (Ft)	1.1					
Confining Pressure (Effective-PSI)	2.0					
Trial No.	12-16					
Water Temp. (°C)	23					
efficient of Permeability						
K @ 20°C (Cm/Sec)	4.2×10^{-5}					
K @ 20°C (Ft/Min)	8.3×10^{-5}					

Representative HELP Model

```
*******************************************************************************
 *******************************************************************************
 **                                                                           **
 **                                                                           **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
 **                    USAE WATERWAYS EXPERIMENT STATION                      **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
 **                                                                           **
 **                                                                           **
 *******************************************************************************
 *******************************************************************************


 PRECIPITATION DATA FILE:    C:\HELP3\silver1.D4
 TEMPERATURE DATA FILE:      C:\HELP3\silver2.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\silver3.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\silver4.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\silver7.D10
 OUTPUT DATA FILE:           C:\HELP3\silver8.OUT


 TIME:  14:23     DATE:   4/16/2015


 *******************************************************************************

      TITLE:  Silver Bow Plant - Enhanced RCRA Cover

 *******************************************************************************


      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
               WERE SPECIFIED BY THE USER.


                                    LAYER  1
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
            THICKNESS                   =     12.00   INCHES
            POROSITY                    =      0.5010 VOL/VOL
            FIELD CAPACITY              =      0.2840 VOL/VOL
            WILTING POINT               =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                    LAYER  2
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
            THICKNESS                   =     30.00   INCHES
            POROSITY                    =      0.4710 VOL/VOL
            FIELD CAPACITY              =      0.3420 VOL/VOL
            WILTING POINT               =      0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC


                                    LAYER  3
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   1
            THICKNESS                   =     12.00   INCHES
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC



                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET



                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     15.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC



                        LAYER 10
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 11
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 12
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     42.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 13
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     48.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
               AND A SLOPE LENGTH OF   50. FEET.

     SCS RUNOFF CURVE NUMBER             =     83.50
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      0.180  ACRES
     EVAPORATIVE ZONE DEPTH              =      24.0   INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      7.512  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     11.664  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.140  INCHES
     INITIAL SNOW WATER                  =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     29.657  INCHES
     TOTAL INITIAL WATER                 =     29.657  INCHES
     TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR



                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               HELENA                MONTANA

          STATION LATITUDE                       =  45.82 DEGREES
          MAXIMUM LEAF AREA INDEX                =   2.00
          START OF GROWING SEASON (JULIAN DATE)  =    138
          END OF GROWING SEASON (JULIAN DATE)    =    266
          EVAPORATIVE ZONE DEPTH                 =  24.0  INCHES
          AVERAGE ANNUAL WIND SPEED              =   7.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  63.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  54.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  49.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  63.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    0.61        0.56        0.81        1.03        1.89        2.27
    1.30        1.11        1.12        0.80        0.62        0.59


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   18.60       22.60       29.20       39.10       47.70       55.70
   63.30       61.70       51.90       42.10       29.40       20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA
                 AND STATION LATITUDE  =  45.82 DEGREES




HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  8
DRAIN #1:  LATERAL DRAINAGE FROM LAYER  7 (RECIRCULATION AND COLLECTION)
```

```
   LEAK  #1:  PERCOLATION OR LEAKAGE THROUGH LAYER  9
   LEAK  #2:  PERCOLATION OR LEAKAGE THROUGH LAYER 13

*****************************************************************************************************

                                    DAILY OUTPUT FOR YEAR    1
 ---------------------------------------------------------------------------------------------------
         S
 DAY  A  O  RAIN  RUNOFF   ET   E. ZONE    HEAD      DRAIN     LEAK      HEAD      DRAIN     LEAK
      I  I                       WATER      #1        #1        #1        #2        #2        #2
      R  L   IN.    IN.    IN.  IN./IN.     IN.       IN.       IN.       IN.       IN.       IN.
 ---  -  -  ----- ------ ------ ------- --------- --------- --------- --------- --------- ---------


    1 *  *   0.00  0.000  0.000  0.3130     3.2905 3.980     .7552E-05    0.0000 .0000E+00 .7552E-05
    2 *  *   0.00  0.000  0.000  0.3130     0.0175 .5933     .2439E-07    0.0000 .0000E+00 .3877E-05
    3 *  *   0.00  0.000  0.000  0.3130     0.0096 .3263     .1704E-07    0.0000 .0000E+00 .4261E-05
    4 *  *   0.00  0.000  0.000  0.3130     0.0066 .2239     .1408E-07    0.0000 .0000E+00 .0000E+00
    5 *  *   0.00  0.000  0.000  0.3130     0.0050 .1693     .1246E-07    0.0000 .0000E+00 .0000E+00
    6 *  *   0.00  0.000  0.000  0.3130     0.0040 .1354     .1142E-07    0.0000 .0000E+00 .0000E+00
    7 *  *   0.00  0.000  0.000  0.3130     0.0033 .1124     .1071E-07    0.0000 .0000E+00 .0000E+00
    8 *  *   0.00  0.000  0.000  0.3130     0.0028 .9571E-01 .1018E-07    0.0000 .0000E+00 .0000E+00
    9 *  *   0.00  0.000  0.000  0.3130     0.0024 .8316E-01 .9780E-08    0.0000 .0000E+00 .0000E+00
   10 *  *   0.00  0.000  0.000  0.3130     0.0022 .7337E-01 .9462E-08    0.0000 .0000E+00 .0000E+00
   11 *  *   0.00  0.000  0.000  0.3130     0.0019 .6553E-01 .9205E-08    0.0000 .0000E+00 .0000E+00
   12 *  *   0.00  0.000  0.000  0.3130     0.0017 .5912E-01 .8992E-08    0.0000 .0000E+00 .0000E+00
   13 *  *   0.00  0.000  0.000  0.3130     0.0016 .5378E-01 .8813E-08    0.0000 .0000E+00 .0000E+00
   14 *  *   0.03  0.000  0.015  0.3130     0.0015 .4928E-01 .8661E-08    0.0000 .0000E+00 .0000E+00
   15 *  *   0.00  0.000  0.012  0.3130     0.0013 .4543E-01 .8530E-08    0.0000 .0000E+00 .0000E+00
   16 *  *   0.00  0.000  0.002  0.3130     0.0012 .4211E-01 .8415E-08    0.0000 .0000E+00 .0000E+00
   17 *  *   0.00  0.000  0.000  0.3130     0.0012 .3921E-01 .8315E-08    0.0000 .0000E+00 .0000E+00
   18 *  *   0.00  0.000  0.000  0.3130     0.0011 .3666E-01 .8226E-08    0.0000 .0000E+00 .0000E+00
   19    *   0.00  0.000  0.000  0.3130     0.0010 .3440E-01 .8147E-08    0.0000 .0000E+00 .0000E+00
   20    *   0.01  0.000  0.007  0.3131     0.0010 .3239E-01 .8076E-08    0.0000 .0000E+00 .0000E+00
   21    *   0.00  0.000  0.000  0.3131     0.0009 .3059E-01 .8012E-08    0.0000 .0000E+00 .0000E+00
   22    *   0.00  0.000  0.000  0.3131     0.0009 .2896E-01 .7954E-08    0.0000 .0000E+00 .0000E+00
   23    *   0.06  0.000  0.014  0.3150     0.0008 .2749E-01 .7901E-08    0.0000 .0000E+00 .0000E+00
   24    *   0.11  0.004  0.015  0.3188     0.0008 .2615E-01 .7853E-08    0.0000 .0000E+00 .0000E+00
   25    *   0.00  0.000  0.000  0.3188     0.0007 .2493E-01 .7809E-08    0.0000 .0000E+00 .0000E+00
   26 *  *   0.00  0.000  0.000  0.3188     0.0007 .2381E-01 .7768E-08    0.0000 .0000E+00 .0000E+00
   27 *  *   0.00  0.000  0.000  0.3188     0.0007 .2278E-01 .7730E-08    0.0000 .0000E+00 .0000E+00
   28 *  *   0.00  0.000  0.000  0.3188     0.0006 .2183E-01 .7695E-08    0.0000 .0000E+00 .0000E+00
   29 *  *   0.09  0.000  0.030  0.3188     0.0006 .2095E-01 .7663E-08    0.0000 .0000E+00 .0000E+00
   30 *  *   0.01  0.000  0.036  0.3188     0.0006 .2013E-01 .7633E-08    0.0000 .0000E+00 .0000E+00
   31 *  *   0.00  0.000  0.035  0.3188     0.0006 .1937E-01 .7604E-08    0.0000 .0000E+00 .0000E+00
   32 *  *   0.00  0.000  0.000  0.3188     0.0005 .1867E-01 .7578E-08    0.0000 .0000E+00 .0000E+00
   33 *  *   0.00  0.000  0.000  0.3188     0.0005 .1800E-01 .7553E-08    0.0000 .0000E+00 .0000E+00
   34 *  *   0.02  0.000  0.020  0.3188     0.0005 .1739E-01 .7530E-08    0.0000 .0000E+00 .0000E+00
   35 *  *   0.00  0.000  0.000  0.3188     0.0005 .1681E-01 .7508E-08    0.0000 .0000E+00 .0000E+00
   36 *  *   0.00  0.000  0.000  0.3188     0.0005 .1626E-01 .7487E-08    0.0000 .0000E+00 .0000E+00
   37 *  *   0.11  0.000  0.026  0.3188     0.0005 .1575E-01 .7468E-08    0.0000 .0000E+00 .0000E+00
   38    *   0.00  0.001  0.039  0.3207     0.0004 .1526E-01 .7450E-08    0.0000 .0000E+00 .0000E+00
   39    *   0.00  0.000  0.000  0.3207     0.0004 .1481E-01 .7432E-08    0.0000 .0000E+00 .0000E+00
   40    *   0.00  0.000  0.000  0.3207     0.0004 .1437E-01 .7415E-08    0.0000 .0000E+00 .0000E+00
   41    *   0.00  0.000  0.000  0.3207     0.0004 .1396E-01 .7400E-08    0.0000 .0000E+00 .0000E+00
   42    *   0.05  0.000  0.014  0.3222     0.0004 .1358E-01 .7385E-08    0.0000 .0000E+00 .0000E+00
   43    *   0.00  0.000  0.000  0.3222     0.0004 .1321E-01 .7371E-08    0.0000 .0000E+00 .0000E+00
   44    *   0.00  0.000  0.000  0.3222     0.0004 .1286E-01 .7357E-08    0.0000 .0000E+00 .0000E+00
   45    *   0.00  0.000  0.000  0.3222     0.0004 .1252E-01 .7344E-08    0.0000 .0000E+00 .0000E+00
   46    *   0.00  0.000  0.000  0.3222     0.0004 .1220E-01 .7332E-08    0.0000 .0000E+00 .0000E+00
   47 *  *   0.05  0.000  0.039  0.3222     0.0004 .1190E-01 .7320E-08    0.0000 .0000E+00 .0000E+00
   48    *   0.00  0.000  0.011  0.3222     0.0003 .1161E-01 .7308E-08    0.0000 .0000E+00 .0000E+00
   49    *   0.00  0.000  0.000  0.3222     0.0003 .1133E-01 .7298E-08    0.0000 .0000E+00 .0000E+00
   50 *  *   0.00  0.000  0.000  0.3222     0.0003 .1107E-01 .7287E-08    0.0000 .0000E+00 .0000E+00
   51    *   0.00  0.000  0.000  0.3222     0.0003 .1082E-01 .7277E-08    0.0000 .0000E+00 .0000E+00
   52 *  *   0.00  0.000  0.000  0.3222     0.0003 .1057E-01 .7268E-08    0.0000 .0000E+00 .0000E+00
   53 *  *   0.00  0.000  0.000  0.3222     0.0003 .1034E-01 .7258E-08    0.0000 .0000E+00 .0000E+00
   54 *  *   0.05  0.000  0.027  0.3222     0.0003 .1012E-01 .7250E-08    0.0000 .0000E+00 .0000E+00
   55 *  *   0.06  0.000  0.034  0.3222     0.0003 .9902E-02 .7241E-08    0.0000 .0000E+00 .0000E+00
   56 *  *   0.13  0.000  0.028  0.3222     0.0003 .9695E-02 .7233E-08    0.0000 .0000E+00 .0000E+00
   57 *  *   0.00  0.000  0.040  0.3222     0.0003 .9496E-02 .7225E-08    0.0000 .0000E+00 .0000E+00
   58 *  *   0.00  0.000  0.052  0.3222     0.0003 .9305E-02 .7217E-08    0.0000 .0000E+00 .0000E+00
   59    *   0.00  0.000  0.052  0.3222     0.0003 .9121E-02 .7210E-08    0.0000 .0000E+00 .0000E+00
   60 *  *   0.05  0.000  0.037  0.3222     0.0003 .8943E-02 .7203E-08    0.0000 .0000E+00 .0000E+00
   61 *  *   0.03  0.000  0.027  0.3222     0.0003 .8772E-02 .7196E-08    0.0000 .0000E+00 .0000E+00
   62 *  *   0.00  0.000  0.022  0.3222     0.0003 .8607E-02 .7189E-08    0.0000 .0000E+00 .0000E+00
   63 *  *   0.00  0.000  0.000  0.3222     0.0002 .8447E-02 .7183E-08    0.0000 .0000E+00 .0000E+00
   64 *  *   0.00  0.000  0.000  0.3222     0.0002 .8293E-02 .7176E-08    0.0000 .0000E+00 .0000E+00
   65 *  *   0.02  0.000  0.020  0.3222     0.0002 .8144E-02 .7170E-08    0.0000 .0000E+00 .0000E+00
   66 *  *   0.00  0.000  0.000  0.3222     0.0002 .8000E-02 .7164E-08    0.0000 .0000E+00 .0000E+00
   67 *  *   0.00  0.000  0.000  0.3222     0.0002 .7860E-02 .7159E-08    0.0000 .0000E+00 .0000E+00
   68 *  *   0.00  0.000  0.000  0.3222     0.0002 .7725E-02 .7153E-08    0.0000 .0000E+00 .0000E+00
```

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*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.021    0.068    0.143    0.169    0.039    0.000
                           0.000    0.000    0.000    0.000    0.024    0.005

    STD. DEVIATIONS        0.063    0.139    0.224    0.195    0.101    0.000
                           0.001    0.000    0.001    0.000    0.052    0.015

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.401    0.456    0.843    2.294    2.510
                           2.075    0.970    0.861    0.558    0.325    0.332

    STD. DEVIATIONS        0.182    0.192    0.159    0.292    0.402    0.560
                           1.024    0.432    0.315    0.230    0.142    0.161

  LATERAL DRAINAGE COLLECTED FROM LAYER  7
  ----------------------------------------
    TOTALS                 0.2220   0.0165   0.0122   0.0093   0.0083   0.0072
                           0.0065   0.0067   0.0061   0.0050   0.0041   0.0044

    STD. DEVIATIONS        1.1891   0.0655   0.0398   0.0261   0.0204   0.0161
                           0.0127   0.0144   0.0125   0.0077   0.0058   0.0062

  PERCOLATION/LEAKAGE THROUGH LAYER  9
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 13
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0036   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0198   0.0001   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


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```

```
     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  12.55    (   1.640)       8200.6     100.00

 RUNOFF                          0.469   (  0.2806)        306.59      3.739

 EVAPOTRANSPIRATION             12.085   (  1.4404)       7896.15     96.287

 LATERAL DRAINAGE COLLECTED      0.30824 (  1.39636)       201.407    2.45600
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.002     0.00002
   LAYER  9

 AVERAGE HEAD ON TOP             0.000 (    0.002)
   OF LAYER  8

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.002     0.00002
   LAYER 13

 CHANGE IN WATER STORAGE        -0.312   (  2.0617)       -203.54     -2.482

*******************************************************************************
```

```
******************************************************************************

               PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
      PRECIPITATION                            1.15          751.410

      RUNOFF                                   0.708         462.3551

      DRAINAGE COLLECTED FROM LAYER  7         3.97996      2600.50635

      PERCOLATION/LEAKAGE THROUGH LAYER  9     0.000008        0.00493

      AVERAGE HEAD ON TOP OF LAYER  8          3.291

      MAXIMUM HEAD ON TOP OF LAYER  8          2.906

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)             12.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER 13     0.000008        0.00493

      SNOW WATER                               1.84         1201.1409


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                0.3474

      MINIMUM VEG. SOIL WATER (VOL/VOL)                0.1725


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
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******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1           3.9454         0.3288

                      2           8.9878         0.2996

                      3           0.5400         0.0450

                      4           0.9600         0.0320

                      5           0.5400         0.0450

                      6           0.5695         0.0475

                      7           0.0020         0.0100

                      8           0.0000         0.0000

                      9           0.1770         0.7500

                     10           0.2700         0.0450

                     11           0.2700         0.0450

                     12           1.8900         0.0450

                     13           2.1600         0.0450

                  SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

Deep Evapotranspiration Zone HELP Model

```
******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************



 PRECIPITATION DATA FILE:    C:\HELP3\silver1.D4
 TEMPERATURE DATA FILE:      C:\HELP3\silver2.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\silver3.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\silver4.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\silver7.D10
 OUTPUT DATA FILE:           C:\HELP3\silver8.OUT



 TIME:  14:32     DATE:   4/16/2015



 ******************************************************************************

      TITLE:  Silver Bow Plant - Enhanced RCRA Cover

 ******************************************************************************



      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
               WERE SPECIFIED BY THE USER.



                                    LAYER  1
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
            THICKNESS                   =    12.00   INCHES
            POROSITY                    =     0.5010 VOL/VOL
            FIELD CAPACITY              =     0.2840 VOL/VOL
            WILTING POINT               =     0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                                    LAYER  2
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
            THICKNESS                   =    30.00   INCHES
            POROSITY                    =     0.4710 VOL/VOL
            FIELD CAPACITY              =     0.3420 VOL/VOL
            WILTING POINT               =     0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC



                                    LAYER  3
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   1
            THICKNESS                   =    12.00   INCHES
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC



                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET



                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC


                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET


                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     15.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD




                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC




                        LAYER 10
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER 11
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER 12
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     42.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER 13
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     48.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
```

```
               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
              FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
              AND A SLOPE LENGTH OF   50. FEET.

    SCS RUNOFF CURVE NUMBER             =     83.50
    FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE  =      0.180  ACRES
    EVAPORATIVE ZONE DEPTH              =     42.0    INCHES
    INITIAL WATER IN EVAPORATIVE ZONE   =     13.668  INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE  =     20.142  INCHES
    LOWER LIMIT OF EVAPORATIVE STORAGE  =      7.920  INCHES
    INITIAL SNOW WATER                  =      0.000  INCHES
    INITIAL WATER IN LAYER MATERIALS    =     29.657  INCHES
    TOTAL INITIAL WATER                 =     29.657  INCHES
    TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR




                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HELENA                MONTANA

         STATION LATITUDE                        =  45.82 DEGREES
         MAXIMUM LEAF AREA INDEX                 =   2.00
         START OF GROWING SEASON (JULIAN DATE)   =    138
         END OF GROWING SEASON (JULIAN DATE)     =    266
         EVAPORATIVE ZONE DEPTH                  =  42.0  INCHES
         AVERAGE ANNUAL WIND SPEED               =   7.80 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  63.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  54.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  49.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  63.00 %



     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    HELENA              MONTANA

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     0.61        0.56        0.81        1.03        1.89        2.27
     1.30        1.11        1.12        0.80        0.62        0.59



     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    HELENA              MONTANA

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    18.60       22.60       29.20       39.10       47.70       55.70
    63.30       61.70       51.90       42.10       29.40       20.90



     NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    HELENA              MONTANA
                AND STATION LATITUDE  =  45.82 DEGREES





  HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  8
  DRAIN #1:  LATERAL DRAINAGE FROM LAYER  7 (RECIRCULATION AND COLLECTION)
```

```
*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.019    0.060    0.128    0.137    0.032    0.000
                           0.000    0.000    0.000    0.000    0.022    0.004

    STD. DEVIATIONS        0.056    0.123    0.210    0.171    0.083    0.000
                           0.001    0.000    0.001    0.000    0.048    0.014

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.401    0.458    0.832    2.246    2.589
                           2.121    1.037    0.892    0.548    0.311    0.332

    STD. DEVIATIONS        0.182    0.193    0.158    0.276    0.396    0.527
                           1.055    0.507    0.332    0.214    0.135    0.162

  LATERAL DRAINAGE COLLECTED FROM LAYER  7
  ----------------------------------------
    TOTALS                 0.2227   0.0170   0.0125   0.0095   0.0084   0.0073
                           0.0066   0.0070   0.0059   0.0045   0.0042   0.0050

    STD. DEVIATIONS        1.1890   0.0657   0.0401   0.0264   0.0207   0.0164
                           0.0130   0.0155   0.0113   0.0065   0.0060   0.0083

  PERCOLATION/LEAKAGE THROUGH LAYER  9
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 13
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0036   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0198   0.0001   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************
```

```
     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  12.55    (   1.640)       8200.6     100.00

 RUNOFF                          0.402   (  0.2506)        262.80      3.205

 EVAPOTRANSPIRATION             12.229   (  1.6251)       7990.46     97.437

 LATERAL DRAINAGE COLLECTED      0.31040 (  1.39695)       202.813    2.47315
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.002     0.00002
   LAYER  9

 AVERAGE HEAD ON TOP             0.000 (    0.002)
   OF LAYER  8

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.002     0.00002
   LAYER 13

 CHANGE IN WATER STORAGE        -0.391   (  2.4267)       -255.47     -3.115

*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              1.15           751.410

      RUNOFF                                     0.656          428.8822

      DRAINAGE COLLECTED FROM LAYER  7           3.97996       2600.50635

      PERCOLATION/LEAKAGE THROUGH LAYER  9       0.000008         0.00493

      AVERAGE HEAD ON TOP OF LAYER  8            3.291

      MAXIMUM HEAD ON TOP OF LAYER  8            2.906

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)               12.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER 13       0.000008         0.00493

      SNOW WATER                                 1.84          1201.1409


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3453

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1886


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

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******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1           3.9837         0.3320

                      2           6.5839         0.2195

                      3           0.5400         0.0450

                      4           0.9600         0.0320

                      5           0.5400         0.0450

                      6           0.5508         0.0459

                      7           0.0020         0.0100

                      8           0.0000         0.0000

                      9           0.1770         0.7500

                     10           0.2700         0.0450

                     11           0.2700         0.0450

                     12           1.8900         0.0450

                     13           2.1600         0.0450

                  SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

Shallow Evapotranspiration Zone HELP Model

```
******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
 **                   USAE WATERWAYS EXPERIMENT STATION                      **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************


 PRECIPITATION DATA FILE:    C:\HELP3\silver1.D4
 TEMPERATURE DATA FILE:      C:\HELP3\silver2.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\silver3.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\silver4.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\silver7.D10
 OUTPUT DATA FILE:           C:\HELP3\silver8.OUT


 TIME:  14:34     DATE:   4/16/2015


 ******************************************************************************

      TITLE:  Silver Bow Plant - Enhanced RCRA Cover

 ******************************************************************************


      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
               WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   9
            THICKNESS                   =     12.00   INCHES
            POROSITY                    =      0.5010 VOL/VOL
            FIELD CAPACITY              =      0.2840 VOL/VOL
            WILTING POINT               =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
            THICKNESS                   =     30.00   INCHES
            POROSITY                    =      0.4710 VOL/VOL
            FIELD CAPACITY              =      0.3420 VOL/VOL
            WILTING POINT               =      0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC


                                  LAYER  3
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   1
            THICKNESS                   =     12.00   INCHES
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC


                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET


                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     15.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC



                        LAYER 10
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 11
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 12
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     42.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 13
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     48.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
               AND A SLOPE LENGTH OF   50. FEET.

     SCS RUNOFF CURVE NUMBER             =     83.50
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      0.180  ACRES
     EVAPORATIVE ZONE DEPTH              =     14.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      4.092  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =      6.954  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.040  INCHES
     INITIAL SNOW WATER                  =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     29.657  INCHES
     TOTAL INITIAL WATER                 =     29.657  INCHES
     TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR



                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               HELENA                MONTANA

          STATION LATITUDE                       =  45.82 DEGREES
          MAXIMUM LEAF AREA INDEX                =   2.00
          START OF GROWING SEASON (JULIAN DATE)  =    138
          END OF GROWING SEASON (JULIAN DATE)    =    266
          EVAPORATIVE ZONE DEPTH                 =  14.0  INCHES
          AVERAGE ANNUAL WIND SPEED              =   7.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  63.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  54.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  49.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  63.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    0.61        0.56        0.81        1.03        1.89        2.27
    1.30        1.11        1.12        0.80        0.62        0.59


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   18.60       22.60       29.20       39.10       47.70       55.70
   63.30       61.70       51.90       42.10       29.40       20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA
                 AND STATION LATITUDE  =  45.82 DEGREES



HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  8
DRAIN #1:  LATERAL DRAINAGE FROM LAYER  7 (RECIRCULATION AND COLLECTION)
```

```
   LEAK  #1:  PERCOLATION OR LEAKAGE THROUGH LAYER  9
   LEAK  #2:  PERCOLATION OR LEAKAGE THROUGH LAYER 13

*****************************************************************************************************

                                    DAILY OUTPUT FOR YEAR    1
 --------------------------------------------------------------------------------------------------
         S
 DAY  A  O  RAIN  RUNOFF   ET   E. ZONE   HEAD      DRAIN     LEAK      HEAD      DRAIN     LEAK
      I  I                       WATER     #1        #1        #1        #2        #2        #2
      R  L   IN.    IN.    IN.  IN./IN.   IN.       IN.       IN.       IN.       IN.       IN.
 ---  -  -  ----- ------ ------ ------- --------- --------- --------- --------- --------- ---------


   1  *  *   0.00  0.000  0.000  0.2923    3.2905 3.980      .7552E-05    0.0000 .0000E+00 .7552E-05
   2  *  *   0.00  0.000  0.000  0.2923    0.0175 .5933      .2439E-07    0.0000 .0000E+00 .3877E-05
   3  *  *   0.00  0.000  0.000  0.2923    0.0096 .3263      .1704E-07    0.0000 .0000E+00 .4261E-05
   4  *  *   0.00  0.000  0.000  0.2923    0.0066 .2239      .1408E-07    0.0000 .0000E+00 .0000E+00
   5  *  *   0.00  0.000  0.000  0.2923    0.0050 .1693      .1246E-07    0.0000 .0000E+00 .0000E+00
   6  *  *   0.00  0.000  0.000  0.2923    0.0040 .1354      .1142E-07    0.0000 .0000E+00 .0000E+00
   7  *  *   0.00  0.000  0.000  0.2923    0.0033 .1124      .1071E-07    0.0000 .0000E+00 .0000E+00
   8  *  *   0.00  0.000  0.000  0.2923    0.0028 .9571E-01 .1018E-07    0.0000 .0000E+00 .0000E+00
   9  *  *   0.00  0.000  0.000  0.2923    0.0024 .8316E-01 .9780E-08    0.0000 .0000E+00 .0000E+00
  10  *  *   0.00  0.000  0.000  0.2923    0.0022 .7337E-01 .9462E-08    0.0000 .0000E+00 .0000E+00
  11  *  *   0.00  0.000  0.000  0.2923    0.0019 .6553E-01 .9205E-08    0.0000 .0000E+00 .0000E+00
  12  *  *   0.00  0.000  0.000  0.2923    0.0017 .5912E-01 .8992E-08    0.0000 .0000E+00 .0000E+00
  13  *  *   0.00  0.000  0.000  0.2923    0.0016 .5378E-01 .8813E-08    0.0000 .0000E+00 .0000E+00
  14  *  *   0.03  0.000  0.015  0.2923    0.0015 .4928E-01 .8661E-08    0.0000 .0000E+00 .0000E+00
  15  *  *   0.00  0.000  0.012  0.2923    0.0013 .4543E-01 .8530E-08    0.0000 .0000E+00 .0000E+00
  16  *  *   0.00  0.000  0.002  0.2923    0.0012 .4211E-01 .8415E-08    0.0000 .0000E+00 .0000E+00
  17  *  *   0.00  0.000  0.000  0.2923    0.0012 .3921E-01 .8315E-08    0.0000 .0000E+00 .0000E+00
  18  *  *   0.00  0.000  0.000  0.2923    0.0011 .3666E-01 .8226E-08    0.0000 .0000E+00 .0000E+00
  19     *   0.00  0.000  0.000  0.2923    0.0010 .3440E-01 .8147E-08    0.0000 .0000E+00 .0000E+00
  20     *   0.01  0.000  0.007  0.2925    0.0010 .3239E-01 .8076E-08    0.0000 .0000E+00 .0000E+00
  21     *   0.00  0.000  0.000  0.2925    0.0009 .3059E-01 .8012E-08    0.0000 .0000E+00 .0000E+00
  22     *   0.00  0.000  0.000  0.2925    0.0009 .2896E-01 .7954E-08    0.0000 .0000E+00 .0000E+00
  23     *   0.06  0.000  0.012  0.2959    0.0008 .2749E-01 .7901E-08    0.0000 .0000E+00 .0000E+00
  24     *   0.11  0.004  0.012  0.3026    0.0008 .2615E-01 .7853E-08    0.0000 .0000E+00 .0000E+00
  25     *   0.00  0.000  0.000  0.3026    0.0007 .2493E-01 .7809E-08    0.0000 .0000E+00 .0000E+00
  26  *  *   0.00  0.000  0.000  0.3026    0.0007 .2381E-01 .7768E-08    0.0000 .0000E+00 .0000E+00
  27  *  *   0.00  0.000  0.000  0.3026    0.0007 .2278E-01 .7730E-08    0.0000 .0000E+00 .0000E+00
  28  *  *   0.00  0.000  0.000  0.3026    0.0006 .2183E-01 .7695E-08    0.0000 .0000E+00 .0000E+00
  29  *  *   0.09  0.000  0.030  0.3026    0.0006 .2095E-01 .7663E-08    0.0000 .0000E+00 .0000E+00
  30  *  *   0.01  0.000  0.036  0.3026    0.0006 .2013E-01 .7633E-08    0.0000 .0000E+00 .0000E+00
  31  *  *   0.00  0.000  0.035  0.3026    0.0006 .1937E-01 .7604E-08    0.0000 .0000E+00 .0000E+00
  32  *  *   0.00  0.000  0.000  0.3026    0.0005 .1867E-01 .7578E-08    0.0000 .0000E+00 .0000E+00
  33  *  *   0.00  0.000  0.000  0.3026    0.0005 .1800E-01 .7553E-08    0.0000 .0000E+00 .0000E+00
  34  *  *   0.02  0.000  0.020  0.3026    0.0005 .1739E-01 .7530E-08    0.0000 .0000E+00 .0000E+00
  35  *  *   0.00  0.000  0.000  0.3026    0.0005 .1681E-01 .7508E-08    0.0000 .0000E+00 .0000E+00
  36  *  *   0.00  0.000  0.000  0.3026    0.0005 .1626E-01 .7487E-08    0.0000 .0000E+00 .0000E+00
  37  *  *   0.11  0.000  0.026  0.3026    0.0005 .1575E-01 .7468E-08    0.0000 .0000E+00 .0000E+00
  38     *   0.00  0.001  0.039  0.3058    0.0004 .1526E-01 .7450E-08    0.0000 .0000E+00 .0000E+00
  39     *   0.00  0.000  0.000  0.3058    0.0004 .1481E-01 .7432E-08    0.0000 .0000E+00 .0000E+00
  40     *   0.00  0.000  0.000  0.3058    0.0004 .1437E-01 .7415E-08    0.0000 .0000E+00 .0000E+00
  41     *   0.00  0.000  0.000  0.3058    0.0004 .1396E-01 .7400E-08    0.0000 .0000E+00 .0000E+00
  42     *   0.05  0.000  0.012  0.3085    0.0004 .1358E-01 .7385E-08    0.0000 .0000E+00 .0000E+00
  43     *   0.00  0.000  0.000  0.3085    0.0004 .1321E-01 .7371E-08    0.0000 .0000E+00 .0000E+00
  44     *   0.00  0.000  0.000  0.3085    0.0004 .1286E-01 .7357E-08    0.0000 .0000E+00 .0000E+00
  45     *   0.00  0.000  0.000  0.3085    0.0004 .1252E-01 .7344E-08    0.0000 .0000E+00 .0000E+00
  46     *   0.00  0.000  0.000  0.3085    0.0004 .1220E-01 .7332E-08    0.0000 .0000E+00 .0000E+00
  47  *  *   0.05  0.000  0.039  0.3085    0.0004 .1190E-01 .7320E-08    0.0000 .0000E+00 .0000E+00
  48     *   0.00  0.000  0.011  0.3085    0.0003 .1161E-01 .7308E-08    0.0000 .0000E+00 .0000E+00
  49     *   0.00  0.000  0.000  0.3085    0.0003 .1133E-01 .7298E-08    0.0000 .0000E+00 .0000E+00
  50  *  *   0.00  0.000  0.000  0.3085    0.0003 .1107E-01 .7287E-08    0.0000 .0000E+00 .0000E+00
  51     *   0.00  0.000  0.000  0.3085    0.0003 .1082E-01 .7277E-08    0.0000 .0000E+00 .0000E+00
  52  *  *   0.00  0.000  0.000  0.3085    0.0003 .1057E-01 .7268E-08    0.0000 .0000E+00 .0000E+00
  53  *  *   0.00  0.000  0.000  0.3085    0.0003 .1034E-01 .7258E-08    0.0000 .0000E+00 .0000E+00
  54  *  *   0.05  0.000  0.027  0.3085    0.0003 .1012E-01 .7250E-08    0.0000 .0000E+00 .0000E+00
  55  *  *   0.06  0.000  0.034  0.3085    0.0003 .9902E-02 .7241E-08    0.0000 .0000E+00 .0000E+00
  56  *  *   0.13  0.000  0.028  0.3085    0.0003 .9695E-02 .7233E-08    0.0000 .0000E+00 .0000E+00
  57  *  *   0.00  0.000  0.040  0.3085    0.0003 .9496E-02 .7225E-08    0.0000 .0000E+00 .0000E+00
  58  *  *   0.00  0.000  0.052  0.3085    0.0003 .9305E-02 .7217E-08    0.0000 .0000E+00 .0000E+00
  59     *   0.00  0.000  0.052  0.3085    0.0003 .9121E-02 .7210E-08    0.0000 .0000E+00 .0000E+00
  60  *  *   0.05  0.000  0.037  0.3085    0.0003 .8943E-02 .7203E-08    0.0000 .0000E+00 .0000E+00
  61  *  *   0.03  0.000  0.027  0.3085    0.0003 .8772E-02 .7196E-08    0.0000 .0000E+00 .0000E+00
  62  *  *   0.00  0.000  0.022  0.3085    0.0003 .8607E-02 .7189E-08    0.0000 .0000E+00 .0000E+00
  63  *  *   0.00  0.000  0.000  0.3085    0.0002 .8447E-02 .7183E-08    0.0000 .0000E+00 .0000E+00
  64  *  *   0.00  0.000  0.000  0.3085    0.0002 .8293E-02 .7176E-08    0.0000 .0000E+00 .0000E+00
  65  *  *   0.02  0.000  0.020  0.3085    0.0002 .8144E-02 .7170E-08    0.0000 .0000E+00 .0000E+00
  66  *  *   0.00  0.000  0.000  0.3085    0.0002 .8000E-02 .7164E-08    0.0000 .0000E+00 .0000E+00
  67  *  *   0.00  0.000  0.000  0.3085    0.0002 .7860E-02 .7159E-08    0.0000 .0000E+00 .0000E+00
  68  *  *   0.00  0.000  0.000  0.3085    0.0002 .7725E-02 .7153E-08    0.0000 .0000E+00 .0000E+00
```

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*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.024    0.077    0.157    0.210    0.048    0.000
                           0.001    0.000    0.000    0.000    0.026    0.006

    STD. DEVIATIONS        0.077    0.157    0.231    0.230    0.120    0.000
                           0.003    0.000    0.001    0.000    0.057    0.017

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.399    0.446    0.963    2.195    2.383
                           1.770    0.922    0.916    0.709    0.409    0.340

    STD. DEVIATIONS        0.182    0.192    0.160    0.402    0.574    0.610
                           0.836    0.476    0.420    0.288    0.136    0.159

  LATERAL DRAINAGE COLLECTED FROM LAYER  7
  ----------------------------------------
    TOTALS                 0.2249   0.0191   0.0151   0.0127   0.0119   0.0109
                           0.0102   0.0104   0.0094   0.0079   0.0070   0.0075

    STD. DEVIATIONS        1.1885   0.0652   0.0395   0.0259   0.0207   0.0167
                           0.0136   0.0153   0.0125   0.0082   0.0072   0.0079

  PERCOLATION/LEAKAGE THROUGH LAYER  9
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 13
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0036   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0198   0.0001   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************
```

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*******************************************************************************


     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                   INCHES            CU. FEET        PERCENT
                              -------------------  -------------   ---------
 PRECIPITATION                12.55    (   1.640)      8200.6     100.00

 RUNOFF                        0.549   (  0.3125)       358.58      4.373

 EVAPOTRANSPIRATION           11.912   (  1.4294)      7783.11     94.909

 LATERAL DRAINAGE COLLECTED    0.34693 (  1.38970)      226.683    2.76423
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH   0.00000 (  0.00000)        0.002     0.00002
   LAYER  9

 AVERAGE HEAD ON TOP           0.000 (    0.002)
   OF LAYER  8

 PERCOLATION/LEAKAGE THROUGH   0.00000 (  0.00000)        0.002     0.00002
   LAYER 13

 CHANGE IN WATER STORAGE      -0.257   (  1.7698)      -167.77     -2.046

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```

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******************************************************************************

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                             (INCHES)      (CU. FT.)
                                            ----------   -------------
      PRECIPITATION                           1.15          751.410

      RUNOFF                                  0.741         484.0527

      DRAINAGE COLLECTED FROM LAYER  7        3.97996      2600.50635

      PERCOLATION/LEAKAGE THROUGH LAYER  9    0.000008        0.00493

      AVERAGE HEAD ON TOP OF LAYER  8         3.291

      MAXIMUM HEAD ON TOP OF LAYER  8         2.906

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)            12.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER 13    0.000008        0.00493

      SNOW WATER                              1.84         1201.1409


      MAXIMUM VEG. SOIL WATER (VOL/VOL)               0.3481

      MINIMUM VEG. SOIL WATER (VOL/VOL)               0.1457


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
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******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            3.9195         0.3266

                      2            9.9817         0.3327

                      3            0.6764         0.0564

                      4            1.1944         0.0398

                      5            0.7106         0.0592

                      6            0.7026         0.0585

                      7            0.0020         0.0100

                      8            0.0000         0.0000

                      9            0.1770         0.7500

                     10            0.2700         0.0450

                     11            0.2700         0.0450

                     12            1.8900         0.0450

                     13            2.1600         0.0450

                  SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

High Leaf Area HELP Model

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*****************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************


 PRECIPITATION DATA FILE:    C:\HELP3\silver1.D4
 TEMPERATURE DATA FILE:      C:\HELP3\silver2.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\silver3.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\silver4.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\silver7.D10
 OUTPUT DATA FILE:           C:\HELP3\silver8.OUT


 TIME:  14:36     DATE:   4/16/2015


 ******************************************************************************

      TITLE:  Silver Bow Plant - Enhanced RCRA Cover

 ******************************************************************************


      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
               WERE SPECIFIED BY THE USER.


                                    LAYER  1
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
            THICKNESS                   =    12.00   INCHES
            POROSITY                    =     0.5010 VOL/VOL
            FIELD CAPACITY              =     0.2840 VOL/VOL
            WILTING POINT               =     0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                    LAYER  2
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
            THICKNESS                   =    30.00   INCHES
            POROSITY                    =     0.4710 VOL/VOL
            FIELD CAPACITY              =     0.3420 VOL/VOL
            WILTING POINT               =     0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC


                                    LAYER  3
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   1
            THICKNESS                   =    12.00   INCHES
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC




                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET




                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     15.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC



                        LAYER 10
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 11
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 12
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     42.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 13
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     48.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
               AND A SLOPE LENGTH OF   50. FEET.

     SCS RUNOFF CURVE NUMBER              =     83.50
     FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      0.180  ACRES
     EVAPORATIVE ZONE DEPTH               =     24.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      7.512  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     11.664  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.140  INCHES
     INITIAL SNOW WATER                   =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     29.657  INCHES
     TOTAL INITIAL WATER                  =     29.657  INCHES
     TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR



                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               HELENA                MONTANA

          STATION LATITUDE                       =  45.82 DEGREES
          MAXIMUM LEAF AREA INDEX                =   3.00
          START OF GROWING SEASON (JULIAN DATE)  =    138
          END OF GROWING SEASON (JULIAN DATE)    =    266
          EVAPORATIVE ZONE DEPTH                 =  24.0  INCHES
          AVERAGE ANNUAL WIND SPEED              =   7.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  63.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  54.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  49.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  63.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    0.61        0.56        0.81        1.03        1.89        2.27
    1.30        1.11        1.12        0.80        0.62        0.59


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   18.60       22.60       29.20       39.10       47.70       55.70
   63.30       61.70       51.90       42.10       29.40       20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA
                 AND STATION LATITUDE  =  45.82 DEGREES




HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  8
DRAIN #1:  LATERAL DRAINAGE FROM LAYER  7 (RECIRCULATION AND COLLECTION)
```

```
   LEAK  #1:  PERCOLATION OR LEAKAGE THROUGH LAYER  9
   LEAK  #2:  PERCOLATION OR LEAKAGE THROUGH LAYER 13

****************************************************************************************************

                                    DAILY OUTPUT FOR YEAR    1
 --------------------------------------------------------------------------------------------------
         S
 DAY  A  O  RAIN  RUNOFF   ET   E. ZONE   HEAD      DRAIN     LEAK      HEAD      DRAIN     LEAK
      I  I                       WATER     #1        #1        #1        #2        #2        #2
      R  L   IN.    IN.    IN.  IN./IN.    IN.       IN.       IN.       IN.       IN.       IN.
 ---  -  -  ----- ------ ------ ------- --------- --------- --------- --------- --------- ---------


   1  *  *   0.00  0.000  0.000  0.3130    3.2905 3.980     .7552E-05    0.0000 .0000E+00 .7552E-05
   2  *  *   0.00  0.000  0.000  0.3130    0.0175 .5933     .2439E-07    0.0000 .0000E+00 .3877E-05
   3  *  *   0.00  0.000  0.000  0.3130    0.0096 .3263     .1704E-07    0.0000 .0000E+00 .4261E-05
   4  *  *   0.00  0.000  0.000  0.3130    0.0066 .2239     .1408E-07    0.0000 .0000E+00 .0000E+00
   5  *  *   0.00  0.000  0.000  0.3130    0.0050 .1693     .1246E-07    0.0000 .0000E+00 .0000E+00
   6  *  *   0.00  0.000  0.000  0.3130    0.0040 .1354     .1142E-07    0.0000 .0000E+00 .0000E+00
   7  *  *   0.00  0.000  0.000  0.3130    0.0033 .1124     .1071E-07    0.0000 .0000E+00 .0000E+00
   8  *  *   0.00  0.000  0.000  0.3130    0.0028 .9571E-01 .1018E-07    0.0000 .0000E+00 .0000E+00
   9  *  *   0.00  0.000  0.000  0.3130    0.0024 .8316E-01 .9780E-08    0.0000 .0000E+00 .0000E+00
  10  *  *   0.00  0.000  0.000  0.3130    0.0022 .7337E-01 .9462E-08    0.0000 .0000E+00 .0000E+00
  11  *  *   0.00  0.000  0.000  0.3130    0.0019 .6553E-01 .9205E-08    0.0000 .0000E+00 .0000E+00
  12  *  *   0.00  0.000  0.000  0.3130    0.0017 .5912E-01 .8992E-08    0.0000 .0000E+00 .0000E+00
  13  *  *   0.00  0.000  0.000  0.3130    0.0016 .5378E-01 .8813E-08    0.0000 .0000E+00 .0000E+00
  14  *  *   0.03  0.000  0.015  0.3130    0.0015 .4928E-01 .8661E-08    0.0000 .0000E+00 .0000E+00
  15  *  *   0.00  0.000  0.012  0.3130    0.0013 .4543E-01 .8530E-08    0.0000 .0000E+00 .0000E+00
  16  *  *   0.00  0.000  0.002  0.3130    0.0012 .4211E-01 .8415E-08    0.0000 .0000E+00 .0000E+00
  17  *  *   0.00  0.000  0.000  0.3130    0.0012 .3921E-01 .8315E-08    0.0000 .0000E+00 .0000E+00
  18  *  *   0.00  0.000  0.000  0.3130    0.0011 .3666E-01 .8226E-08    0.0000 .0000E+00 .0000E+00
  19     *   0.00  0.000  0.000  0.3130    0.0010 .3440E-01 .8147E-08    0.0000 .0000E+00 .0000E+00
  20     *   0.01  0.000  0.008  0.3131    0.0010 .3239E-01 .8076E-08    0.0000 .0000E+00 .0000E+00
  21     *   0.00  0.000  0.000  0.3131    0.0009 .3059E-01 .8012E-08    0.0000 .0000E+00 .0000E+00
  22     *   0.00  0.000  0.000  0.3131    0.0009 .2896E-01 .7954E-08    0.0000 .0000E+00 .0000E+00
  23     *   0.06  0.000  0.018  0.3148    0.0008 .2749E-01 .7901E-08    0.0000 .0000E+00 .0000E+00
  24     *   0.11  0.004  0.019  0.3185    0.0008 .2615E-01 .7853E-08    0.0000 .0000E+00 .0000E+00
  25     *   0.00  0.000  0.000  0.3185    0.0007 .2493E-01 .7809E-08    0.0000 .0000E+00 .0000E+00
  26  *  *   0.00  0.000  0.000  0.3185    0.0007 .2381E-01 .7768E-08    0.0000 .0000E+00 .0000E+00
  27  *  *   0.00  0.000  0.000  0.3185    0.0007 .2278E-01 .7730E-08    0.0000 .0000E+00 .0000E+00
  28  *  *   0.00  0.000  0.000  0.3185    0.0006 .2183E-01 .7695E-08    0.0000 .0000E+00 .0000E+00
  29  *  *   0.09  0.000  0.030  0.3185    0.0006 .2095E-01 .7663E-08    0.0000 .0000E+00 .0000E+00
  30  *  *   0.01  0.000  0.036  0.3185    0.0006 .2013E-01 .7633E-08    0.0000 .0000E+00 .0000E+00
  31  *  *   0.00  0.000  0.035  0.3185    0.0006 .1937E-01 .7604E-08    0.0000 .0000E+00 .0000E+00
  32  *  *   0.00  0.000  0.000  0.3185    0.0005 .1867E-01 .7578E-08    0.0000 .0000E+00 .0000E+00
  33  *  *   0.00  0.000  0.000  0.3185    0.0005 .1800E-01 .7553E-08    0.0000 .0000E+00 .0000E+00
  34  *  *   0.02  0.000  0.020  0.3185    0.0005 .1739E-01 .7530E-08    0.0000 .0000E+00 .0000E+00
  35  *  *   0.00  0.000  0.000  0.3185    0.0005 .1681E-01 .7508E-08    0.0000 .0000E+00 .0000E+00
  36  *  *   0.00  0.000  0.000  0.3185    0.0005 .1626E-01 .7487E-08    0.0000 .0000E+00 .0000E+00
  37  *  *   0.11  0.000  0.026  0.3185    0.0005 .1575E-01 .7468E-08    0.0000 .0000E+00 .0000E+00
  38     *   0.00  0.001  0.039  0.3203    0.0004 .1526E-01 .7450E-08    0.0000 .0000E+00 .0000E+00
  39     *   0.00  0.000  0.000  0.3203    0.0004 .1481E-01 .7432E-08    0.0000 .0000E+00 .0000E+00
  40     *   0.00  0.000  0.000  0.3203    0.0004 .1437E-01 .7415E-08    0.0000 .0000E+00 .0000E+00
  41     *   0.00  0.000  0.000  0.3203    0.0004 .1396E-01 .7400E-08    0.0000 .0000E+00 .0000E+00
  42     *   0.05  0.000  0.018  0.3217    0.0004 .1358E-01 .7385E-08    0.0000 .0000E+00 .0000E+00
  43     *   0.00  0.000  0.000  0.3217    0.0004 .1321E-01 .7371E-08    0.0000 .0000E+00 .0000E+00
  44     *   0.00  0.000  0.000  0.3217    0.0004 .1286E-01 .7357E-08    0.0000 .0000E+00 .0000E+00
  45     *   0.00  0.000  0.000  0.3217    0.0004 .1252E-01 .7344E-08    0.0000 .0000E+00 .0000E+00
  46     *   0.00  0.000  0.000  0.3217    0.0004 .1220E-01 .7332E-08    0.0000 .0000E+00 .0000E+00
  47  *  *   0.05  0.000  0.039  0.3217    0.0004 .1190E-01 .7320E-08    0.0000 .0000E+00 .0000E+00
  48     *   0.00  0.000  0.011  0.3217    0.0003 .1161E-01 .7308E-08    0.0000 .0000E+00 .0000E+00
  49     *   0.00  0.000  0.000  0.3217    0.0003 .1133E-01 .7298E-08    0.0000 .0000E+00 .0000E+00
  50  *  *   0.00  0.000  0.000  0.3217    0.0003 .1107E-01 .7287E-08    0.0000 .0000E+00 .0000E+00
  51     *   0.00  0.000  0.000  0.3217    0.0003 .1082E-01 .7277E-08    0.0000 .0000E+00 .0000E+00
  52  *  *   0.00  0.000  0.000  0.3217    0.0003 .1057E-01 .7268E-08    0.0000 .0000E+00 .0000E+00
  53  *  *   0.00  0.000  0.000  0.3217    0.0003 .1034E-01 .7258E-08    0.0000 .0000E+00 .0000E+00
  54  *  *   0.05  0.000  0.027  0.3217    0.0003 .1012E-01 .7250E-08    0.0000 .0000E+00 .0000E+00
  55  *  *   0.06  0.000  0.034  0.3217    0.0003 .9902E-02 .7241E-08    0.0000 .0000E+00 .0000E+00
  56  *  *   0.13  0.000  0.028  0.3217    0.0003 .9695E-02 .7233E-08    0.0000 .0000E+00 .0000E+00
  57  *  *   0.00  0.000  0.040  0.3217    0.0003 .9496E-02 .7225E-08    0.0000 .0000E+00 .0000E+00
  58  *  *   0.00  0.000  0.052  0.3217    0.0003 .9305E-02 .7217E-08    0.0000 .0000E+00 .0000E+00
  59     *   0.00  0.000  0.052  0.3217    0.0003 .9121E-02 .7210E-08    0.0000 .0000E+00 .0000E+00
  60  *  *   0.05  0.000  0.037  0.3217    0.0003 .8943E-02 .7203E-08    0.0000 .0000E+00 .0000E+00
  61  *  *   0.03  0.000  0.027  0.3217    0.0003 .8772E-02 .7196E-08    0.0000 .0000E+00 .0000E+00
  62  *  *   0.00  0.000  0.022  0.3217    0.0003 .8607E-02 .7189E-08    0.0000 .0000E+00 .0000E+00
  63  *  *   0.00  0.000  0.000  0.3217    0.0002 .8447E-02 .7183E-08    0.0000 .0000E+00 .0000E+00
  64  *  *   0.00  0.000  0.000  0.3217    0.0002 .8293E-02 .7176E-08    0.0000 .0000E+00 .0000E+00
  65  *  *   0.02  0.000  0.020  0.3217    0.0002 .8144E-02 .7170E-08    0.0000 .0000E+00 .0000E+00
  66  *  *   0.00  0.000  0.000  0.3217    0.0002 .8000E-02 .7164E-08    0.0000 .0000E+00 .0000E+00
  67  *  *   0.00  0.000  0.000  0.3217    0.0002 .7860E-02 .7159E-08    0.0000 .0000E+00 .0000E+00
  68  *  *   0.00  0.000  0.000  0.3217    0.0002 .7725E-02 .7153E-08    0.0000 .0000E+00 .0000E+00
```

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******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.021    0.067    0.142    0.168    0.038    0.000
                           0.000    0.000    0.000    0.000    0.024    0.005

    STD. DEVIATIONS        0.065    0.137    0.222    0.194    0.099    0.000
                           0.001    0.000    0.001    0.000    0.051    0.015

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.401    0.458    0.844    2.311    2.812
                           1.785    0.976    0.850    0.545    0.313    0.333

    STD. DEVIATIONS        0.182    0.193    0.158    0.291    0.380    0.637
                           0.931    0.450    0.317    0.218    0.132    0.162

  LATERAL DRAINAGE COLLECTED FROM LAYER  7
  ----------------------------------------
    TOTALS                 0.2222   0.0166   0.0122   0.0094   0.0082   0.0071
                           0.0066   0.0069   0.0059   0.0047   0.0042   0.0046

    STD. DEVIATIONS        1.1891   0.0655   0.0398   0.0261   0.0204   0.0160
                           0.0130   0.0150   0.0114   0.0069   0.0058   0.0067

  PERCOLATION/LEAKAGE THROUGH LAYER  9
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 13
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0036   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0198   0.0001   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

******************************************************************************
```

```
*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  30
-------------------------------------------------------------------------------
                                   INCHES            CU. FEET       PERCENT

                              -------------------   -------------   ---------
PRECIPITATION                  12.55    (   1.640)       8200.6     100.00

RUNOFF                          0.465   (  0.2789)        303.94      3.706

EVAPOTRANSPIRATION             12.088   (  1.4317)       7898.10     96.311

LATERAL DRAINAGE COLLECTED      0.30868 (  1.39612)        201.691    2.45946
  FROM LAYER  7

PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)          0.002     0.00002
  LAYER  9

AVERAGE HEAD ON TOP             0.000   (  0.002)
  OF LAYER  8

PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)          0.002     0.00002
  LAYER 13

CHANGE IN WATER STORAGE        -0.311   (  2.0405)       -203.12     -2.477

*******************************************************************************
```

```
******************************************************************************

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------   -------------
      PRECIPITATION                             1.15          751.410

      RUNOFF                                    0.703         459.0752

      DRAINAGE COLLECTED FROM LAYER  7          3.97996      2600.50635

      PERCOLATION/LEAKAGE THROUGH LAYER  9      0.000008        0.00493

      AVERAGE HEAD ON TOP OF LAYER  8           3.291

      MAXIMUM HEAD ON TOP OF LAYER  8           2.906

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)              12.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER 13      0.000008        0.00493

      SNOW WATER                                1.84         1201.1409


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3465

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1725


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                  LAYER        (INCHES)       (VOL/VOL)
                  -----        --------       ---------
                    1           3.8817          0.3235

                    2           9.0396          0.3013

                    3           0.5400          0.0450

                    4           0.9600          0.0320

                    5           0.5437          0.0453

                    6           0.5969          0.0497

                    7           0.0020          0.0100

                    8           0.0000          0.0000

                    9           0.1770          0.7500

                   10           0.2700          0.0450

                   11           0.2700          0.0450

                   12           1.8900          0.0450

                   13           2.1600          0.0450

                  SNOW WATER    0.000

******************************************************************************
******************************************************************************
```

High Liner Defects HELP Model

```
******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************



 PRECIPITATION DATA FILE:    C:\HELP3\silver1.D4
 TEMPERATURE DATA FILE:      C:\HELP3\silver2.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\silver3.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\silver4.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\silver7.D10
 OUTPUT DATA FILE:           C:\HELP3\silver8.OUT



 TIME:  14:40     DATE:   4/16/2015




 ******************************************************************************

      TITLE:  Silver Bow Plant - Enhanced RCRA Cover

 ******************************************************************************



      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
               WERE SPECIFIED BY THE USER.



                                    LAYER  1
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
            THICKNESS                    =     12.00   INCHES
            POROSITY                     =      0.5010 VOL/VOL
            FIELD CAPACITY               =      0.2840 VOL/VOL
            WILTING POINT                =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT   =      0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. CONDUCT. =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.




                                    LAYER  2
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
            THICKNESS                    =     30.00   INCHES
            POROSITY                     =      0.4710 VOL/VOL
            FIELD CAPACITY               =      0.3420 VOL/VOL
            WILTING POINT                =      0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT   =      0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC



                                    LAYER  3
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   1
            THICKNESS                    =     12.00   INCHES
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC



                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET



                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      2.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     30.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD




                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC




                        LAYER 10
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER 11
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER 12
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     42.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER 13
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     48.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
               AND A SLOPE LENGTH OF   50. FEET.

     SCS RUNOFF CURVE NUMBER             =     83.50
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      0.180  ACRES
     EVAPORATIVE ZONE DEPTH              =      24.0   INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =       7.512  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     11.664  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.140  INCHES
     INITIAL SNOW WATER                  =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     29.657  INCHES
     TOTAL INITIAL WATER                 =     29.657  INCHES
     TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR



                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               HELENA                MONTANA

          STATION LATITUDE                       =  45.82 DEGREES
          MAXIMUM LEAF AREA INDEX                =   2.00
          START OF GROWING SEASON (JULIAN DATE)  =    138
          END OF GROWING SEASON (JULIAN DATE)    =    266
          EVAPORATIVE ZONE DEPTH                 =  24.0  INCHES
          AVERAGE ANNUAL WIND SPEED              =   7.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  63.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  54.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  49.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  63.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    0.61        0.56        0.81        1.03        1.89        2.27
    1.30        1.11        1.12        0.80        0.62        0.59


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   18.60       22.60       29.20       39.10       47.70       55.70
   63.30       61.70       51.90       42.10       29.40       20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA
                 AND STATION LATITUDE  =  45.82 DEGREES




HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  8
DRAIN #1:  LATERAL DRAINAGE FROM LAYER  7 (RECIRCULATION AND COLLECTION)
```

```
   LEAK  #1:  PERCOLATION OR LEAKAGE THROUGH LAYER  9
   LEAK  #2:  PERCOLATION OR LEAKAGE THROUGH LAYER 13

****************************************************************************************************

                                    DAILY OUTPUT FOR YEAR    1
 --------------------------------------------------------------------------------------------------
         S
 DAY  A  O  RAIN  RUNOFF   ET   E. ZONE   HEAD      DRAIN     LEAK      HEAD      DRAIN     LEAK
      I  I                       WATER     #1        #1        #1        #2        #2        #2
      R  L   IN.    IN.    IN.  IN./IN.    IN.       IN.       IN.       IN.       IN.       IN.
 ---  -  -  -----  ------ ------ ------- --------- --------- --------- --------- --------- ---------


   1  *  *   0.00  0.000  0.000  0.3130    3.2905 3.980     .1473E-04    0.0000 .0000E+00 .3816E-05
   2  *  *   0.00  0.000  0.000  0.3130    0.0175 .5933     .4198E-07    0.0000 .0000E+00 .4305E-05
   3  *  *   0.00  0.000  0.000  0.3130    0.0096 .3263     .2727E-07    0.0000 .0000E+00 .0000E+00
   4  *  *   0.00  0.000  0.000  0.3130    0.0066 .2239     .2136E-07    0.0000 .0000E+00 .0000E+00
   5  *  *   0.00  0.000  0.000  0.3130    0.0050 .1693     .1811E-07    0.0000 .0000E+00 .3947E-05
   6  *  *   0.00  0.000  0.000  0.3130    0.0040 .1354     .1605E-07    0.0000 .0000E+00 .5810E-05
   7  *  *   0.00  0.000  0.000  0.3130    0.0033 .1124     .1461E-07    0.0000 .0000E+00 .5658E-05
   8  *  *   0.00  0.000  0.000  0.3130    0.0028 .9571E-01 .1356E-07    0.0000 .0000E+00 .0000E+00
   9  *  *   0.00  0.000  0.000  0.3130    0.0024 .8316E-01 .1276E-07    0.0000 .0000E+00 .0000E+00
  10  *  *   0.00  0.000  0.000  0.3130    0.0022 .7337E-01 .1212E-07    0.0000 .0000E+00 .0000E+00
  11  *  *   0.00  0.000  0.000  0.3130    0.0019 .6553E-01 .1161E-07    0.0000 .0000E+00 .0000E+00
  12  *  *   0.00  0.000  0.000  0.3130    0.0017 .5912E-01 .1118E-07    0.0000 .0000E+00 .0000E+00
  13  *  *   0.00  0.000  0.000  0.3130    0.0016 .5378E-01 .1082E-07    0.0000 .0000E+00 .0000E+00
  14  *  *   0.03  0.000  0.015  0.3130    0.0015 .4928E-01 .1052E-07    0.0000 .0000E+00 .0000E+00
  15  *  *   0.00  0.000  0.012  0.3130    0.0013 .4543E-01 .1026E-07    0.0000 .0000E+00 .0000E+00
  16  *  *   0.00  0.000  0.002  0.3130    0.0012 .4211E-01 .1003E-07    0.0000 .0000E+00 .0000E+00
  17  *  *   0.00  0.000  0.000  0.3130    0.0012 .3921E-01 .9827E-08    0.0000 .0000E+00 .0000E+00
  18  *  *   0.00  0.000  0.000  0.3130    0.0011 .3666E-01 .9649E-08    0.0000 .0000E+00 .0000E+00
  19     *   0.00  0.000  0.000  0.3130    0.0010 .3440E-01 .9491E-08    0.0000 .0000E+00 .0000E+00
  20     *   0.01  0.000  0.007  0.3131    0.0010 .3239E-01 .9349E-08    0.0000 .0000E+00 .0000E+00
  21     *   0.00  0.000  0.000  0.3131    0.0009 .3059E-01 .9221E-08    0.0000 .0000E+00 .0000E+00
  22     *   0.00  0.000  0.000  0.3131    0.0009 .2896E-01 .9105E-08    0.0000 .0000E+00 .0000E+00
  23     *   0.06  0.000  0.014  0.3150    0.0008 .2749E-01 .8999E-08    0.0000 .0000E+00 .0000E+00
  24     *   0.11  0.004  0.015  0.3188    0.0008 .2615E-01 .8902E-08    0.0000 .0000E+00 .0000E+00
  25     *   0.00  0.000  0.000  0.3188    0.0007 .2493E-01 .8814E-08    0.0000 .0000E+00 .0000E+00
  26  *  *   0.00  0.000  0.000  0.3188    0.0007 .2381E-01 .8732E-08    0.0000 .0000E+00 .0000E+00
  27  *  *   0.00  0.000  0.000  0.3188    0.0007 .2278E-01 .8657E-08    0.0000 .0000E+00 .0000E+00
  28  *  *   0.00  0.000  0.000  0.3188    0.0006 .2183E-01 .8587E-08    0.0000 .0000E+00 .0000E+00
  29  *  *   0.09  0.000  0.030  0.3188    0.0006 .2095E-01 .8522E-08    0.0000 .0000E+00 .0000E+00
  30  *  *   0.01  0.000  0.036  0.3188    0.0006 .2013E-01 .8462E-08    0.0000 .0000E+00 .0000E+00
  31  *  *   0.00  0.000  0.035  0.3188    0.0006 .1937E-01 .8405E-08    0.0000 .0000E+00 .0000E+00
  32  *  *   0.00  0.000  0.000  0.3188    0.0005 .1867E-01 .8353E-08    0.0000 .0000E+00 .0000E+00
  33  *  *   0.00  0.000  0.000  0.3188    0.0005 .1800E-01 .8303E-08    0.0000 .0000E+00 .0000E+00
  34  *  *   0.02  0.000  0.020  0.3188    0.0005 .1739E-01 .8257E-08    0.0000 .0000E+00 .0000E+00
  35  *  *   0.00  0.000  0.000  0.3188    0.0005 .1681E-01 .8213E-08    0.0000 .0000E+00 .0000E+00
  36  *  *   0.00  0.000  0.000  0.3188    0.0005 .1626E-01 .8172E-08    0.0000 .0000E+00 .0000E+00
  37  *  *   0.11  0.000  0.026  0.3188    0.0005 .1575E-01 .8133E-08    0.0000 .0000E+00 .0000E+00
  38     *   0.00  0.001  0.039  0.3207    0.0004 .1526E-01 .8096E-08    0.0000 .0000E+00 .0000E+00
  39     *   0.00  0.000  0.000  0.3207    0.0004 .1481E-01 .8061E-08    0.0000 .0000E+00 .0000E+00
  40     *   0.00  0.000  0.000  0.3207    0.0004 .1437E-01 .8028E-08    0.0000 .0000E+00 .0000E+00
  41     *   0.00  0.000  0.000  0.3207    0.0004 .1396E-01 .7996E-08    0.0000 .0000E+00 .0000E+00
  42     *   0.05  0.000  0.014  0.3222    0.0004 .1358E-01 .7966E-08    0.0000 .0000E+00 .0000E+00
  43     *   0.00  0.000  0.000  0.3222    0.0004 .1321E-01 .7938E-08    0.0000 .0000E+00 .0000E+00
  44     *   0.00  0.000  0.000  0.3222    0.0004 .1286E-01 .7911E-08    0.0000 .0000E+00 .0000E+00
  45     *   0.00  0.000  0.000  0.3222    0.0004 .1252E-01 .7885E-08    0.0000 .0000E+00 .0000E+00
  46     *   0.00  0.000  0.000  0.3222    0.0004 .1220E-01 .7860E-08    0.0000 .0000E+00 .0000E+00
  47  *  *   0.05  0.000  0.039  0.3222    0.0004 .1190E-01 .7836E-08    0.0000 .0000E+00 .0000E+00
  48     *   0.00  0.000  0.011  0.3222    0.0003 .1161E-01 .7814E-08    0.0000 .0000E+00 .0000E+00
  49     *   0.00  0.000  0.000  0.3222    0.0003 .1133E-01 .7792E-08    0.0000 .0000E+00 .0000E+00
  50  *  *   0.00  0.000  0.000  0.3222    0.0003 .1107E-01 .7771E-08    0.0000 .0000E+00 .0000E+00
  51     *   0.00  0.000  0.000  0.3222    0.0003 .1082E-01 .7751E-08    0.0000 .0000E+00 .0000E+00
  52  *  *   0.00  0.000  0.000  0.3222    0.0003 .1057E-01 .7732E-08    0.0000 .0000E+00 .0000E+00
  53  *  *   0.00  0.000  0.000  0.3222    0.0003 .1034E-01 .7714E-08    0.0000 .0000E+00 .0000E+00
  54  *  *   0.05  0.000  0.027  0.3222    0.0003 .1012E-01 .7696E-08    0.0000 .0000E+00 .0000E+00
  55  *  *   0.06  0.000  0.034  0.3222    0.0003 .9902E-02 .7679E-08    0.0000 .0000E+00 .0000E+00
  56  *  *   0.13  0.000  0.028  0.3222    0.0003 .9695E-02 .7662E-08    0.0000 .0000E+00 .0000E+00
  57  *  *   0.00  0.000  0.040  0.3222    0.0003 .9496E-02 .7646E-08    0.0000 .0000E+00 .0000E+00
  58  *  *   0.00  0.000  0.052  0.3222    0.0003 .9305E-02 .7631E-08    0.0000 .0000E+00 .0000E+00
  59     *   0.00  0.000  0.052  0.3222    0.0003 .9121E-02 .7616E-08    0.0000 .0000E+00 .0000E+00
  60  *  *   0.05  0.000  0.037  0.3222    0.0003 .8943E-02 .7602E-08    0.0000 .0000E+00 .0000E+00
  61  *  *   0.03  0.000  0.027  0.3222    0.0003 .8772E-02 .7588E-08    0.0000 .0000E+00 .0000E+00
  62  *  *   0.00  0.000  0.022  0.3222    0.0003 .8607E-02 .7575E-08    0.0000 .0000E+00 .0000E+00
  63  *  *   0.00  0.000  0.000  0.3222    0.0002 .8447E-02 .7562E-08    0.0000 .0000E+00 .0000E+00
  64  *  *   0.00  0.000  0.000  0.3222    0.0002 .8293E-02 .7550E-08    0.0000 .0000E+00 .0000E+00
  65  *  *   0.02  0.000  0.020  0.3222    0.0002 .8144E-02 .7537E-08    0.0000 .0000E+00 .0000E+00
  66  *  *   0.00  0.000  0.000  0.3222    0.0002 .8000E-02 .7526E-08    0.0000 .0000E+00 .0000E+00
  67  *  *   0.00  0.000  0.000  0.3222    0.0002 .7860E-02 .7514E-08    0.0000 .0000E+00 .0000E+00
  68  *  *   0.00  0.000  0.000  0.3222    0.0002 .7725E-02 .7503E-08    0.0000 .0000E+00 .0000E+00
```

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*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.021    0.068    0.143    0.169    0.039    0.000
                           0.000    0.000    0.000    0.000    0.024    0.005

    STD. DEVIATIONS        0.063    0.139    0.224    0.195    0.101    0.000
                           0.001    0.000    0.001    0.000    0.052    0.015

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.401    0.456    0.843    2.294    2.510
                           2.075    0.970    0.861    0.558    0.325    0.332

    STD. DEVIATIONS        0.182    0.192    0.159    0.292    0.402    0.560
                           1.024    0.432    0.315    0.230    0.142    0.161

  LATERAL DRAINAGE COLLECTED FROM LAYER  7
  ----------------------------------------
    TOTALS                 0.2220   0.0165   0.0122   0.0093   0.0083   0.0072
                           0.0065   0.0067   0.0061   0.0050   0.0041   0.0044

    STD. DEVIATIONS        1.1891   0.0655   0.0398   0.0261   0.0204   0.0161
                           0.0127   0.0144   0.0125   0.0077   0.0058   0.0062

  PERCOLATION/LEAKAGE THROUGH LAYER  9
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 13
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0036   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0198   0.0001   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************
```

```
     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
--------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  12.55    (   1.640)       8200.6     100.00

 RUNOFF                          0.469   (  0.2806)        306.59      3.739

 EVAPOTRANSPIRATION             12.085   (  1.4404)       7896.15     96.287

 LATERAL DRAINAGE COLLECTED      0.30824 (  1.39636)       201.407    2.45600
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.002     0.00002
   LAYER  9

 AVERAGE HEAD ON TOP             0.000 (    0.002)
   OF LAYER  8

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.002     0.00003
   LAYER 13

 CHANGE IN WATER STORAGE        -0.312   (  2.0617)       -203.54     -2.482

********************************************************************************
```

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******************************************************************************

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
      PRECIPITATION                             1.15          751.410

      RUNOFF                                    0.708          462.3551

      DRAINAGE COLLECTED FROM LAYER  7          3.97995       2600.50146

      PERCOLATION/LEAKAGE THROUGH LAYER  9      0.000015         0.00963

      AVERAGE HEAD ON TOP OF LAYER  8           3.291

      MAXIMUM HEAD ON TOP OF LAYER  8           2.906

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)              12.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER 13      0.000006         0.00380

      SNOW WATER                                1.84          1201.1409


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3474

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1725


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

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******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1           3.9454         0.3288

                      2           8.9878         0.2996

                      3           0.5400         0.0450

                      4           0.9600         0.0320

                      5           0.5400         0.0450

                      6           0.5695         0.0475

                      7           0.0020         0.0100

                      8           0.0000         0.0000

                      9           0.1770         0.7500

                     10           0.2700         0.0450

                     11           0.2700         0.0450

                     12           1.8900         0.0450

                     13           2.1600         0.0450

                  SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

Ineffective Liner Soil HELP Model

```
******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************



 PRECIPITATION DATA FILE:    C:\HELP3\silver1.D4
 TEMPERATURE DATA FILE:      C:\HELP3\silver2.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\silver3.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\silver4.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\silver9.D10
 OUTPUT DATA FILE:           C:\HELP3\silver8.OUT



 TIME:  14:46     DATE:   4/16/2015



 ******************************************************************************

      TITLE:  Silver Bow Plant - Enhanced RCRA Cover

 ******************************************************************************



      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
               WERE SPECIFIED BY THE USER.



                                    LAYER  1
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
            THICKNESS                  =     12.00   INCHES
            POROSITY                   =      0.5010 VOL/VOL
            FIELD CAPACITY             =      0.2840 VOL/VOL
            WILTING POINT              =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT =      0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                                    LAYER  2
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
            THICKNESS                  =     30.00   INCHES
            POROSITY                   =      0.4710 VOL/VOL
            FIELD CAPACITY             =      0.3420 VOL/VOL
            WILTING POINT              =      0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT =      0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC



                                    LAYER  3
                                    --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   1
            THICKNESS                  =     12.00   INCHES
```

```
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     30.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC




                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC




                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET




                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     15.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.4270 VOL/VOL
FIELD CAPACITY              =      0.4180 VOL/VOL
WILTING POINT               =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC



                        LAYER 10
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 11
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 12
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     42.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC



                        LAYER 13
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     48.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
               AND A SLOPE LENGTH OF   50. FEET.

     SCS RUNOFF CURVE NUMBER             =     83.50
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      0.180  ACRES
     EVAPORATIVE ZONE DEPTH              =     24.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      7.512  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     11.664  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.140  INCHES
     INITIAL SNOW WATER                  =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     29.581  INCHES
     TOTAL INITIAL WATER                 =     29.581  INCHES
     TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR




                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               HELENA                MONTANA

          STATION LATITUDE                       =  45.82 DEGREES
          MAXIMUM LEAF AREA INDEX                =   2.00
          START OF GROWING SEASON (JULIAN DATE)  =    138
          END OF GROWING SEASON (JULIAN DATE)    =    266
          EVAPORATIVE ZONE DEPTH                 =  24.0  INCHES
          AVERAGE ANNUAL WIND SPEED              =   7.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  63.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  54.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  49.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  63.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    0.61        0.56        0.81        1.03        1.89        2.27
    1.30        1.11        1.12        0.80        0.62        0.59


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   18.60       22.60       29.20       39.10       47.70       55.70
   63.30       61.70       51.90       42.10       29.40       20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    HELENA              MONTANA
                 AND STATION LATITUDE  =  45.82 DEGREES




HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  8
DRAIN #1:  LATERAL DRAINAGE FROM LAYER  7 (RECIRCULATION AND COLLECTION)
```

```
   LEAK  #1:  PERCOLATION OR LEAKAGE THROUGH LAYER  9
   LEAK  #2:  PERCOLATION OR LEAKAGE THROUGH LAYER 13

****************************************************************************************************

                                   DAILY OUTPUT FOR YEAR    1
 --------------------------------------------------------------------------------------------------
          S
 DAY  A   O  RAIN  RUNOFF   ET   E. ZONE   HEAD      DRAIN     LEAK      HEAD      DRAIN     LEAK
      I   I                       WATER     #1        #1        #1        #2        #2        #2
      R   L   IN.    IN.    IN.  IN./IN.    IN.       IN.       IN.       IN.       IN.       IN.
 ---  -   -  ----- ------ ------ ------- --------- --------- --------- --------- --------- ---------

   1  *   *   0.00  0.000  0.000  0.3130     3.2905 3.980      .1026E-03    0.0000 .0000E+00 .3817E-05
   2  *   *   0.00  0.000  0.000  0.3130     0.0175 .5933      .2429E-06    0.0000 .0000E+00 .0000E+00
   3  *   *   0.00  0.000  0.000  0.3130     0.0096 .3263      .1441E-06    0.0000 .0000E+00 .0000E+00
   4  *   *   0.00  0.000  0.000  0.3130     0.0066 .2239      .1044E-06    0.0000 .0000E+00 .0000E+00
   5  *   *   0.00  0.000  0.000  0.3130     0.0050 .1693      .8261E-07    0.0000 .0000E+00 .0000E+00
   6  *   *   0.00  0.000  0.000  0.3130     0.0040 .1354      .6875E-07    0.0000 .0000E+00 .0000E+00
   7  *   *   0.00  0.000  0.000  0.3130     0.0033 .1124      .5915E-07    0.0000 .0000E+00 .0000E+00
   8  *   *   0.00  0.000  0.000  0.3130     0.0028 .9571E-01 .5210E-07    0.0000 .0000E+00 .0000E+00
   9  *   *   0.00  0.000  0.000  0.3130     0.0024 .8316E-01 .4671E-07    0.0000 .0000E+00 .0000E+00
  10  *   *   0.00  0.000  0.000  0.3130     0.0022 .7337E-01 .4244E-07    0.0000 .0000E+00 .0000E+00
  11  *   *   0.00  0.000  0.000  0.3130     0.0019 .6553E-01 .3899E-07    0.0000 .0000E+00 .0000E+00
  12  *   *   0.00  0.000  0.000  0.3130     0.0017 .5912E-01 .3614E-07    0.0000 .0000E+00 .0000E+00
  13  *   *   0.00  0.000  0.000  0.3130     0.0016 .5378E-01 .3374E-07    0.0000 .0000E+00 .0000E+00
  14  *   *   0.03  0.000  0.015  0.3130     0.0015 .4928E-01 .3170E-07    0.0000 .0000E+00 .0000E+00
  15  *   *   0.00  0.000  0.012  0.3130     0.0013 .4543E-01 .2994E-07    0.0000 .0000E+00 .0000E+00
  16  *   *   0.00  0.000  0.002  0.3130     0.0012 .4211E-01 .2841E-07    0.0000 .0000E+00 .0000E+00
  17  *   *   0.00  0.000  0.000  0.3130     0.0012 .3921E-01 .2706E-07    0.0000 .0000E+00 .0000E+00
  18  *   *   0.00  0.000  0.000  0.3130     0.0011 .3666E-01 .2587E-07    0.0000 .0000E+00 .0000E+00
  19      *   0.00  0.000  0.000  0.3130     0.0010 .3440E-01 .2481E-07    0.0000 .0000E+00 .0000E+00
  20      *   0.01  0.000  0.007  0.3131     0.0010 .3239E-01 .2386E-07    0.0000 .0000E+00 .0000E+00
  21      *   0.00  0.000  0.000  0.3131     0.0009 .3059E-01 .2300E-07    0.0000 .0000E+00 .0000E+00
  22      *   0.00  0.000  0.000  0.3131     0.0009 .2896E-01 .2222E-07    0.0000 .0000E+00 .3974E-05
  23      *   0.06  0.000  0.014  0.3150     0.0008 .2749E-01 .2152E-07    0.0000 .0000E+00 .0000E+00
  24      *   0.11  0.004  0.015  0.3188     0.0008 .2615E-01 .2087E-07    0.0000 .0000E+00 .0000E+00
  25      *   0.00  0.000  0.000  0.3188     0.0007 .2493E-01 .2027E-07    0.0000 .0000E+00 .0000E+00
  26  *   *   0.00  0.000  0.000  0.3188     0.0007 .2381E-01 .1973E-07    0.0000 .0000E+00 .0000E+00
  27  *   *   0.00  0.000  0.000  0.3188     0.0007 .2278E-01 .1922E-07    0.0000 .0000E+00 .0000E+00
  28  *   *   0.00  0.000  0.000  0.3188     0.0006 .2183E-01 .1875E-07    0.0000 .0000E+00 .0000E+00
  29  *   *   0.09  0.000  0.030  0.3188     0.0006 .2095E-01 .1832E-07    0.0000 .0000E+00 .0000E+00
  30  *   *   0.01  0.000  0.036  0.3188     0.0006 .2013E-01 .1792E-07    0.0000 .0000E+00 .0000E+00
  31  *   *   0.00  0.000  0.035  0.3188     0.0006 .1937E-01 .1754E-07    0.0000 .0000E+00 .0000E+00
  32  *   *   0.00  0.000  0.000  0.3188     0.0005 .1867E-01 .1718E-07    0.0000 .0000E+00 .0000E+00
  33  *   *   0.00  0.000  0.000  0.3188     0.0005 .1800E-01 .1685E-07    0.0000 .0000E+00 .0000E+00
  34  *   *   0.02  0.000  0.020  0.3188     0.0005 .1739E-01 .1654E-07    0.0000 .0000E+00 .0000E+00
  35  *   *   0.00  0.000  0.000  0.3188     0.0005 .1681E-01 .1625E-07    0.0000 .0000E+00 .3032E-05
  36  *   *   0.00  0.000  0.000  0.3188     0.0005 .1626E-01 .1597E-07    0.0000 .0000E+00 .3700E-05
  37  *   *   0.11  0.000  0.026  0.3188     0.0005 .1575E-01 .1571E-07    0.0000 .0000E+00 .3756E-05
  38      *   0.00  0.001  0.039  0.3207     0.0004 .1526E-01 .1546E-07    0.0000 .0000E+00 .1502E-04
  39      *   0.00  0.000  0.000  0.3207     0.0004 .1481E-01 .1523E-07    0.0000 .0000E+00 .1501E-04
  40      *   0.00  0.000  0.000  0.3207     0.0004 .1437E-01 .1501E-07    0.0000 .0000E+00 .1500E-04
  41      *   0.00  0.000  0.000  0.3207     0.0004 .1396E-01 .1480E-07    0.0000 .0000E+00 .1499E-04
  42      *   0.05  0.000  0.014  0.3222     0.0004 .1358E-01 .1460E-07    0.0000 .0000E+00 .4396E-05
  43      *   0.00  0.000  0.000  0.3222     0.0004 .1321E-01 .1441E-07    0.0000 .0000E+00 .0000E+00
  44      *   0.00  0.000  0.000  0.3222     0.0004 .1286E-01 .1422E-07    0.0000 .0000E+00 .0000E+00
  45      *   0.00  0.000  0.000  0.3222     0.0004 .1252E-01 .1405E-07    0.0000 .0000E+00 .1049E-08
  46      *   0.00  0.000  0.000  0.3222     0.0004 .1220E-01 .1388E-07    0.0000 .0000E+00 .6572E-08
  47  *   *   0.05  0.000  0.039  0.3222     0.0004 .1190E-01 .1372E-07    0.0000 .0000E+00 .1260E-07
  48      *   0.00  0.000  0.011  0.3222     0.0003 .1161E-01 .1357E-07    0.0000 .0000E+00 .5110E-05
  49      *   0.00  0.000  0.000  0.3222     0.0003 .1133E-01 .1343E-07    0.0000 .0000E+00 .1502E-04
  50  *   *   0.00  0.000  0.000  0.3222     0.0003 .1107E-01 .1329E-07    0.0000 .0000E+00 .5212E-05
  51      *   0.00  0.000  0.000  0.3222     0.0003 .1082E-01 .1315E-07    0.0000 .0000E+00 .0000E+00
  52  *   *   0.00  0.000  0.000  0.3222     0.0003 .1057E-01 .1303E-07    0.0000 .0000E+00 .0000E+00
  53  *   *   0.00  0.000  0.000  0.3222     0.0003 .1034E-01 .1290E-07    0.0000 .0000E+00 .0000E+00
  54  *   *   0.05  0.000  0.027  0.3222     0.0003 .1012E-01 .1278E-07    0.0000 .0000E+00 .0000E+00
  55  *   *   0.06  0.000  0.034  0.3222     0.0003 .9902E-02 .1267E-07    0.0000 .0000E+00 .0000E+00
  56  *   *   0.13  0.000  0.028  0.3222     0.0003 .9695E-02 .1256E-07    0.0000 .0000E+00 .0000E+00
  57  *   *   0.00  0.000  0.040  0.3222     0.0003 .9496E-02 .1245E-07    0.0000 .0000E+00 .0000E+00
  58  *   *   0.00  0.000  0.052  0.3222     0.0003 .9305E-02 .1235E-07    0.0000 .0000E+00 .0000E+00
  59      *   0.00  0.000  0.052  0.3222     0.0003 .9121E-02 .1225E-07    0.0000 .0000E+00 .0000E+00
  60  *   *   0.05  0.000  0.037  0.3222     0.0003 .8943E-02 .1215E-07    0.0000 .0000E+00 .0000E+00
  61  *   *   0.03  0.000  0.027  0.3222     0.0003 .8772E-02 .1206E-07    0.0000 .0000E+00 .0000E+00
  62  *   *   0.00  0.000  0.022  0.3222     0.0003 .8607E-02 .1197E-07    0.0000 .0000E+00 .0000E+00
  63  *   *   0.00  0.000  0.000  0.3222     0.0002 .8447E-02 .1189E-07    0.0000 .0000E+00 .0000E+00
  64  *   *   0.00  0.000  0.000  0.3222     0.0002 .8293E-02 .1180E-07    0.0000 .0000E+00 .0000E+00
  65  *   *   0.02  0.000  0.020  0.3222     0.0002 .8144E-02 .1172E-07    0.0000 .0000E+00 .0000E+00
  66  *   *   0.00  0.000  0.000  0.3222     0.0002 .8000E-02 .1164E-07    0.0000 .0000E+00 .0000E+00
  67  *   *   0.00  0.000  0.000  0.3222     0.0002 .7860E-02 .1157E-07    0.0000 .0000E+00 .0000E+00
  68  *   *   0.00  0.000  0.000  0.3222     0.0002 .7725E-02 .1149E-07    0.0000 .0000E+00 .0000E+00
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                  MONTHLY TOTALS (IN INCHES) FOR YEAR   30
-------------------------------------------------------------------------------

                                JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
                                ------- ------- ------- ------- ------- -------

PRECIPITATION                    0.37    0.30    1.01    1.01    1.64    3.48
                                 1.27    1.98    1.65    1.24    1.31    0.59

RUNOFF                           0.000   0.000   0.080   0.235   0.000   0.001
                                 0.000   0.000   0.000   0.000   0.149   0.029

EVAPOTRANSPIRATION               0.420   0.301   0.550   0.595   2.112   2.883
                                 2.494   1.933   0.943   0.605   0.353   0.444

LATERAL DRAINAGE COLLECTED       0.0009  0.0008  0.0008  0.0008  0.0007  0.0007
  FROM LAYER  7                  0.0008  0.0008  0.0008  0.0004  0.0003  0.0004

PERCOLATION/LEAKAGE THROUGH      0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  9                       0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

PERCOLATION/LEAKAGE THROUGH      0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER 13                       0.0000  0.0000  0.0000  0.0000  0.0000  0.0000


-------------------------------------------------------------------------------
                   MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


AVERAGE DAILY HEAD ON            0.000   0.000   0.000   0.000   0.000   0.000
  TOP OF LAYER  8                0.000   0.000   0.000   0.000   0.000   0.000

STD. DEVIATION OF DAILY          0.000   0.000   0.000   0.000   0.000   0.000
  HEAD ON TOP OF LAYER  8        0.000   0.000   0.000   0.000   0.000   0.000

*******************************************************************************


*******************************************************************************

                          ANNUAL TOTALS FOR YEAR   30
-------------------------------------------------------------------------------
                                         INCHES          CU. FEET     PERCENT
                                        --------        ----------    -------
  PRECIPITATION                           15.85          10356.391    100.00

  RUNOFF                                   0.494           322.693      3.12

  EVAPOTRANSPIRATION                      13.633          8907.828     86.01

  DRAINAGE COLLECTED FROM LAYER  7         0.0082            5.367      0.05

  PERC./LEAKAGE THROUGH LAYER  9           0.000002          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  8             0.0000

  PERC./LEAKAGE THROUGH LAYER 13           0.000000          0.000      0.00

  CHANGE IN WATER STORAGE                  1.715          1120.498     10.82

  SOIL WATER AT START OF YEAR             18.470         12067.989

  SOIL WATER AT END OF YEAR               20.235         13221.851

  SNOW WATER AT START OF YEAR              0.051            33.364      0.32

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000            0.004      0.00

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*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.021    0.068    0.143    0.169    0.039    0.000
                           0.000    0.000    0.000    0.000    0.024    0.005

    STD. DEVIATIONS        0.063    0.139    0.224    0.195    0.101    0.000
                           0.001    0.000    0.001    0.000    0.052    0.015

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.401    0.456    0.843    2.294    2.510
                           2.075    0.970    0.861    0.558    0.325    0.332

    STD. DEVIATIONS        0.182    0.192    0.159    0.292    0.402    0.560
                           1.024    0.432    0.315    0.230    0.142    0.161

  LATERAL DRAINAGE COLLECTED FROM LAYER  7
  ----------------------------------------
    TOTALS                 0.2219   0.0165   0.0122   0.0093   0.0083   0.0072
                           0.0065   0.0067   0.0061   0.0050   0.0041   0.0044

    STD. DEVIATIONS        1.1891   0.0655   0.0398   0.0261   0.0204   0.0161
                           0.0127   0.0144   0.0125   0.0077   0.0058   0.0062

  PERCOLATION/LEAKAGE THROUGH LAYER  9
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 13
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0036   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0198   0.0001   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************
```

```
     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  12.55    (   1.640)       8200.6     100.00

 RUNOFF                          0.469   (  0.2806)        306.59      3.739

 EVAPOTRANSPIRATION             12.085   (  1.4404)       7896.15     96.287

 LATERAL DRAINAGE COLLECTED      0.30824 (  1.39634)       201.405     2.45597
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00002)         0.004     0.00005
   LAYER  9

 AVERAGE HEAD ON TOP             0.000 (    0.002)
   OF LAYER  8

 PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00002)         0.004     0.00005
   LAYER 13

 CHANGE IN WATER STORAGE        -0.312   (  2.0617)       -203.54     -2.482

*******************************************************************************



******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              1.15          751.410

      RUNOFF                                     0.708         462.3551

      DRAINAGE COLLECTED FROM LAYER  7           3.97987      2600.44458

      PERCOLATION/LEAKAGE THROUGH LAYER  9       0.000103        0.06704

      AVERAGE HEAD ON TOP OF LAYER  8            3.290

      MAXIMUM HEAD ON TOP OF LAYER  8            2.906

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)               12.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER 13       0.000015        0.00981

      SNOW WATER                                 1.84         1201.1409


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3474

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1725


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************




******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
```

```
                    -----         --------       ---------
                       1            3.9454         0.3288

                       2            8.9878         0.2996

                       3            0.5400         0.0450

                       4            0.9600         0.0320

                       5            0.5400         0.0450

                       6            0.5695         0.0475

                       7            0.0020         0.0100

                       8            0.0000         0.0000

                       9            0.1008         0.4270

                      10            0.2700         0.0450

                      11            0.2700         0.0450

                      12            1.8900         0.0450

                      13            2.1600         0.0450

                  SNOW WATER        0.000

********************************************************************************
********************************************************************************
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Appendix K

Predictive Groundwater Quality Evaluation

Appendix K

Predictive Groundwater Quality Evaluation
Supplemental Waste Plan

Three approaches to the evaluation are presented in order to provide a more comprehensive picture than any single approach would provide. The three approaches are: 1) Partition Model - modeling using estimated leachate quality based on the constituent concentrations calculated for the clarifier material; 2) Leachate Model - modeling using leachate quality estimates based on measured data (TCLP); and 3) Solids Concentration – modeling using target groundwater quality to estimate the acceptable concentrations in the crude phosphorus. All three approaches have two elements in common. The first common element is use of the HELP model to estimate the rate of infiltration/percolation through the enhanced cap. The HELP model results for the enhanced cap and evapotranspiration cap are presented in Appendix J and Appendix Q, respectively. The second common element is use of an EPA screening model to represent the interactions between infiltration/percolation and groundwater. The EPA model is presented in "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites," peer review draft, dated March 2001, p. 4-24 (EPA 2001). For simplicity, this model will be referred to as the SSL model, or more generically as predictive groundwater modeling calculations.

Crude Phosphorus

This section describes the three approaches regarding leaching of metals from crude phosphorus.

Partition Model

The partition model involves two steps:

1) Estimating the concentrations of metals in the clarifier materials. The mass balance is summarized in Table K-1 and additional information concerning the mass balance analysis is presented in Attachment 1. The calculated crude phosphorus concentrations are shown in Table K-2, and repeated for the reader's convenience in Table K-3 and K-4.

2) Applying the SSL model to estimate leachate concentrations and resultant groundwater concentrations.

In this application, the SSL model uses total metals concentrations to produce a conservative equilibrium estimate of leachate quality. The model then blends the leachate with the groundwater flow beneath the clarifier. The model makes conservative simplifying assumptions. The SSL guidance identifies a number of simplifying assumptions for the migration to groundwater pathway calculation. Some of the simplifying assumptions of note for this application include:

- Infinite source (the source is not diminished over time as mass leaches out, and the model is two-dimensional, so the source is considered to be infinitely wide)
- Uniformly distributed contamination from the surface to the top of the aquifer
- No contaminant attenuation in soil
- Instantaneous and linear equilibrium soil/water partitioning.

Because the SSL model is two-dimensional it provides an estimate of the conditions along the widest point of the clarifier, rather than accounting for its circular shape. The model uses a simple linear equilibrium solid/liquid partition equation to estimate the equilibrium leachate concentrations (SSL Equation 10 [EPA 2001]). The equation is as follows:

$$C_L = \frac{C_{CP}}{K_D + \frac{\Theta_w + \Theta_a H^1}{\rho_b}}$$

Where: C_L = Equilibrium leachate concentration [mg/L]

C_{CP} = Concentration in crude phosphorus [mg/kg]

K_D = Soil-water partition coefficient [L/kg]

Θ_W = Water-filled soil porosity

Θ_a = Air-filled soil porosity

H^1 = Dimensionless Henry's Law constant

ρ_b = Bulk density of crude phosphorus

For most constituents, the SSL model guidance provides the necessary partition coefficients. In the case of lead, a supplementary document "Understanding Variation in Partition Coefficient, K_d, Values" (EPA, 1999) was used for this modeling. A pH of 6.0 was used in selecting partition coefficients for the SSL model because elemental phosphorus in water naturally tends to that pH.

The equilibrium leachate concentrations calculated from the crude phosphorus metals concentrations for the enhanced RCRA cap and the evapotranspiration cap are shown in the third column of Table K-3 and Table K-4, respectively.

These equilibrium leachate concentrations can then be used in the groundwater mixing model to estimate the potential groundwater concentrations. A site-specific dilution and attenuation (DAF) factor is applied to the leachate concentration to reflect the mixing with the underlying groundwater unit. The site-specific DAF was calculated according to the following equation (Equation 4-11 in EPA 2001):

Where: DAF = Dilution attenuation factor (unitless)

$$DAF = 1 + \frac{K\ x\ i\ x\ d}{I\ x\ L}$$

K = Aquifer hydraulic conductivity (1 ft/day); based on the geometric mean of the slug test results for the monitoring wells near the clarifier (Barr 2013)

i = Hydraulic gradient (0.006 ft/ft); based on groundwater levels in nearby well in fall 2013.

d = mixing zone depth (11 ft)

I = Infiltration Rate (enhanced cap: 0.000006 inches/yr; evapotranspiration cap: 0.014 inches/yr)

L = Source length parallel to groundwater flow (100 ft)

Equation 12 (EPA 2001) was used to estimate the mixing zone depth (d) based on the site-specific groundwater parameters:

$$d = \sqrt{0.112\ L^2} + d_a(1 - e^{(\frac{-L\ x\ I}{K\ x\ i\ x\ d_a})})$$

Where: d = Mixing zone depth (ft)

L = Source length parallel to groundwater flow (100 ft)

I = Infiltration rate (same as above)

K = Aquifer hydraulic conductivity (same as above)

i = Hydraulic gradient (same as above)

d_a = Aquifer Thickness (300 ft)

The predicted groundwater concentrations based on the enhanced cap and evapotranspiration cap are shown in the fourth column of Table K-3 and Table K-4, respectively. These concentrations can be compared to MCLs or to DEQ-7 Montana groundwater standards, shown in the fifth and sixth columns of the respective tables. This comparison confirms that there would be no exceedances of groundwater quality due to leachate from the crude phosphorus contained in a capped clarifier.

The SSL groundwater concentration estimates, based on the conservative simplifying assumptions of the SSL model, are generally more than a factor of 10 lower than groundwater quality standards. The estimated concentrations for many of the parameters are more than a factor of 100 lower than groundwater quality standards.

Leachate Model

Another way to apply the SSL model is to use measured leachate quality rather than the very conservative linear estimation methods supplied with the model. The SSL guidance suggests the synthetic precipitation leaching procedure (SPLP) can be used to estimate the concentration in the leachate (EPA, 2001). This approach of measuring the quality of a laboratory-generated leachate can be a better indicator of actual leachate constituent concentrations in that it inherently accounts for natural mechanisms that inhibit dissolution and tests the leaching behavior of the actual material in question.

Although SPLP data is not available for the clarifier contents, data from another leaching procedure, the Toxicity Characteristic Leaching Procedure (TCLP) (EPA Method 1311), is available. It is reasonable to use TCLP to represent a conservative estimate of leachate quality for the crude phosphorus material. TCLP was designed by EPA to determine the leachability of organic and inorganic analytes present in liquid, solid and multiphasic wastes. See *e.g.,* 51 FR at 21653 (June 13, 1986,) (proposed TCLP Rule). The TCLP method uses an aggressive, low pH-leaching agent (typically pH 4.93) that simulates waste leaching from a municipal landfill. This is a more aggressive (*i.e.*, more conservative) approach than use SPLP or other procedures that simulate more neutral pH environments. It should be noted that leachate from the crude phosphorus is expected to be on the acidic side of neutral because the pH naturally tends to 6.0 when water is in contact with elemental phosphorus.

TCLP results represent a high-end dissolved concentration for the crude phosphorus, for the primary parameters of concern, except chromium. Solvay conducted a sensitivity analysis using the SSL model equilibrium relationships for the metals parameters. This was done by varying the pH between

5.0 and 8.0 and calculating change in equilibrium concentrations. This analysis is presented in Attachment 1 of this appendix. The sensitivity analysis demonstrates that arsenic, barium, cadmium, lead and silver concentrations should increase as the pH is lowered (i.e., more acidic conditions). Conversely, chromium and selenium concentrations are expected to decrease as the pH is lowered. Of those two metals, chromium but not selenium has been identified as a potential contaminant of concern. The sensitivity analysis results mean that groundwater modeling based on TCLP results would potentially over-predict potential groundwater contamination for arsenic, barium, cadmium, lead and silver. The TCLP results could potentially underestimate potential groundwater concentrations for chromium and selenium. However, as seen in the results in Table K-3, the SSL model chromium and selenium concentrations are about a factor of 100 below the groundwater standards, so some underestimation of their concentrations can be tolerated without compromising the conclusions from the analysis.

Thus, because TCLP uses an extraction fluid of pH less than 6.0, using TCLP values in the predictive modeling in this Supplemental Waste Plan should result in a high-end estimate of potential contamination for all the metals except chromium and selenium. In fact, EPA said when it proposed use of the TCLP,

> *[T]the Agency believes that the predicted degree of contaminant concentration in leachate could reasonably occur in the course of other types of land based waste management (e.g., surface impoundments). The TCLP, as well as the EP, basically involve mixing the waste with an aqueous leaching media, and seeing if certain contaminants can migrate from the waste to a significant degree.*[1/]

It is precisely for that purpose that Solvay proposes to use the TCLP.

Using the TCLP data in the SSL model produces the predicted groundwater concentrations shown in the eighth column of Table K-3 and K-4. The TCLP results for the crude phosphorus samples did not detect any of the metal constituents, at a detection limit one-tenth of the TCLP regulatory limits. (See seventh column of the respective tables). These detection limits were used as the leachate metals concentrations in the SSL modeling, even though the actual concentrations may be significantly lower.

The predicted groundwater concentrations using the measured leachate quality approach can be compared to MCLs or to DEQ-7 Montana groundwater standards in Table K-3 and K-4. This

---

[1/] 51 FR at 21655 (June 13, 1986).

comparison confirms that there would be no exceedances of groundwater quality due to leachate from the crude phosphorus contained in a capped clarifier. In fact, the SSL groundwater concentration estimates are generally more than a factor of 100 lower than groundwater quality standards. These values are especially significant given the conservative simplifying assumptions of the SSL model, the conservative over-estimate of leachate concentrations from the TCLP testing, and the conservative use of detection limits.

Solids Concentration

The third way of using the SSL model is to calculate the minimum metals concentrations in the solid phase (in the crude phosphorus) in order for there to be the potential for leachate to cause groundwater to exceed drinking water quality standards.

The model uses the same equations described earlier for the SSL model, but starts from the desired water quality, calculates a corresponding leachate quality, and finally solves the partitioning equations for the metals concentrations in the solid phase. This is a “totals” concentration which can be directly compared to the crude phosphorus metals concentrations (see second column of the respective table). The SSL model solids metals concentrations are shown on the final column of Table K-3 and K-4.

Conclusion

The predictive groundwater quality evaluations indicate that either cap design would remain protective even if the metals concentrations in the crude phosphorus were underestimated by more than one order of magnitude.

Crude Phosphorus Distillation Residues

As part of the on-site phosphorus recovery alternative, a CAMU would be designated for the clarifier (SWMU 2). This CAMU would be the long-term disposal unit for the mud still solid residues, which would be placed back into the clarifier and the crude phosphorus that cannot be safely and practicably removed from the clarifier or that is entrained in the crevices of the clarifier. The CAMU would be covered with an evapotranspiration cap that meets the requirements of 40 CFR 264.552(e)(6)(iv). The leachability of crude phosphorus closed with an evapotranspiration cap was evaluated in the crude phosphorus section, which demonstrated that the evapotranspiration cap would be protective of groundwater based on metals concentrations in crude phosphorus.

This section describes the three approaches regarding leaching of metals from crude phosphorus distillation residues that would be placed back into the clarifier. Mud still residue was not analyzed for total metals, only for TCLP leachable levels of metals. Roaster residue is, however, very similar to the mud still residue. Roaster residue was generated from the same feedstock (i.e., crude phosphorus sludge from the clarifier) using a very similar distillation process at about the same temperature. Neither distillation process would add or remove metals from the residue. As such, sample results on roaster residue are very good surrogates for the mud still residue.

Table K-5 shows the predicted groundwater concentrations from the various leachate models as follows:

Column 4 -	Partitioning Model using the total metals concentrations for the roaster residue samples from Table K-1.
Column 8-	Leachate Model using the SPLP data for the roaster residue samples from Table 5.5.14-9 of the RFI Report (Barr 2013). The higher concentration of the two samples was selected for this evaluation.
Column 10-	Leachate Model using the TCLP data for the mud still residue analyzed during the treatability study (Franklin 2012). A summary of the TCLP data and statistical evaluation is in Attachment 2. This data indicates that the mud still residue could be a characteristic hazardous waste for cadmium, but no other metals exceeded the regulatory level. The mud still residue TCLP concentrations shown in Table K-5 are the regulatory levels for the metals except for cadmium. The 95% UCL of the mean, based on a normal distribution, was calculated for cadmium using ProUCL version 5.00.

The sensitivity analysis (Table 4 and Figure 4 of Attachment 1) demonstrates that cadmium concentrations should increase as the pH of the leaching solution is lowered (i.e., more acidic conditions). As such, the leachate model using the TCLP data overestimates the leachate concentrations and still does not predict an exceedance of groundwater criteria, even if the leachate concentrations are added to the crude phosphorus leachate concentrations in Table K-4.

This evaluation demonstrates that the evapotranspiration cap would be protective of groundwater quality based on metals concentrations in crude phosphorus distillation residues.

Conclusions

The predictive groundwater quality evaluations indicate that either cap design would remain protective even if the metals concentrations in the crude phosphorus were underestimated by more than one order of magnitude. The evapotranspiration cap would also be protective of groundwater based on modeled leaching from mud still residue.

References:

Barr 2013. RCRA Facility Investigation Report. Prepared for Rhodia Inc., Submitted to EPA Region 8, May 1, 2013.

EPA 1999. Understanding Variation in Partition Coefficient, K_d, Values. U.S. EPA Radiation Protection Programs Remediation Technology and Tools, EPA 402-R-99-004A&B. August 1999.

EPA 2001. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, March 2001.

Franklin 2012. Clarifier Material Treatability Study; Phase 3 Report – Pilot Plant Operation. Prepared for Rhodia, Inc. February 2012.

Tables

Table K-1

Analytical Data for Inputs and Outputs
Mass Balance Roaster Process

Silver Bow Plant

	Roaster Residue						
	RR001-97	**RR002-97**	**RS-03**	**RS-04**	**RS-05**		**Average**
Parameters	[mg/Kg]	[mg/Kg]	[mg/Kg]	[mg/Kg]	[mg/Kg]		**[mg/Kg]**
As	<5	<5	1.93	3.17	2.27		2.5
Ba	39	42	55.3	55.4	49.1		48
Cd	20	21	R	R	R		21
Cr	250	270	388	381	327		320
Pb	65	70	108	134	81.1		92
Hg	N/A	N/A	<0.002	0.007	0.004		0.006
Se	<5	5	4.5	4.2	2.4		4.0
Ag	31	34	45.2	50.2	37.4		40

	Nodule Fines		
	NF003-97	**NF004-97**	**Average**
Parameters	[mg/Kg]	[mg/Kg]	**[mg/Kg]**
As	<5	<5	5
Ba	35	39	37
Cd	1	1	1
Cr	210	190	200
Pb	<5	<5	5
Hg	N/A	N/A	N/A
Se	<5	<5	5
Ag	7	7	7

	P4 Product - Solution Analysis					
	SB001-97	**SB002-97**	**SB003-97**	**SB004-97**	**SB005-97**	**SB006-97**
Parameters	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
P4 Mass [g]	22.981	19.900	21.321	22.281	21.286	0.000
Solvent Volume [mL]	200.0	200.0	200.0	200.0	200.0	200.0
As	4.3	3.5	3.6	3.8	3.4	<0.1
Ba	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cr	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pb	1.5	1.2	1.3	1.8	2	1.2
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ag	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

	P4 Product[1]						
	SB001-97	**SB002-97**	**SB003-97**	**SB004-97**	**SB005-97**	**SB006-97**	**Average**
Parameters	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]	**[mg/Kg]**
As	37	35	34	34	32	--	34.5
Ba	0.87	1.01	0.94	0.90	0.94	--	0.93
Cd	0.87	1.01	0.94	0.90	0.94	--	0.93
Cr	4.4	5.0	4.7	4.5	4.7	--	4.7
Pb[2]	3	0.0	1	5	8	--	3.3
Hg	0.0087	0.010	0.0094	0.0090	0.0094	--	0.0093
Se	0.87	1.01	0.94	0.90	0.94	--	0.93
Ag	0.87	1.01	0.94	0.90	0.94	--	0.93

[1] P4 Product concentrations = (P4 Solution concentration) * (Solvent Volume) / (P4 Mass)

[2] The lead concentration in the blank (BB006-97) was subtracted.

Table K-2

Mass Balance Roaster Process
Silver Bow Plant

	Outputs		Inputs	
Parameter	**Roaster Residue**	**P4 Product**	**Nodule Fines[2]**	**Crude Phosphorus**
Volume Basis [gal]	--	1,840	--	10,000
Density[1] [lbs/gal]	--	15.2	--	10.5
Mass Basis [lbs]	130,000	27,900	52,500	105,000
Source	**Table 1**	**Table 1**	**Table 1**	**Calculated**
Units	**[mg/Kg]**	**[mg/Kg]**	**[mg/Kg]**	**[mg/Kg]**
As	2.5	34	5	9.8
Ba	48	0.93	37	41
Cd	21	0.93	1	26
Cr	320	4.7	200	300
Pb	92	3.3	5	110
Hg	0.006	0.0093	N/A	--
Se	4	0.93	5	2.7
Ag	40	0.93	7	46

[1] Specific Gravity of P4 Product is 1.82. Density = 1.82 X 8.34 lbs/gal = 15.2 lbs/gal.

[2] Feed ratio [2:1] was described in Appendix F of the Waste Plan.

Table K-3

Enhanced RCRA Cap - Clarifier
Estimated Groundwater Concentration and Comparison to Groundwater Standards

	Partitioning Model			Drinking Water Standards		Leachate (TCLP) Model		Solids Conc.
Parameter	**Crude Phosphorus [mg/Kg]**	**Leachate[2] [pH = 6.0] [mg/L]**	**Predicted Groundwater Concentration[3] [mg/l]**	**MDEQ DEQ-7[1] [mg/l]**	**MCL [mg/l]**	**Crude Phosphorus [mg/l TCLP]**	**Predicted Groundwater Concentration[3] [mg/l]**	**Metals Concentration to equal DEQ-7 [mg/Kg]**
Arsenic	9.8	0.36	7.2E-07	1.0E-02	1.0E-02	<0.5	1.0E-06	139,000
Barium	41	1.4	2.7E-06	1.0E+00	2.0E+00	<10	2.0E-05	15,400,000
Cadmium	26	0.69	1.4E-06	5.0E-03	5.0E-03	<0.1	2.0E-07	94,000
Chromium	300	13	2.6E-05	1.0E-01	1.0E-01	<0.5	1.0E-06	1,190,000
Lead	110	0.067	1.3E-07	1.5E-02	1.5E-02	<0.5	1.0E-06	12,300,000
Mercury	--	--	--	2.0E-03	2.0E-03	<0.02	4.0E-08	4,350
Selenium	2.7	0.31	6.1E-07	5.0E-02	5.0E-02	<0.1	2.0E-07	233,000
Silver	46	30	6.0E-05	1.0E-01	--	<0.5	1.0E-06	101,000

Partitioning Equation Inputs

Θw = 0.3
Θa = 0.117
n = 0.417
ρ [Kg/L] 1.26
H' = 0
H' (Mercury) = 4.67E-01

Parameter	**K_D[4] @ pH = 6.0**	
Arsenic	27	L/Kg
Barium	30	L/Kg
Cadmium	37	L/Kg
Chromium	23	L/Kg
Lead[5]	1,639	L/Kg
Mercury	3.5	L/Kg
Selenium	8.6	L/Kg
Silver	1.3	L/Kg

DAF Inputs

I = 6.E-06 inches/yr
K = 1 ft/day
i = 0.006 ft/ft
L = 100 ft
d_a = 300 ft

Calculated Values

d[6] = 11 ft
DAF[7] = 500,000

Notes:

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[1] DEQ-7 Effective Date: October 2012.

[2] Equation 4-10, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

[3] Predicted Groundwater Concentration = $C_{Leachate}$ / DAF

[4] K_D values from Exhibit C-4 (EPA 2001)

[5] K_D value for Lead from Appendix F (EPA 1999)

[6] Equation 4-12, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

[7] Equation 4-11, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

Table K-4

Evapotranspiration Cap (Crude Phosphorus) - Clarifier
Estimated Groundwater Concentration and
Comparison to Groundwater Standards

	Partitioning Model			Drinking Water Standards		Leachate (TCLP) Model		Solids Conc.
Parameter	**Crude Phosphorus [mg/Kg]**	**Leachate[2] [pH = 6.0] [mg/L]**	**Predicted Groundwater Concentration[3] [mg/l]**	**MDEQ DEQ-7[1] [mg/l]**	**MCL [mg/l]**	**Crude Phosphorus [mg/l TCLP]**	**Predicted Groundwater Concentration[3] [mg/l]**	**Metals Concentration to equal DEQ-7 [mg/Kg]**
Arsenic	9.8	0.36	6.0E-04	1.0E-02	1.0E-02	<0.5	8.3E-04	170
Barium	41	1.4	2.3E-03	1.0E+00	2.0E+00	<10	1.7E-02	18,000
Cadmium	26	0.69	1.2E-03	5.0E-03	5.0E-03	<0.1	1.7E-04	110
Chromium	300	13	2.2E-02	1.0E-01	1.0E-01	<0.5	8.3E-04	1,400
Lead	110	0.067	1.1E-04	1.5E-02	1.5E-02	<0.5	8.3E-04	15,000
Mercury	--	--	--	2.0E-03	2.0E-03	<0.02	3.3E-05	5.2
Selenium	2.7	0.31	5.1E-04	5.0E-02	5.0E-02	<0.1	1.7E-04	280
Silver	46	30	5.0E-02	1.0E-01	--	<0.5	8.3E-04	121

Partitioning Equation Inputs

theta w = 0.3
theta a = 0.117
n = 0.417
Bulk Density [Kg/L] 1.26
H' = 0
H' (Mercury) = 4.67E-01

Parameter	**K_D[4] @ pH = 6.0**	
Arsenic	27	L/Kg
Barium	30	L/Kg
Cadmium	37	L/Kg
Chromium	23	L/Kg
Lead[5]	1,639	L/Kg
Mercury	3.5	L/Kg
Selenium	8.6	L/Kg
Silver	1.3	L/Kg

DAF Inputs

I = 0.014 inches/yr
K = 1 ft/day
i = 0.006 ft/ft
L = 100 ft
d_a = 300 ft

Calculated Values

d[6] = 29 ft
DAF[7] = 600

Notes:

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[1] DEQ-7 Effective Date: October 1999.

[2] Equation 4-10, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

[3] Predicted Groundwater Concentration = $C_{Leachate}$ / DAF

[4] K_D values from Exhibit C-4 (EPA 2001)

[5] K_D value for Lead from Appendix F (EPA 1999)

[6] Equation 4-12, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

[7] Equation 4-11, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

Table K-5

Evapotranspiration Cap (Residue) - Clarifier
Estimated Groundwater Concentration and
Comparison to Groundwater Standards

	Partitioning Model			Drinking Water Standards		Leachate (SPLP) Model		Leachate (TCLP) Model	
Parameter	**Roaster Residue [mg/Kg]**	**Leachate[2] [pH = 6.0] [mg/L]**	**Predicted Groundwater Concentration[3] [mg/l]**	**MDEQ DEQ-7[1] [mg/l]**	**MCL [mg/l]**	**Roaster Residue [mg/l SPLP]**	**Predicted Groundwater Concentration[3] [mg/l]**	**Mud Still Residue [mg/l TCLP]**	**Predicted Groundwater Concentration[3] [mg/l]**
Arsenic	2.5	0.09	1.5E-04	1.0E-02	1.0E-02	0.0009	1.5E-06	<0.5	8.3E-04
Barium	48	1.6	2.6E-03	1.0E+00	2.0E+00	0.082	1.4E-04	<0.5	8.3E-04
Cadmium	21	0.56	9.4E-04	5.0E-03	5.0E-03	0.028	4.7E-05	2.1	3.5E-03
Chromium	320	14	2.3E-02	1.0E-01	1.0E-01	0.039	6.5E-05	<0.5	8.3E-04
Lead	92	0.056	9.4E-05	1.5E-02	1.5E-02	0.09	1.5E-04	2.0	3.3E-03
Mercury	--	--	--	2.0E-03	2.0E-03	0.001	1.7E-06	0.11	1.8E-04
Selenium	4.0	0.45	7.5E-04	5.0E-02	5.0E-02	0.001	1.7E-06	<0.5	8.3E-04
Silver	40	26	4.3E-02	1.0E-01	--	0.03	5.0E-05	<0.5	8.3E-04

Partitioning Equation Inputs

theta w =	0.3
theta a =	0.117
n =	0.417
Bulk Density [Kg/L]	1.26
H' =	0
H' (Mercury) =	4.67E-01

Parameter	**K_D[4] @ pH = 6.0**	
Arsenic	27	L/Kg
Barium	30	L/Kg
Cadmium	37	L/Kg
Chromium	23	L/Kg
Lead[5]	1,639	L/Kg
Mercury	3.5	L/Kg
Selenium	8.6	L/Kg
Silver	1.3	L/Kg

DAF Inputs

I =	0.014	inches/yr
K =	1	ft/day
i =	0.006	ft/ft
L =	100	ft
d_a =	300	ft
Calculated Values		
d[6] =	29	ft
DAF[7] =	600	

Notes:

---

[1] DEQ-7 Effective Date: October 2012.

[2] Equation 4-10, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

[3] Predicted Groundwater Concentration = $C_{Leachate}$ / DAF

[4] K_D values from Exhibit C-4 (EPA 2001)

[5] K_D value for Lead from Appendix F (EPA 1999)

[6] Equation 4-12, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

[7] Equation 4-11, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA OSWER 9355.4-24

Attachment 1

Sensitivity Analysis of Predictive Groundwater Modeling Calculations

Memorandum

To: Solvay File
From: Tom Mattison
Subject: Sensitivity of Predictive Groundwater Modeling Calculations
Project: Supplemental Waste Plan – Clarifier Materials
c:

This memorandum evaluates the sensitivity of the mass balance calculations to the various input parameters used in the calculations. The sensitivity to changes in infiltration, hydraulic conductivity, and mixing zone depth were evaluated as described below.

Infiltration

The infiltration rate was obtained from the HELP model (version 3.07) presented in Appendix J of the Supplemental Waste Plan. The model indicates that the infiltration rate should be approximately 0.000003 inches/year through the enhanced cap. This value was varied between –50% (0.000002 inches per year) and +100% (0.000006 inches per year) of the value from the HELP model and the potential maximum groundwater concentration was calculated for each varied value. The percent change in maximum groundwater concentration was then computed from the base case calculation (0.000003 inches /yr).

Table 1 summarizes the sensitivity calculations for changes to infiltration rates. Figure 1 shows a graph of the relationship between changes in infiltration rate and changes in maximum groundwater concentrations. This evaluation indicates a linear relationship between infiltration rate and maximum groundwater concentrations.

Hydraulic Conductivity

The hydraulic conductivity value was obtained from the geometric mean of the slug test results for the monitoring wells near the clarifier. This value was varied between –50% (0.5 ft/day) and +50% (1ft/day) based on the geometric mean of the slug test results for the monitoring wells near the clarifier (Barr 2013).

The potential maximum groundwater concentration was calculated, varying only the K value in the DAF equation of the SSL model, for each sensitivity value, and the percent change in maximum groundwater concentration was then computed from the base case calculation (1 ft/day).

Table 2 summarizes the sensitivity calculations for changes to hydraulic conductivity. Figure 2 shows a graph of the relationship between changes in hydraulic conductivity and changes in maximum groundwater concentrations. This evaluation indicates an inverse relationship between hydraulic conductivity and maximum groundwater concentrations. Lower hydraulic conductivities result in higher maximum groundwater concentrations in that a 200% reduction in hydraulic conductivity causes the maximum groundwater concentration to double.

Mixing Zone Depth

The leachate mixing zone depth value was obtained from the EPA's SSL model. For the clarifier, this depth was very similar to the length of the monitoring well screens installed at the clarifier as part of the preclosure groundwater monitoring program, 10 feet. During the October 17, 2001 meeting, the EPA requested that a 50-foot mixing zone depth also be evaluated. This sensitivity analysis includes the 50-foot and also a100-foot depth. The potential maximum groundwater concentration was calculated for each depth value and the percent change in maximum groundwater concentration was then computed from the base case calculation (10 feet).

Table 3 summarizes the sensitivity calculations for changes to mixing zone depth. Figure 3 shows a graph of the relationship between changes in mixing zone depth and changes in maximum groundwater concentrations. A greater mixing zone depth significantly decreases the maximum groundwater concentration especially in the top 50 feet.

pH

The pH value of the crude phosphorus was varied between 5 and 8 to evaluate the effect of differing leaching solutions on the resulting equilibrium leachate concentrations. The pH values correspond to the pH ranges on "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites" peer review draft, March 2001, Exhibit C-4 (EPA 2001). The pH-dependent partition coefficient (K_d) values used to calculate the equilibrium leachate concentration for the respective metal species, except for lead, were taken from that same Exhibit C-4. The pH-dependent K_d value for lead was obtained from a correlation presented in "Understanding Variation in Partition Coefficient, K_d, Values" (EPA 1999).

Table 4 summarizes the sensitivity calculations for changes to pH. Figure 4 shows a graph of the relationship between changes in pH and percent change in the corresponding equilibrium leachate concentration. This evaluation indicates that leachate concentrations of arsenic, barium, cadmium, lead, and silver should decrease as the pH is raised between pH = 5 and pH = 8. The leachate concentrations chromium and selenium should increase as the as the pH is raised between pH = 5 and pH = 8.

The figure 4 graph is normalized to pH = 6, so parameters whose graphs slope up to the left (arsenic, barium, cadmium, lead, and silver) are metals whose equilibrium leachate concentration increases with decreasing pH. The 2 metals whose graphs slope up to the right, chromium and selenium, have increasing equilibrium leachate concentrations with increasing pH.

References:

Barr 2013. RCRA Facility Investigation Report. Prepared for Rhodia Inc., Submitted to EPA Region 8, May 1, 2013.

EPA 1999. *Understanding Variation in Partition Coefficient, K_d, Values*. U.S. EPA Radiation Protection Programs Remediation Technology and Tools, EPA 402-R-99-004A&B. August 1999.

EPA 2001. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24, March 2001.

Table 1

Sensitivity to Changes in Infiltration
Estimated Groundwater Concentration

Mass Balance Inputs		
I	inches/yr	0.000003
K	ft/day	1
i	ft/ft	0.006
L	ft	100
d_a	ft	300
d	ft	11
DAF		900,000

Sensitivity Summary

% Change Inf	Inf	% Change GW Prediction
-50%	0.000002	-50%
-25%	0.000002	-25%
0%	0.000003	0%
25%	0.000004	25%
50%	0.000005	50%
75%	0.000005	75%
100%	0.000006	100%

Figure 1 - Sensitivity to Changes in Infiltration

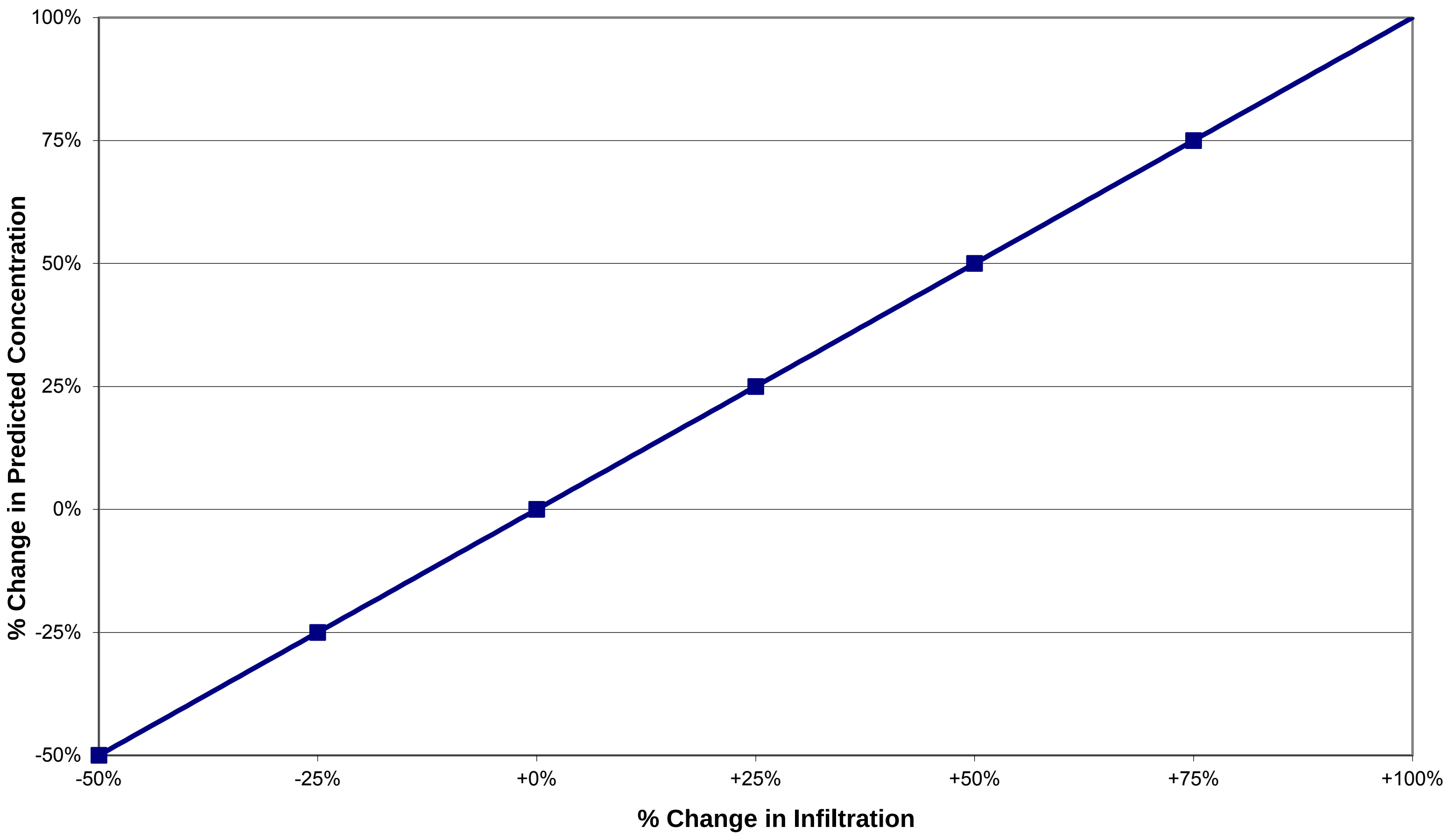


Table 2

Sensitivity to Changes in Hydraulic Conductivity
Estimated Groundwater Concentration

Mass Balance Inputs		
I	inches/yr	0.00002
K	ft/day	1
i	ft/ft	0.006
L	ft	100
d_a	ft	300
d	ft	11
DAF		100,000

Sensitivity Summary

% Change K	K	% Change GW Prediction
-50%	0.5	100%
-25%	0.8	33%
0%	1.0	0%
25%	1.3	-20%
50%	1.5	-33%

Figure 2 - Sensitivity to Changes in Hydraulic Conductivity

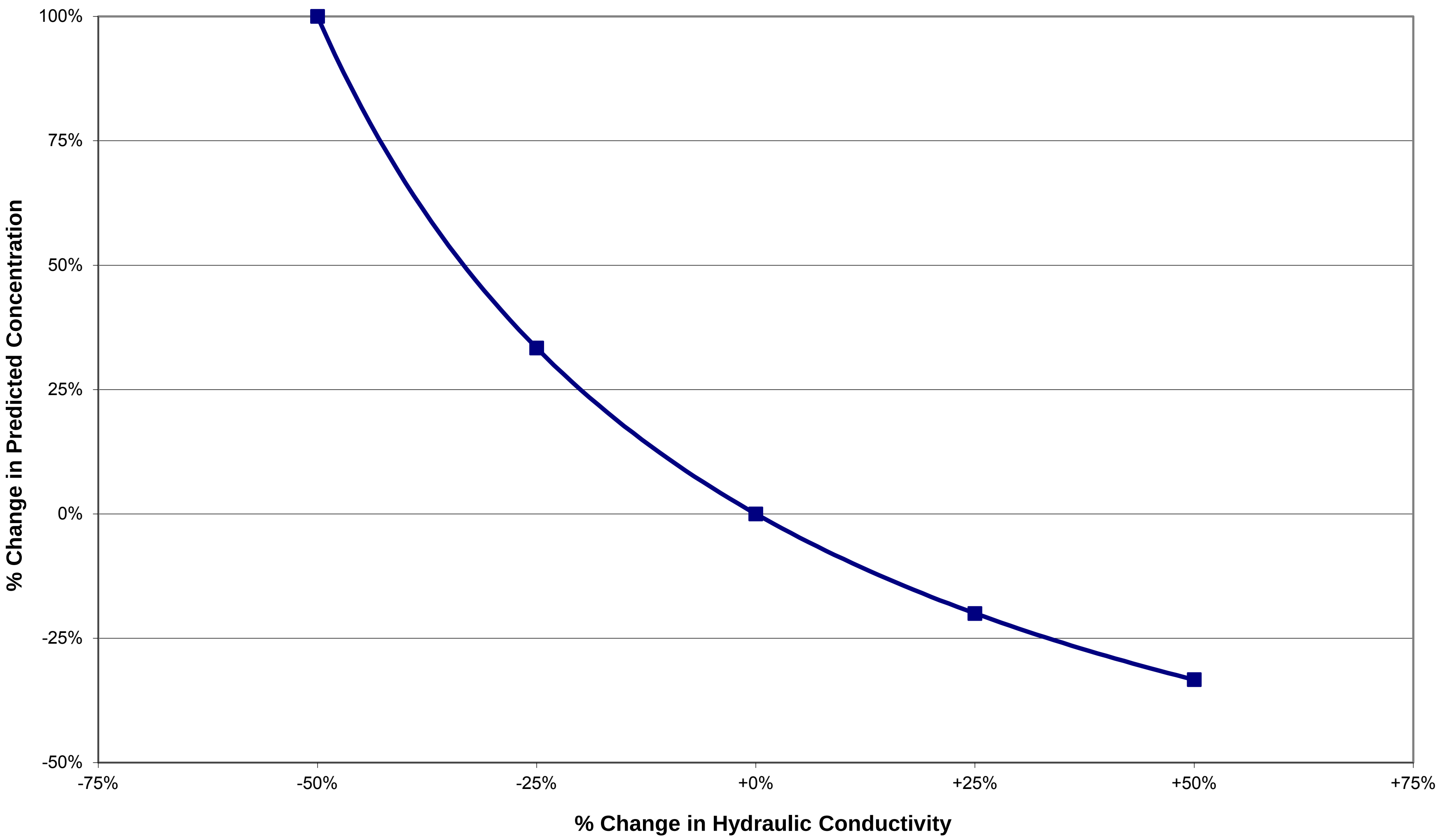


Table 3

Sensitivity to Mixing Zone Depth
Estimated Groundwater Concentration

Mass Balance Inputs		
I	inches/yr	0.00002
K	ft/day	1
i	ft/ft	0.006
L	ft	100
d_a	ft	300
d	ft	11
DAF		100,000

Sensitivity Summary

Penetration Depth	% Change GW Prediction
10	0%
50	-80%
100	-90%

Figure 3 - Sensitivity to Changes in Mixing Zone Depth

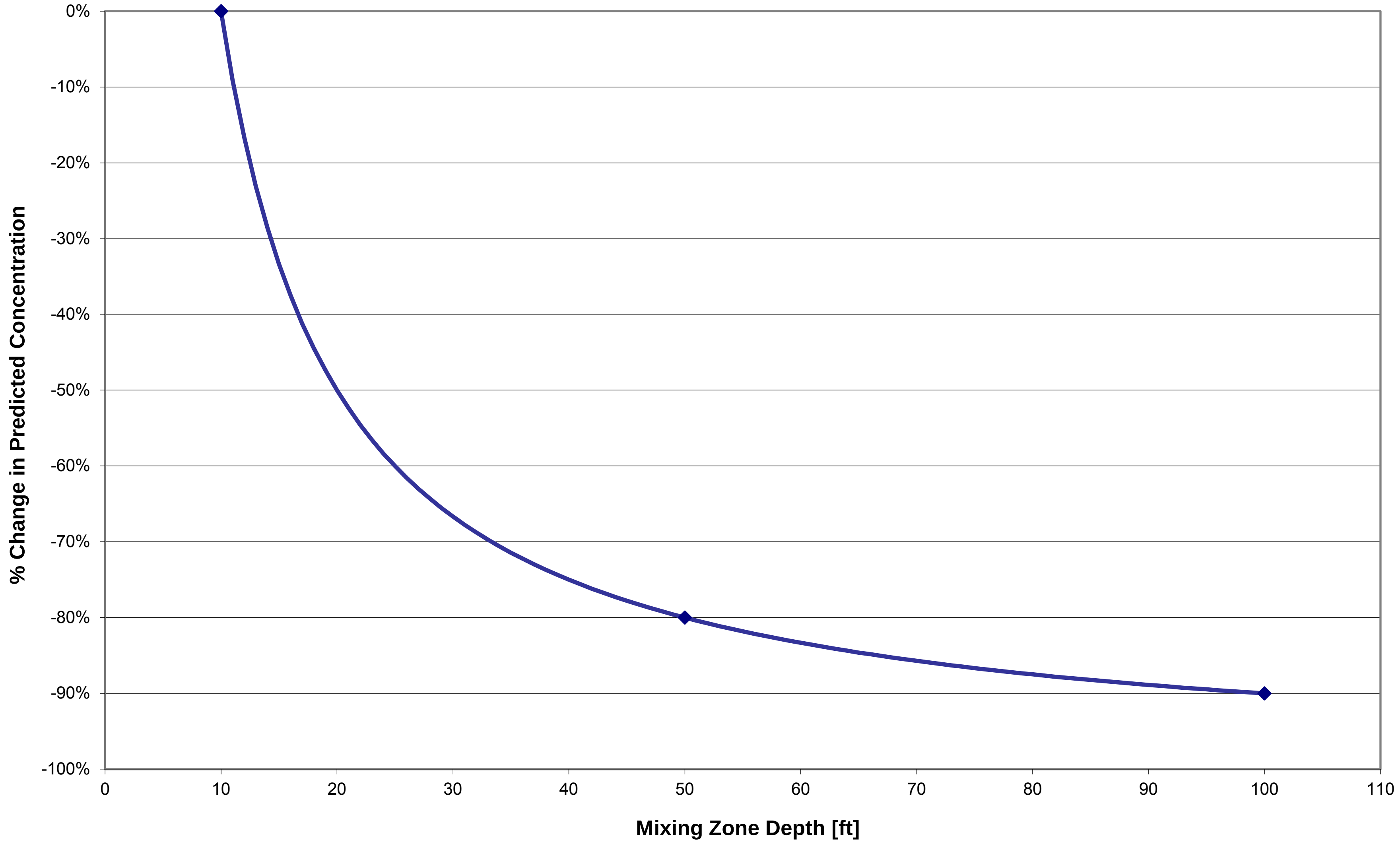


Table 4

Sensitivity to Changes in pH
Estimated Groundwater Concentration

Partitioning Equation Inputs	
Θ_W	0.3
Θ_A	0.117
n	0.417
ρ_B	1.26
H'	0

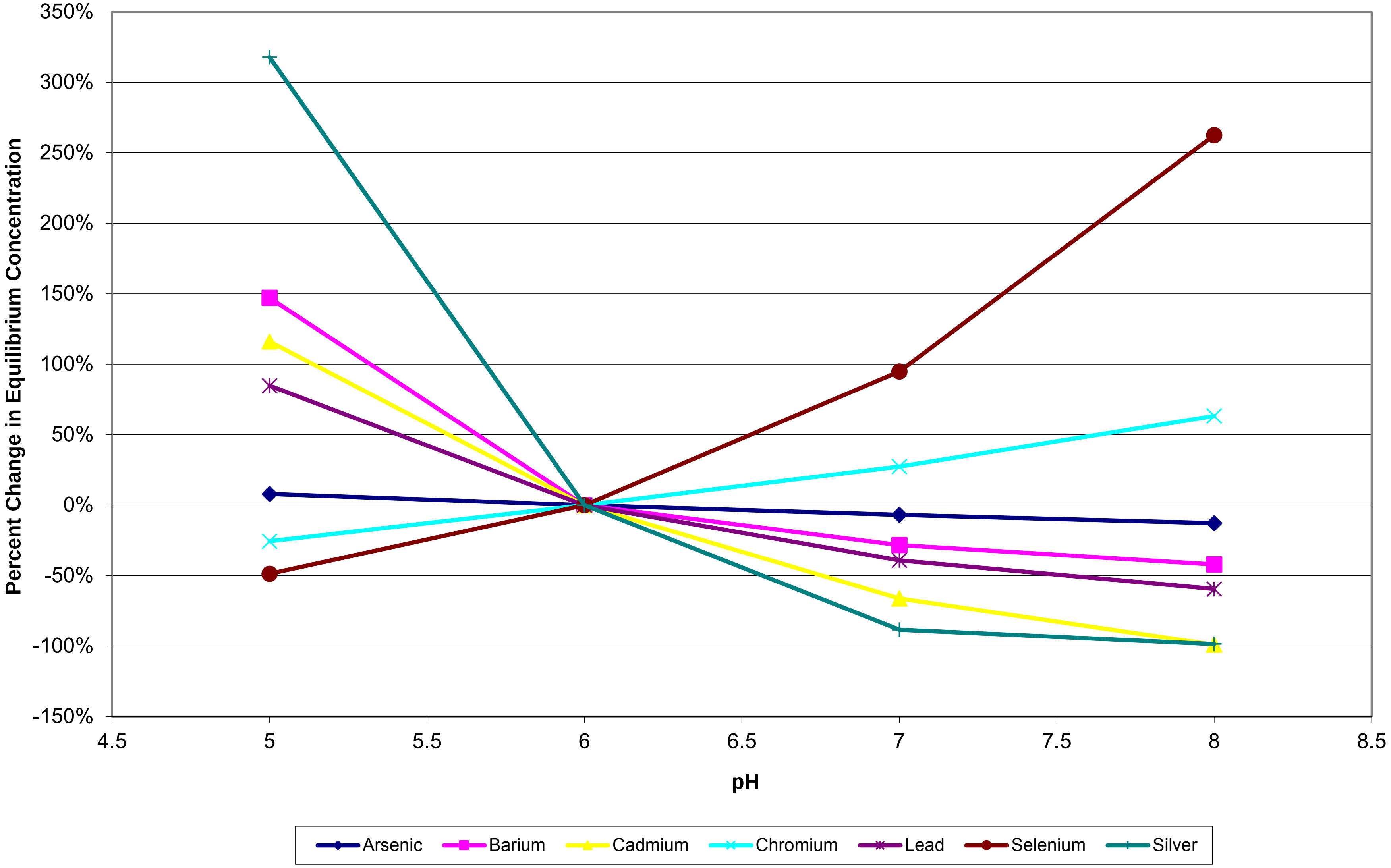
Parameter	Crude Phosphorus [mg/Kg]
Arsenic	9.8
Barium	41
Cadmium	26
Chromium	300
Lead	110
Mercury	--
Selenium	2.7
Silver	46

Parameter	K_D			
	pH = 5.0 [L/Kg]	pH = 6.0 [L/Kg]	pH = 7.0 [L/Kg]	pH = 8.0 [L/Kg]
Arsenic	25	27	29	31
Barium	12	30	42	52
Cadmium	17	37	110	4300
Chromium	31	23	18	14
Lead[1]	887	1,639	2,692	4,045
Mercury	0.06	3.5	82	200
Selenium	17	8.6	4.3	2.2
Silver	0.13	1.3	13	110

	Equilibrium Concentration							
Sensitivity of pH	Arsenic [mg/L]	Barium [mg/L]	Cadmium [mg/L]	Chromium [mg/L]	Lead [mg/L]	Mercury [mg/L]	Selenium [mg/L]	Silver [mg/L]
5	0.39	3.36	1.49	9.60	0.12	--	0.16	124.97
6	0.36	1.36	0.69	12.91	0.07	--	0.31	29.91
7	0.33	0.97	0.23	16.45	0.04	--	0.59	3.47
8	0.31	0.79	0.01	21.07	0.03	--	1.11	0.42

	Percent Change in Equilibrium Concentration							
Sensitivity of pH	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
5	8%	147%	116%	-26%	85%	--	-49%	318%
6	0%	0%	0%	0%	0%	--	0%	0%
7	-7%	-28%	-66%	27%	-39%	--	95%	-88%
8	-13%	-42%	-99%	63%	-59%	--	263%	-99%

Figure 4 - Sensitivity to Changes to pH



United States
Environmental Protection
Agency

Solid Waste and
Emergency Response

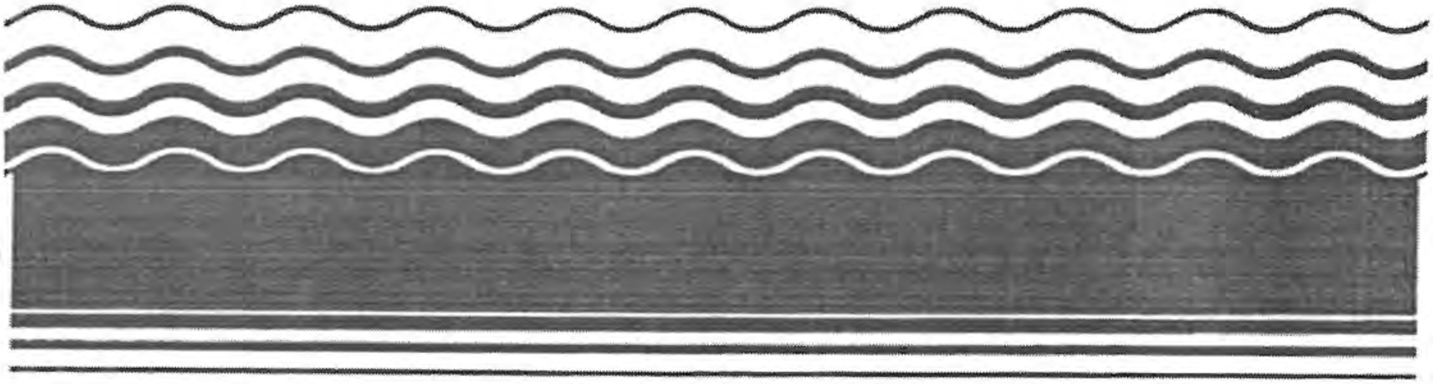
OSWER 9355.4-24
March 2001

Superfund

EPA

SUPPLEMENTAL GUIDANCE FOR DEVELOPING SOIL SCREENING LEVELS FOR SUPERFUND SITES

Peer Review Draft



OSWER 9355.4-24
March 2001

SUPPLEMENTAL GUIDANCE FOR DEVELOPING SOIL SCREENING LEVELS FOR SUPERFUND SITES

Peer Review Draft

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

Disclaimer

This document provides guidance to EPA Regions concerning how the Agency intends to exercise its discretion in implementing one aspect of the CERCLA remedy selection process. The guidance is designed to implement national policy on these issues.

The statutory provisions and EPA regulations described in this document contain legally binding requirements. However, this document does not substitute for those provisions or regulations, nor is it a regulation itself. Thus, it cannot impose legally-binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. Any decisions regarding a particular remedy selection decision will be made based on the statute and regulations, and EPA decisionmakers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. EPA may change this guidance in the future.

Migration to Ground Water.

This guidance calculates commercial/industrial SSLs for the ingestion of leachate-contaminated ground water using the same set of equations and default input values presented in the 1996 *SSG*. Thus, the generic SSLs for this pathway are the same under commercial/industrial and residential land use scenarios.

EPA has adopted this approach for two reasons. First, it protects off-site receptors, including residents, who may ingest contaminated ground water that migrates from the site. Second, it protects potentially potable ground water aquifers that may exist beneath commercial/ industrial properties (see text box for EPA's policy on ground water classification). Thus, this approach is appropriate for protecting ground water resources and human health; however, it may necessitate that sites meet stringent SSLs if the migration to ground water pathway applies, regardless of future land use.

The simple site-specific ground water approach consists of two steps. First, it employs a simple linear equilibrium soil/water partition equation to estimate the contaminant concentration in soil leachate. Alternatively, the synthetic precipitation leachate procedure (SPLP) can be used to estimate this concentration. Next, a simple water balance equation is used to calculate a dilution factor to account for reduction of soil leachate concentration from mixing in an aquifer. This calculation is based on conservative, simplified assumptions about the release and transport of contaminants in the subsurface (see Exhibit 4-3). These assumptions should be reviewed for consistency with the CSM to determine the applicability of SSLs to the migration to ground water pathway.

Ground Water Classification

In order to demonstrate that the ingestion of ground water exposure pathway is not applicable for a site, site managers may either perform a detailed fate and transport analysis (as discussed in the *TBD* to the 1996 *SSG*), or may show that the underlying ground water has been classified as non-potable. EPA's current policy regarding ground water classification for Superfund sites is outlined in an OSWER directive (U.S. EPA, 1997e). EPA evaluates ground water at a site according to the federal ground water classification system, which includes four classes:

1 - sole source aquifers;
2A - currently used for drinking water;
2B - potentially usable for drinking water; and
3 - not usable for drinking water.

Generally, this pathway applies to all potentially potable water (i.e., classes 1, 2A, and 2B), unless the state has made a different determination through a process analogous to the Comprehensive State Ground Water Protection Plan (CSGWPP). Through this process, ground water classification is based on an aquifer or watershed analysis of relevant hydrogeological information, with public participation, in consultation with water suppliers, and using a methodology that is consistently applied throughout the state. If a state has no CSGWPP or similar plan, EPA will defer to the state's ground water classification only if it is more protective than EPA's. As of February 2001, 11 states (AL, CT, DE, GA, IL, MA, NH, NV, OK, VT, and WI) have approved CSGWPP plans.

Equation 4-10 is the soil/water partition equation; it is appropriate for calculating SSLs corresponding to target leachate contaminant concentrations in the zone of contamination. Equations 4-11 and 4-12 are appropriate for determining the dilution attenuation factor (DAF) by which concentrations are reduced when leachate mixes with a clean aquifer. Because of the wide variability in subsurface conditions that affect contaminant migration in ground water, default values are not provided for input parameters for these dilution equations. Instead, EPA has developed two possible default DAFs (DAF=20 and DAF=1) that are appropriate for deriving generic SSLs for this pathway. The selection of a default DAF is discussed in Appendix A, and the derivation of these defaults is described in the *TBD* to the 1996 *SSG*. The default DAFs also can be used for calculating simple site-specific SSLs, or the site manager can develop a site-specific DAF using equations 4-11 and 4-12.

Exhibit 4-3

Simplifying Assumptions for the SSL Migration to Ground Water Pathway

- Infinite source (i.e., steady-state concentrations are maintained over the exposure period)
- Uniformly distributed contamination from the surface to the top of the aquifer
- No contaminant attenuation (i.e., adsorption, biodegradation, chemical degradation) in soil
- Instantaneous and linear equilibrium soil/water partitioning
- Unconfined, unconsolidated aquifer with homogeneous and isotropic hydrologic properties
- Receptor well at the downgradient edge of the source and screened within the plume
- No contaminant attenuation in the aquifer
- No NAPLs present (if NAPLs are present, the SSLs do not apply)

To calculate SSLs for the migration to ground water pathway, the acceptable ground water concentration is multiplied by the DAF to obtain a target soil leachate concentration (C_w).[20] For example, if the DAF is 20 and the acceptable ground water concentration is 0.05 mg/L, the target soil leachate concentration would be 1.0 mg/L. Next, the partition equation is used to calculate the total soil concentration (i.e., SSL) corresponding to this soil leachate concentration. Alternatively, if a leach test is used, the target soil leachate concentration is compared directly to extract concentrations from the leach tests.

For more information on the development of SSLs for this pathway, please consult the 1996 *SSG*.

Mass-Limit SSLs. Equations 4-13 and 4-14 present models for calculating mass-limit SSLs for the outdoor inhalation of volatiles and migration to ground water pathways, respectively. These models can be used only if the depth and area of contamination are known or can be estimated with confidence. These equations are identical to those in the 1996 *SSG*. Please consult that guidance for information on using mass-limit SSL models.

---

[20] The acceptable ground water concentration is, in order of preference: a non-zero Maximum Contaminant Level Goal (MCLG), a Maximum Contaminant Level (MCL), or a health-based level (HBL) calculated based on an ingestion rate of 2L/day and a target cancer risk of 1×10^{-6} or an HQ of 1. These values are presented in Appendix C.

Equation 4-10
Soil Screening Level Partitioning Equation for Migration to Ground Water

$$\text{Screening Level in Soil (mg/kg)} = C_w \left[K_D + \frac{(\theta_w + \theta_a H')}{\rho_b} \right]$$

Parameter/Definition (units)	Default
C_w/target soil leachate concentration (mg/L)	(nonzero MCLG, MCL, or HBL)[a] × dilution factor
K_d/soil-water partition coefficient (L/kg)	for organics: $K_d = K_{oc} \times f_{oc}$ for inorganics: see Appendix C[b]
K_{oc}/soil organic carbon/water partition coefficient (L/kg)	chemical-specific[c]
f_{oc}/fraction organic carbon in soil (g/g)	**0.002 (0.2%)**
θ_w/water-filled soil porosity (L_{water}/L_{soil})	**0.3**
θ_a/air-filled soil porosity (L_{air}/L_{soil})	$n - \theta_w$
ρ_b/dry soil bulk density (kg/L)	**1.5**
n/soil porosity (L_{pore}/L_{soil})	$1 - (\rho_b/\rho_s)$
ρ_s/soil particle density (kg/L)	2.65
H′/dimensionless Henry's law constant	chemical-specific[c] (assume to be zero for inorganic contaminants except mercury)

[a] Chemical-specific (see Appendix C).

[b] Assume a pH of 6.8 when selecting default K_d values for metals.

[c] See Appendix C.

Equation 4-11
Derivation of Dilution Attenuation Factor

$$\text{Dilution Attenuation Factor (DAF)} = 1 + \frac{K \times i \times d}{I \times L}$$

Parameter/Definition (units)	Default
DAF/dilution attenuation factor (unitless)	**20 or 1 (0.5-acre source)**
K/aquifer hydraulic conductivity (m/yr)	**Site-specific**
i/hydraulic gradient (m/m)	**Site-specific**
I/infiltration rate (m/yr)	**Site-specific**
d/mixing zone depth (m)	**Site-specific**
L/source length parallel to ground water flow (m)	**Site-specific**

Equation 4-12
Estimation of Mixing Zone Depth

$$d = (0.0112L^2)^{0.5} + d_a(1 - \exp[(-L \times I)/(K \times i \times d_a)])$$

Parameter/Definition (units)	**Default**
d/mixing zone depth (m)	**Site-specific**
L/source length parallel to ground water flow (m)	**Site-specific**
I/infiltration rate (m/yr)	**Site-specific**
K/aquifer hydraulic conductivity (m/yr)	**Site-specific**
i/hydraulic gradient (m/m)	**Site-specific**
d_a/aquifer thickness (m)	**Site-specific**

Equation 4-13
Mass-Limit Volatilization Factor - Commercial/Industrial Scenario

$$VF = Q/C_{vol} \times \frac{[T \times (3.15 \times 10^7 s/yr)]}{(\rho_b \times d_s \times 10^6 g/Mg)}$$

Parameter/Definition (units)	**Default**
d_s/average source depth (m)	**site-specific**
T/exposure interval (yr)	**30**
Q/C_{vol}/inverse of mean conc. at center of a square source (g/m^2-s per kg/m^3)	**68.18 (for 0.5 acre source)**
ρ_b/dry soil bulk density (kg/L or Mg/m^3)	**1.5**

Equation 4-14
Mass-Limit Soil Screening Level for Migration to Ground Water

$$\text{Screening Level in Soil (mg/kg)} = \frac{(C_w \times I \times ED)}{\rho_b \times d_s}$$

Parameter/Definition (units)	**Default**
C_w/target soil leachate concentration (mg/L)	(nonzero MCLG, MCL, or HBL)[a] × dilution factor
d_s/depth of source (m)	**site-specific**
I/infiltration rate (m/yr)	**0.18**
ED/exposure duration (yr)	70
ρ_b/dry soil bulk density (kg/L)	**1.5**

[a] Chemical-specific, see Appendix C.

APPENDIX C

Chemical Properties and Regulatory/Human Health Benchmarks for SSL Calculations

This appendix provides the chemical properties and regulatory and human health benchmarks necessary to calculate SSLs for 110 chemicals commonly found at NPL sites. It consists of the following exhibits:

- Exhibit C-1 provides chemical-specific organic carbon-water partition coefficients (K_{oc}), air and water diffusivities (D_a and D_w), water solubilities (S), and dimensionless Henry's law constants (H').
- Exhibit C-2 provides pH-specific K_{oc} values for nine organic contaminants that ionize under natural pH conditions. Site-specific soil pH measurements (see EPA's 1996 *SSG*, Section 2.3.5) can be used to select appropriate K_{oc} values for these contaminants. Where site-specific soil pH values are not available, values corresponding to a pH of 6.8 should be used. Note that K_{oc} values presented in Exhibit C-1 for these contaminants are based on a default pH of 6.8).
- Exhibit C-3 provides the physical state (liquid or solid) for organic contaminants. This information is needed to apply and interpret soil saturation limit (C_{sat}) results when calculating SSLs for the inhalation of volatiles in outdoor air pathway.
- Exhibit C-4 provides pH-specific soil-water partition coefficients (K_d) for metals. Site-specific soil pH measurements (see 1996 *SSG*, Section 2.3.5) can be used to select appropriate K_d values for these metals. Where site-specific soil pH values are not available, values corresponding to a pH of 6.8 should be used.
- Exhibit C-5 provides chemical-specific regulatory and human health benchmarks for organic and inorganic contaminants. The chemical-specific Maximum Contaminant Level Goal (MCLG), Maximum Contaminant Level (MCL), Water Health Based Limit (HBL), Cancer Slope Factor (CSF), Unit Risk Factor (URF), Reference Dose (RfD), and Reference Concentration (RfC) values presented in this exhibit are used as inputs in the SSL equations in Sections 3, 4, and 5 of this document.
- Exhibit C-6 presents chemical-specific absorption percentages for dermal contact (ABS_d) for all contaminants for which this pathway is relevant. The values presented represent the average dermal absorption values across a range of soil types, loading rates, and chemical concentrations for these contaminants.
- Exhibit C-7 provides gastrointestinal absorption factors (ABS_{GI}) for contaminants of concern for the dermal pathway. These values are used for route-to-route extrapolation of toxicity values. Specifically, these factors are used to adjust the oral reference dose (RfD) and cancer slope factor (SF) for a contaminant, which is based

on administered dose, to more accurately reflect the dermal dose, which is an absorbed dose. Where there is greater than 50 percent gastrointestinal absorption (e.g., ABS_{GI}>.5), no adjustment is made.

With the exception of values for air diffusivity (D_a), water diffusivity (D_w), and certain K_{oc} values, all of the chemical properties used to calculate SSLs are also reported in the Superfund Chemical Data Matrix (SCDM). Water and air diffusivities were obtained from EPA's CHEMDAT8 and WATER8 models. For more information on the derivation of K_{oc} values, or for a more detailed discussion of the chemical properties presented in Exhibits C-1 through C-4, please refer to the *Technical Background Document* for the 1996 *Soil Screening Guidance (SSG)*.

The sources for the regulatory and human health benchmarks include the list of National Primary Drinking Water Regulations (NPDWRs), maintained by EPA's Office of Ground Water and Drinking Water, and EPA's *Integrated Risk Information System* (IRIS). The full list of sources for the regulatory and chronic human health benchmarks is presented at the end of Exhibit C-5. Chemical-specific dermal and gastro-intestinal absorption fractions for the dermal contact pathway were obtained from EPA's *RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment* (U.S. EPA, in press).

All of the sources of the values listed in Exhibits C-1 through C-5 are regularly updated by EPA. In addition, the information in Exhibits C-6 and C-7 was obtained from *RAGS, Part E*. Therefore, prior to calculating SSLs for a site, regulatory/health benchmarks and chemical properties should be checked against the most recent versions of the appropriate sources to ensure that they are up to date. These sources may also be useful for identifying properties and benchmarks for additional contaminants of concern not included in this appendix. Several of these sources are available on-line at the following EPA web sites:

IRIS: http://www.epa.gov/ngispgm3/iris/
NPDWRs: http://www.epa.gov/safewater/mcl.html
SCDM: http://www.epa.gov/superfund/resources/scdm/index.htm
CHEMDAT8: http://www.epa.gov/ttn/chief/software.html
WATER8: http://www.epa.gov/ttn/chief/software.html

Exhibit C-4

METAL K_d VALUES (L/kg) AS A FUNCTION OF pH[a]

pH	Arsenic	Barium	Beryllium	Cadmium	Chromium (+III)	Chromium (+VI)	Mercury	Nickel	Silver	Selenium	Thallium	Zinc
4.9	2.5E+01	1.1E+01	2.3E+01	1.5E+01	1.2E+03	3.1E+01	4.0E-02	1.6E+01	1.0E-01	1.8E+01	4.4E+01	1.6E+01
5.0	2.5E+01	1.2E+01	2.6E+01	1.7E+01	1.9E+03	3.1E+01	6.0E-02	1.8E+01	1.3E-01	1.7E+01	4.5E+01	1.8E+01
5.1	2.5E+01	1.4E+01	2.8E+01	1.9E+01	3.0E+03	3.0E+01	9.0E-02	2.0E+01	1.6E-01	1.6E+01	4.6E+01	1.9E+01
5.2	2.6E+01	1.5E+01	3.1E+01	2.1E+01	4.9E+03	2.9E+01	1.4E-01	2.2E+01	2.1E-01	1.5E+01	4.7E+01	2.1E+01
5.3	2.6E+01	1.7E+01	3.5E+01	2.3E+01	8.1E+03	2.8E+01	2.0E-01	2.4E+01	2.6E-01	1.4E+01	4.8E+01	2.3E+01
5.4	2.6E+01	1.9E+01	3.8E+01	2.5E+01	1.3E+04	2.7E+01	3.0E-01	2.6E+01	3.3E-01	1.3E+01	5.0E+01	2.5E+01
5.5	2.6E+01	2.1E+01	4.2E+01	2.7E+01	2.1E+04	2.7E+01	4.6E-01	2.8E+01	4.2E-01	1.2E+01	5.1E+01	2.6E+01
5.6	2.6E+01	2.2E+01	4.7E+01	2.9E+01	3.5E+04	2.6E+01	6.9E-01	3.0E+01	5.3E-01	1.1E+01	5.2E+01	2.8E+01
5.7	2.7E+01	2.4E+01	5.3E+01	3.1E+01	5.5E+04	2.5E+01	1.0E+00	3.2E+01	6.7E-01	1.1E+01	5.4E+01	3.0E+01
5.8	2.7E+01	2.6E+01	6.0E+01	3.3E+01	8.7E+04	2.5E+01	1.6E+00	3.4E+01	8.4E-01	9.8E+00	5.5E+01	3.2E+01
5.9	2.7E+01	2.8E+01	6.9E+01	3.5E+01	1.3E+05	2.4E+01	2.3E+00	3.6E+01	1.1E+00	9.2E+00	5.6E+01	3.4E+01
6.0	2.7E+01	3.0E+01	8.2E+01	3.7E+01	2.0E+05	2.3E+01	3.5E+00	3.8E+01	1.3E+00	8.6E+00	5.8E+01	3.6E+01
6.1	2.7E+01	3.1E+01	9.9E+01	4.0E+01	3.0E+05	2.3E+01	5.1E+00	4.0E+01	1.7E+00	8.0E+00	5.9E+01	3.9E+01
6.2	2.8E+01	3.3E+01	1.2E+02	4.2E+01	4.2E+05	2.2E+01	7.5E+00	4.2E+01	2.1E+00	7.5E+00	6.1E+01	4.2E+01
6.3	2.8E+01	3.5E+01	1.6E+02	4.4E+01	5.8E+05	2.2E+01	1.1E+01	4.5E+01	2.7E+00	7.0E+00	6.2E+01	4.4E+01
6.4	2.8E+01	3.6E+01	2.1E+02	4.8E+01	7.7E+05	2.1E+01	1.6E+01	4.7E+01	3.4E+00	6.5E+00	6.4E+01	4.7E+01
6.5	2.8E+01	3.7E+01	2.8E+02	5.2E+01	9.9E+05	2.0E+01	2.2E+01	5.0E+01	4.2E+00	6.1E+00	6.6E+01	5.1E+01
6.6	2.8E+01	3.9E+01	3.9E+02	5.7E+01	1.2E+06	2.0E+01	3.0E+01	5.4E+01	5.3E+00	5.7E+00	6.7E+01	5.4E+01
6.7	2.9E+01	4.0E+01	5.5E+02	6.4E+01	1.5E+06	1.9E+01	4.0E+01	5.8E+01	6.6E+00	5.3E+00	6.9E+01	5.8E+01
6.8	2.9E+01	4.1E+01	7.9E+02	7.5E+01	1.8E+06	1.9E+01	5.2E+01	6.5E+01	8.3E+00	5.0E+00	7.1E+01	6.2E+01
6.9	2.9E+01	4.2E+01	1.1E+03	9.1E+01	2.1E+06	1.8E+01	6.6E+01	7.4E+01	1.0E+01	4.7E+00	7.3E+01	6.8E+01
7.0	2.9E+01	4.2E+01	1.7E+03	1.1E+02	2.5E+06	1.8E+01	8.2E+01	8.8E+01	1.3E+01	4.3E+00	7.4E+01	7.5E+01
7.1	2.9E+01	4.3E+01	2.5E+03	1.5E+02	2.8E+06	1.7E+01	9.9E+01	1.1E+02	1.6E+01	4.1E+00	7.6E+01	8.3E+01
7.2	3.0E+01	4.4E+01	3.8E+03	2.0E+02	3.1E+06	1.7E+01	1.2E+02	1.4E+02	2.0E+01	3.8E+00	7.8E+01	9.5E+01
7.3	3.0E+01	4.4E+01	5.7E+03	2.8E+02	3.4E+06	1.6E+01	1.3E+02	1.8E+02	2.5E+01	3.5E+00	8.0E+01	1.1E+02
7.4	3.0E+01	4.5E+01	8.6E+03	4.0E+02	3.7E+06	1.6E+01	1.5E+02	2.5E+02	3.1E+01	3.3E+00	8.2E+01	1.3E+02
7.5	3.0E+01	4.6E+01	1.3E+04	5.9E+02	3.9E+06	1.6E+01	1.6E+02	3.5E+02	3.9E+01	3.1E+00	8.5E+01	1.6E+02
7.6	3.1E+01	4.6E+01	2.0E+04	8.7E+02	4.1E+06	1.5E+01	1.7E+02	4.9E+02	4.8E+01	2.9E+00	8.7E+01	1.9E+02
7.7	3.1E+01	4.7E+01	3.0E+04	1.3E+03	4.2E+06	1.5E+01	1.8E+02	7.0E+02	5.9E+01	2.7E+00	8.9E+01	2.4E+02
7.8	3.1E+01	4.9E+01	4.6E+04	1.9E+03	4.3E+06	1.4E+01	1.9E+02	9.9E+02	7.3E+01	2.5E+00	9.1E+01	3.1E+02
7.9	3.1E+01	5.0E+01	6.9E+04	2.9E+03	4.3E+06	1.4E+01	1.9E+02	1.4E+03	8.9E+01	2.4E+00	9.4E+01	4.0E+02
8.0	3.1E+01	5.2E+01	1.0E+05	4.3E+03	4.3E+06	1.4E+01	2.0E+02	1.9E+03	1.1E+02	2.2E+00	9.6E+01	5.3E+02

[a] Non pH-dependent inorganic K_d values for antimony, cyanide, and vanadium are 45, 9.9, and 1,000 (L/kg), respectively.

United States
Environmental Protection
Agency

Office of Air and Radiation

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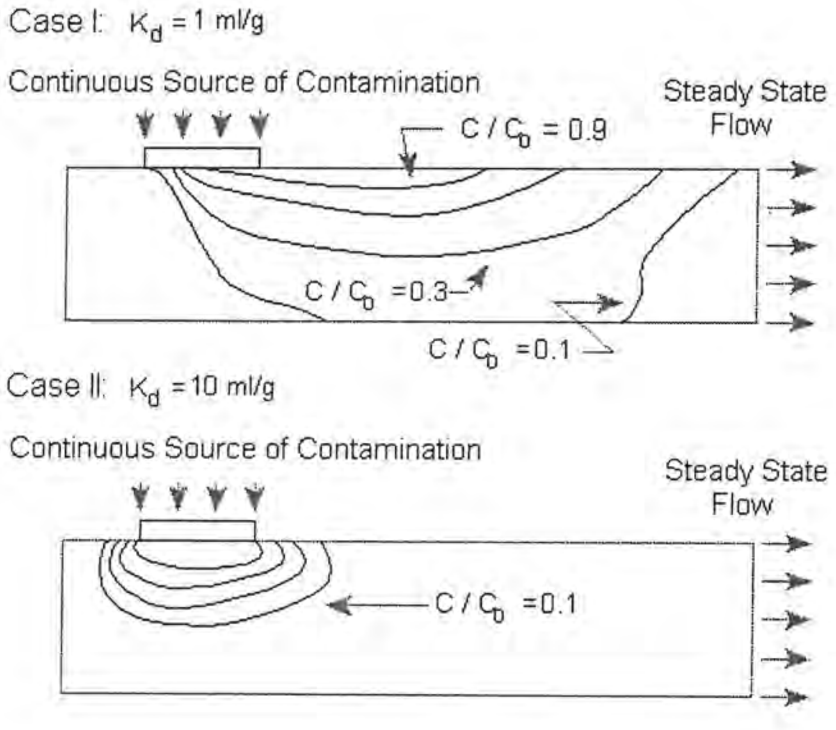
August 1999

UNDERSTANDING VARIATION IN PARTITION COEFFICIENT, K_d, VALUES

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

Volume II:

Review of Geochemistry and Available K_d Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (^3H), and Uranium



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August 1999

A Cooperative Effort By:

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NOTICE

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FOREWORD

Understanding the long-term behavior of contaminants in the subsurface is becoming increasingly more important as the nation addresses groundwater contamination. Groundwater contamination is a national concern as about 50 percent of the United States population receives its drinking water from groundwater. It is the goal of the Environmental Protection Agency (EPA) to prevent adverse effects to human health and the environment and to protect the environmental integrity of the nation's groundwater.

Once groundwater is contaminated, it is important to understand how the contaminant moves in the subsurface environment. Proper understanding of the contaminant fate and transport is necessary in order to characterize the risks associated with the contamination and to develop, when necessary, emergency or remedial action plans. The parameter known as the partition (or distribution) coefficient (K_d) is one of the most important parameters used in estimating the migration potential of contaminants present in aqueous solutions in contact with surface, subsurface and suspended solids.

This two-volume report describes: (1) the conceptualization, measurement, and use of the partition coefficient parameter; and (2) the geochemical aqueous solution and sorbent properties that are most important in controlling adsorption/retardation behavior of selected contaminants. Volume I of this document focuses on providing EPA and other environmental remediation professionals with a reasoned and documented discussion of the major issues related to the selection and measurement of the partition coefficient for a select group of contaminants. The selected contaminants investigated in this two-volume document include: chromium, cadmium, cesium, lead, plutonium, radon, strontium, thorium, tritium (^{3}H), and uranium. This two-volume report also addresses a void that has existed on this subject in both this Agency and in the user community.

It is important to note that soil scientists and geochemists knowledgeable of sorption processes in natural environments have long known that generic or default partition coefficient values found in the literature can result in significant errors when used to predict the absolute impacts of contaminant migration or site-remediation options. Accordingly, one of the major recommendations of this report is that for site-specific calculations, partition coefficient values measured at site-specific conditions are absolutely essential.

For those cases when the partition coefficient parameter is not or cannot be measured, Volume II of this document: (1) provides a "thumb-nail sketch" of the key geochemical processes affecting the sorption of the selected contaminants; (2) provides references to related key experimental and review articles for further reading; (3) identifies the important aqueous- and solid-phase parameters controlling the sorption of these contaminants in the subsurface environment under oxidizing conditions; and (4) identifies, when possible, minimum and maximum conservative partition coefficient values for each contaminant as a function of the key geochemical processes affecting their sorption.

APPENDIX F

Partition Coefficients For Lead

Appendix F

Partition Coefficients For Lead

F.1.0 Background

The review of lead K_d data reported in the literature for a number of soils led to the following important conclusions regarding the factors which influence lead adsorption on minerals, soils, and sediments. These principles were used to evaluate available quantitative data and generate a look-up table. These conclusions are:

- Lead may precipitate in soils if soluble concentrations exceed about 4 mg/l at pH 4 and about 0.2 mg/l at pH 8. In the presence of phosphate and chloride, these solubility limits may be as low as 0.3 mg/l at pH 4 and 0.001 mg/l at pH 8. Therefore, in experiments in which concentrations of lead exceed these values, the calculated K_d values may reflect precipitation reactions rather than adsorption reactions.

- Anionic constituents such as phosphate, chloride, and carbonate are known to influence lead reactions in soils either by precipitation of minerals of limited solubility or by reducing adsorption through complex formation.

- A number of adsorption studies indicate that within the pH range of soils (4 to 11), lead adsorption increases with increasing pH.

- Adsorption of lead increases with increasing organic matter content of soils.

- Increasing equilibrium solution concentrations correlates with decreasing lead adsorption (decrease in K_d).

Lead adsorption behavior on soils and soil constituents (clays, oxides, hydroxides, oxyhydroxides, and organic matter) has been studied extensively. However, calculations by Rickard and Nriagu (1978) show that the solution lead concentrations used in a number of adsorption studies may be high enough to induce precipitation. For instance, their calculations show that lead may precipitate in soils if soluble concentrations exceed about 4 mg/l at pH 4 and about 0.2 mg/l at pH 8. In the presence of phosphate and chloride, these solubility limits may be as low as 0.3 mg/l at pH 4 and 0.001 mg/l at pH 8. Therefore, in experiments in which concentrations of lead exceed these values, the calculated K_d values may reflect precipitation reactions rather than adsorption reactions.

Based on lead adsorption behavior of 12 soils from Italy, Soldatini *et al.* (1976) concluded that soil organic matter and clay content were 2 major factors which influence lead adsorption. In these experiments, the maximum adsorption appeared to exceed the cation exchange capacity

(CEC) of the soils. Such an anomaly may have resulted from precipitation reactions brought about by high initial lead concentrations used in these experiments (20 to 830 mg/l).

Lead adsorption characteristics of 7 alkaline soils from India were determined by Singh and Sekhon (1977). The authors concluded that soil clay, organic matter, and the calcium carbonate influenced lead adsorption by these soils. However, the initial lead concentrations used in these experiments ranged from 5 to 100 mg/l, indicating that in these alkaline soils the dominant lead removal mechanism was quite possibly precipitation.

In another adsorption study, Abd-Elfattah and Wada (1981) measured the lead adsorption behavior of 7 Japanese soils. They concluded that soil mineral components which influenced lead adsorption ranged in the order: iron oxides>halloysite>imogolite, allophane>humus, kaolinite>montmorillonite. These data may not be reliable because high lead concentrations (up to 2,900 mg/l) used in these experiments may have resulted in precipitation reactions dominating the experimental system.

Anionic constituents, such as phosphate, chloride, and carbonate, are known to influence lead reactions in soils either by precipitation of minerals of limited solubility or by reducing adsorption through complex formation (Rickard and Nriagu, 1978). A recent study by Bargar *et al.* (1998) showed that chloride solutions could induce precipitation of lead as solid PbOHCl. Presence of synthetic chelating ligands such as ethylenediaminetetraacetic acid (EDTA) has been shown to reduce lead adsorption on soils (Peters and Shem, 1992). These investigators showed that the presence of strongly chelating EDTA in concentrations as low as 0.01 M reduced K_d for lead by about 3 orders of magnitude. By comparison quantitative data is lacking on the effects of more common inorganic ligands (phosphate, chloride, and carbonate) on lead adsorption on soils.

A number of adsorption studies indicate that within the pH range of soils (4 to 11), lead adsorption increases with increasing pH (Bittel and Miller, 1974; Braids *et al.*, 1972; Griffin and Shimp, 1976; Haji-Djafari *et al.*, 1981; Hildebrand and Blum, 1974; Overstreet and Krishnamurthy, 1950; Scrudato and Estes, 1975; Zimdahl and Hassett, 1977). Griffin and Shimp (1976) also noted that clay minerals adsorbing increasing amounts of lead with increasing pH may also be attributed to the formation of lead carbonate precipitates which was observed when the solution pH values exceeded 5 or 6.

Solid organic matter such as humic material in soils and sediments are known to adsorb lead (Rickard and Nriagu, 1978; Zimdahl and Hassett, 1977). Additionally, soluble organic matter such as fulvates and amino acids are known to chelate soluble lead and affect its adsorption on soils (Rickard and Nriagu, 1978). Gerritse *et al.* (1982) examined the lead adsorption properties of soils as a function of organic matter content of soils. Initial lead concentrations used in these experiments ranged from 0.001 to 0.1 mg/l. Based on adsorption data, the investigators expressed K_d value for a soil as a function of organic matter content (as wt.%) and the distribution coefficient of the organic matter. The data also indicated that irrespective of soil organic matter content, lead adsorption increased with increasing soil pH (from 4 to 8). In certain soils, lead is also known to form methyl- lead complexes (Rickard and Nriagu, 1978). However, quantitative relationship between the redox status of soils and its effect on overall lead adsorption due to methylation of lead species is not known.

Tso (1970), and Sheppard *et al.* (1989) studied the retention of ^{210}Pb in soils and its uptake by plants. These investigators found that lead in trace concentrations was strongly retained on soils (high K_d values). Lead adsorption by a subsurface soil sample from Hanford, Washington was investigated by Rhoads *et al.* (1992). Adsorption data from these experiments showed that K_d values increased with decreasing lead concentrations in solution (from 0.2 mg/l to 0.0062 mg/l). At a fixed pH of 8.35, the authors found that K_d values were log-linearly correlated with equilibrium concentrations of lead in solution. Calculations showed that if lead concentrations exceeded about 0.207 mg/l, lead-hydroxycarbonate (hydrocerussite) would probably precipitate in this soil.

The K_d data described above are listed in Table F.1.

F.2.0 Approach

The initial step in developing a look-up table consisted of identifying the key parameters which were correlated with lead adsorption (K_d values) on soils and sediments. Data sets developed by Gerritse *et al.* (1982) and Rhoads *et al.* (1992) containing both soil pH and equilibrium lead concentrations as independent variables were selected to develop regression relationships with K_d as the dependent variable. From these data it was found that a polynomial relationship existed between K_d values and soil pH measurements. This relationship (Figure F.1) with a correlation coefficient of 0.971 (r^2) could be expressed as:

$$K_d\ (\mathrm{ml/g}) = 1639 - 902.4(\mathrm{pH}) + 150.4(\mathrm{pH})^2 \qquad (\mathrm{F.1})$$

The relationship between equilibrium concentrations of lead and K_d values for a Hanford soil at a fixed pH was expressed by Rhoads *et al.* (1992) as:

$$K_d\ (\mathrm{ml/g}) = 9{,}550\ C^{-0.335} \qquad (\mathrm{F.2})$$

where C is the equilibrium concentration of lead in µg/l. The look-up table (Table F.2) was developed from using the relationships F.1 and F.2. Four equilibrium concentration and 3 pH categories were used to estimate the maximum and minimum K_d values in each category. The relationship between the K_d values and the 2 independent variables (pH and the equilibrium concentration) is shown as a 3-dimensional surface (Figure F.2). This graph illustrates that the highest K_d values are encountered under conditions of high pH values and very low equilibrium lead concentrations and in contrast, the lowest K_d values are encountered under lower pH and higher lead concentrations. The K_d values listed in the look-up table encompasses the ranges of pH and lead concentrations normally encountered in surface and subsurface soils and sediments.

Table F.1. Summary of K_d values for lead adsorption on soils.

Soil Description	Clay Content (wt.%)	Organic Carbon (wt.%)	Iron Oxide content (wt.%)	pH	CEC (meq/100g)	K_d (ml/g)	Experimental Parameters	Reference
Sediment, Split Rock Formation, Wyoming	--	--	--	2.0	--	20	--	Haji-Djafari *et al.*, 1981
	--	--	--	4.5	--	100	--	
	--	--	--	5.75	--	1,500	--	
	--	--	--	7.0	--	4,000	--	
Sand (Soil C)	0	--	--	4.5	22	280	Batch Experiment	Gerritse *et al.* (1982)
Sand (Soil C)	0	--	--	5.0	22	1295	Batch Experiment	
Sandy Loam (Soil D)	2	--	--	7.5	16	3,000	Batch Experiment	
Sandy Loam (Soil D)	2	--	--	8.0	16	4,000	Batch Experiment	
Loam (Soil 2)	15	--	--	7.3	17	21,000	Batch Experiment	Sheppard *et al.* (1989)
Medium Sand (Soil 3)	2	--	--	4.9	5.8	19	Batch Experiment	
Organic soil (Soil 4)	<1	--	--	5.5	120	30,000	Batch Experiment	
Fine Sandy Loam (Soil 6)	11	--	--	7.4	8.7	59,000	Batch Experiment	
Sand (Hanford)	0.06	<0.01	0.41	8.35	5.27	13,000 - 79,000	Batch tracer studies (Initial activities 2.38 - 23.4 μCi/l	Rhoads *et al.* (1992)

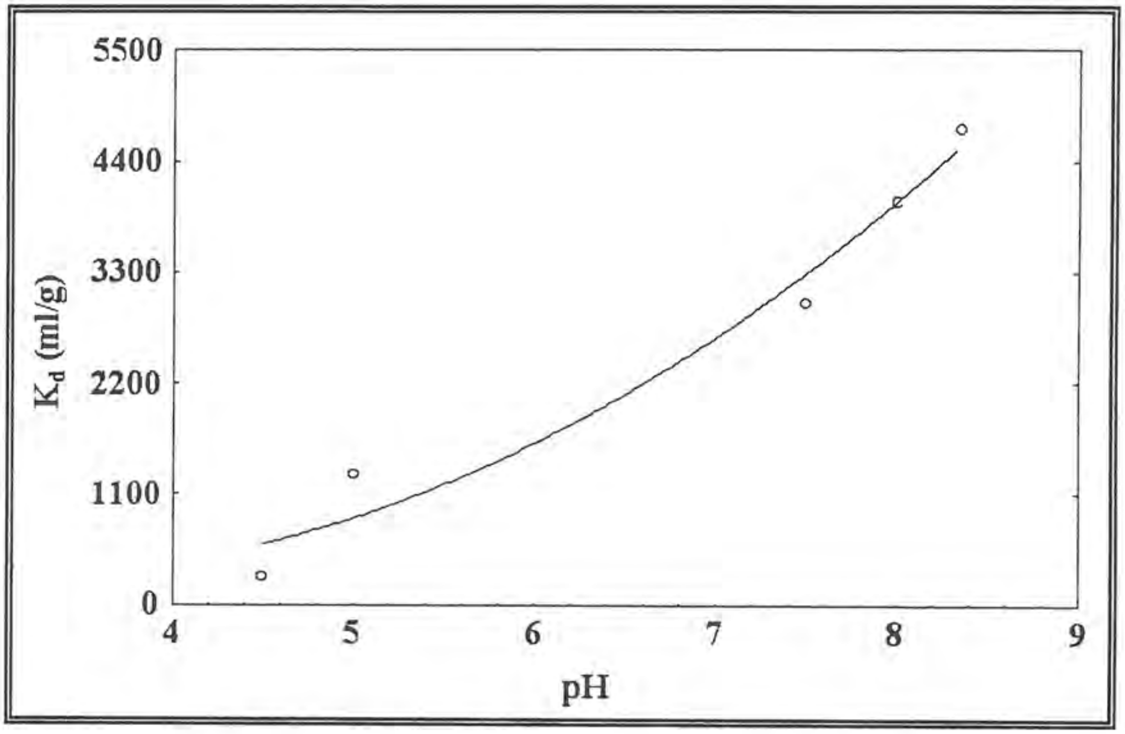

Figure F.1. Correlative relationship between K_d and pH.

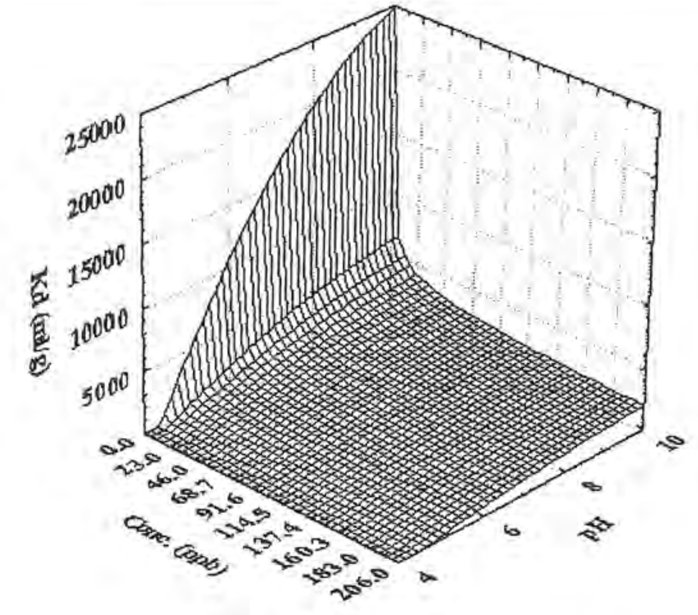

Figure F.2. Variation of K_d as a function of pH and the equilibrium lead concentrations.

F.3.0 Data Set for Soils

The data sets developed by Gerritse *et al.* (1982) and Rhoads *et al.* (1992) were used to develop the look-up table (Table F.2). Gerritse *et al.* (1982) developed adsorption data for 2 well-characterized soils using a range of lead concentrations (0.001 to 0.1 mg/l) which precluded the possibility of precipitation reactions. Similarly, adsorption data developed by Rhoads *et al.* (1992) encompassed a range of lead concentrations from 0.0001 to 0.2 mg/l at a fixed pH value. Both these data sets were used for estimating the range of K_d values for the range of pH and lead concentration values found in soils.

Table F.2. Estimated range of K_d values for lead as a function of soil pH, and equilibrium lead concentrations.

Equilibrium Lead Concentration (µg/l)	K_d (ml/g)	Soil pH		
		4.0 - 6.3	**6.4 - 8.7**	**8.8 - 11.0**
0.1 - 0.9	Minimum	940	4,360	11,520
	Maximum	8,650	23,270	44,580
1.0 - 9.9	Minimum	420	1,950	5,160
	Maximum	4,000	10,760	20,620
10 - 99.9	Minimum	190	900	2,380
	Maximum	1,850	4,970	9,530
100 - 200	Minimum	150	710	1,880
	Maximum	860	2,300	4,410

F.4.0 References

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Attachment 2

Mud Still Residue Data – TCLP And Statistical Analysis

Attachment 2

Mud Still Residue - TCLP Metals
Silver Bow Plant

[concentration in mg/l]

Run #	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
1	<0.5	<0.5	0.269	<0.5	0.66	<0.1	<0.5	<0.5
2	<0.5	<0.5	0.72	<0.5	1.07	0.11	<0.5	<0.5
2 Reanalysis	<0.05	0.05	1.86	0.11	1.12	0.03	<0.05	<0.05
3	<0.5	<0.5	2.03	<0.5	1.79	<0.01	<0.5	<0.5
2 Reanalysis	<0.05	<0.05	3.06	<0.01	1.33	0.02	<0.05	<0.05
4	<0.5	0.13	0.43	<0.05	0.83	<0.01	<0.05	<0.05
5	<0.5	0.08	1.56	<0.05	3.05	<0.01	<0.05	<0.05
6	<0.5	0.06	2.53	0.15	3.15	0.06	<0.05	<0.05
7	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	--	--
9	<0.5	<0.5	2.65	<0.5	1.31	<0.1	<0.5	<0.5
10	<0.5	<0.5	1.45	<0.5	<0.5	<0.1	<0.5	<0.5
11	<0.5	<0.5	<0.5	<0.5	1.4	<0.1	<0.5	<0.5
12	--	--	--	--	--	--	--	--
Concentration **Rationale**	**0.5** **Detection Limit**	**0.5** **Detection Limit**	**2.1** **95% KM(t) UCL** **ProUCL V5.0**	**0.5** **Detection Limit**	**2.0** **95% KM(t) UCL** **ProUCL V5.0**	**0.11** **Maximum**	**0.5** **Detection Limit**	**0.5** **Detection Limit**

Source: Clarifier Material Treatability Study; Phase 3 Report – Pilot Plant Operation (Franklin 2012).

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	10/10/2014 12:17:32 PM
From File	Mud Still Residue TCLP Summary.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cd

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
Number of Detects	10	Number of Non-Detects	1
Number of Distinct Detects	10	Number of Distinct Non-Detects	1
Minimum Detect	0.269	Minimum Non-Detect	0.5
Maximum Detect	3.06	Maximum Non-Detect	0.5
Variance Detects	0.918	Percent Non-Detects	9.091%
Mean Detects	1.656	SD Detects	0.958
Median Detects	1.71	CV Detects	0.579
Skewness Detects	-0.136	Kurtosis Detects	-1.179
Mean of Logged Detects	0.268	SD of Logged Detects	0.824

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.951	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.136	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.28	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	1.537	Standard Error of Mean	0.3
SD	0.945	95% KM (BCA) UCL	2.019
95% KM (t) UCL	2.082	95% KM (Percentile Bootstrap) UCL	2.03
95% KM (z) UCL	2.031	95% KM Bootstrap t UCL	2.042
90% KM Chebyshev UCL	2.438	95% KM Chebyshev UCL	2.847
97.5% KM Chebyshev UCL	3.413	99% KM Chebyshev UCL	4.526

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.445	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.735	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.212	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.269	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.269	k star (bias corrected MLE)	1.655
Theta hat (MLE)	0.73	Theta star (bias corrected MLE)	1.001
nu hat (MLE)	45.37	nu star (bias corrected)	33.1

MLE Mean (bias corrected)	1.656	MLE Sd (bias corrected)	1.287
Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	2.647	nu hat (KM)	58.24
Approximate Chi Square Value (58.24, α)	41.7	Adjusted Chi Square Value (58.24, β)	39.43
95% Gamma Approximate KM-UCL (use when n>=50)	2.147	95% Gamma Adjusted KM-UCL (use when n<50)	2.271
Gamma ROS Statistics using Imputed Non-Detects			
GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
GROS may not be used when kstar of detected data is small such as < 0.1			
For such situations, GROS method tends to yield inflated values of UCLs and BTVs			
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
Minimum	0.269	Mean	1.552
Maximum	3.06	Median	1.56
SD	0.972	CV	0.627
k hat (MLE)	2.097	k star (bias corrected MLE)	1.586
Theta hat (MLE)	0.74	Theta star (bias corrected MLE)	0.979
nu hat (MLE)	46.13	nu star (bias corrected)	34.88
MLE Mean (bias corrected)	1.552	MLE Sd (bias corrected)	1.232
		Adjusted Level of Significance (β)	0.0278
Approximate Chi Square Value (34.88, α)	22.37	Adjusted Chi Square Value (34.88, β)	20.75
95% Gamma Approximate UCL (use when n>=50)	2.419	95% Gamma Adjusted UCL (use when n<50)	2.608
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Test Statistic	0.874	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.25	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.28	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	1.544	Mean in Log Scale	0.166
SD in Original Scale	0.982	SD in Log Scale	0.852
95% t UCL (assumes normality of ROS data)	2.08	95% Percentile Bootstrap UCL	1.99
95% BCA Bootstrap UCL	2.06	95% Bootstrap t UCL	2.102
95% H-UCL (Log ROS)	3.536		
UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed			
KM Mean (logged)	0.146	95% H-UCL (KM -Log)	3.395
KM SD (logged)	0.843	95% Critical H Value (KM-Log)	2.707
KM Standard Error of Mean (logged)	0.269		
DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.528	Mean in Log Scale	0.118
SD in Original Scale	1.003	SD in Log Scale	0.927
95% t UCL (Assumes normality)	2.076	95% H-Stat UCL	4
DL/2 is not a recommended method, provided for comparisons and historical reasons			

Nonparametric Distribution Free UCL Statistics							
Detected Data appear Normal Distributed at 5% Significance Level							
Suggested UCL to Use							
95% KM (t) UCL	2.1	95% KM (Percentile Bootstrap) UCL					2.0
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
Recommendations are based upon data size, data distribution, and skewness.							
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							

UCL Statistics for Data Sets with Non-Detects			
User Selected Options			
Date/Time of Computation	10/10/2014 12:18:21 PM		
From File	Mud Still Residue TCLP Summary.xls		
Full Precision	OFF		
Confidence Coefficient	95%		
Number of Bootstrap Operations	2000		
Pb			
General Statistics			
Total Number of Observations	11	Number of Distinct Observations	11
Number of Detects	10	Number of Non-Detects	1
Number of Distinct Detects	10	Number of Distinct Non-Detects	1
Minimum Detect	0.66	Minimum Non-Detect	0.5
Maximum Detect	3.15	Maximum Non-Detect	0.5
Variance Detects	0.746	Percent Non-Detects	9.091%
Mean Detects	1.571	SD Detects	0.864
Median Detects	1.32	CV Detects	0.55
Skewness Detects	1.242	Kurtosis Detects	0.404
Mean of Logged Detects	0.332	SD of Logged Detects	0.505
Normal GOF Test on Detects Only			
Shapiro Wilk Test Statistic	0.821	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.278	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.28	Detected Data appear Normal at 5% Significance Level	
Detected Data appear Approximate Normal at 5% Significance Level			
Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	1.474	Standard Error of Mean	0.267
SD	0.84	95% KM (BCA) UCL	1.901
95% KM (t) UCL	1.957	95% KM (Percentile Bootstrap) UCL	1.917
95% KM (z) UCL	1.913	95% KM Bootstrap t UCL	2.388
90% KM Chebyshev UCL	2.274	95% KM Chebyshev UCL	2.637
97.5% KM Chebyshev UCL	3.141	99% KM Chebyshev UCL	4.13
Gamma GOF Tests on Detected Observations Only			
A-D Test Statistic	0.494	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.729	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.229	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.268	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics on Detected Data Only			
k hat (MLE)	4.321	k star (bias corrected MLE)	3.091
Theta hat (MLE)	0.364	Theta star (bias corrected MLE)	0.508
nu hat (MLE)	86.42	nu star (bias corrected)	61.83

MLE Mean (bias corrected)	1.571	MLE Sd (bias corrected)	0.894
Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	3.078	nu hat (KM)	67.72
Approximate Chi Square Value (67.72, α)	49.78	Adjusted Chi Square Value (67.72, β)	47.28
95% Gamma Approximate KM-UCL (use when n>=50)	2.005	95% Gamma Adjusted KM-UCL (use when n<50)	2.111
Gamma ROS Statistics using Imputed Non-Detects			
GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
GROS may not be used when kstar of detected data is small such as < 0.1			
For such situations, GROS method tends to yield inflated values of UCLs and BTVs			
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
Minimum	0.044	Mean	1.432
Maximum	3.15	Median	1.31
SD	0.94	CV	0.656
k hat (MLE)	1.609	k star (bias corrected MLE)	1.231
Theta hat (MLE)	0.89	Theta star (bias corrected MLE)	1.163
nu hat (MLE)	35.4	nu star (bias corrected)	27.08
MLE Mean (bias corrected)	1.432	MLE Sd (bias corrected)	1.291
		Adjusted Level of Significance (β)	0.0278
Approximate Chi Square Value (27.08, α)	16.21	Adjusted Chi Square Value (27.08, β)	14.86
95% Gamma Approximate UCL (use when n>=50)	2.392	95% Gamma Adjusted UCL (use when n<50)	2.61
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Test Statistic	0.934	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.196	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.28	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	1.465	Mean in Log Scale	0.22
SD in Original Scale	0.891	SD in Log Scale	0.605
95% t UCL (assumes normality of ROS data)	1.952	95% Percentile Bootstrap UCL	1.9
95% BCA Bootstrap UCL	1.972	95% Bootstrap t UCL	2.296
95% H-UCL (Log ROS)	2.333		
UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed			
KM Mean (logged)	0.238	95% H-UCL (KM -Log)	2.159
KM SD (logged)	0.543	95% Critical H Value (KM-Log)	2.234
KM Standard Error of Mean (logged)	0.173		
DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.451	Mean in Log Scale	0.175
SD in Original Scale	0.911	SD in Log Scale	0.705
95% t UCL (Assumes normality)	1.949	95% H-Stat UCL	2.654
DL/2 is not a recommended method, provided for comparisons and historical reasons			

Nonparametric Distribution Free UCL Statistics			
Detected Data appear Approximate Normal Distributed at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	2.0	95% KM (Percentile Bootstrap) UCL	1.9
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Appendix L

Assumptions for Crew Size and Exposure Duration

Table L-1

Crew Size and Task Duration Assumptions
Clarifier Materials

Enhanced RCRA Cap

	Baseline Worker Scenario						Protected Worker Scenario				
	Crew			Crew Size (persons)	Task Duration (hours)	Duration Assumption	Assumed Level of Protection	Incremental Addition to:		Crew Size (persons)	Task Duration (hours)
Risk - Contributing Exposure	**Forman**	**Operator**	**Laborer**					**Crew Size (persons)**	**Task Duration Factor**		
A	**B**	**C**	**D**	**E=(B+C+D)**	**F**	**G**	**H**	**I**	**J**	**K = (E + I)**	**L = (F X J)**
Site Preparation	1	1	1	3	20	1/2 week	1	--	1.0	3	20
Subgrade Placement	1	4	1	6	80	2 weeks	2	0.5	1.1	6.5	88
Surcharge Placement/Removal	1	4	1	6	80	2 weeks	1	--	1.0	6	80
Consolidation Monitoring	1	--	1	2	20	1 hr/ week for 20 weeks	1	--	1.0	2	20
Gas Collection System Installation	1	1	2	4	20	1/2 week	2	0.5	1.1	4.5	22
Subgrade Placement	1	9	2	12	40	1 week	1	--	1.0	12	40
Subgrade Regrading	1	1	--	2	60	1.5 weeks	1	--	1.0	2	60
Liner Placement	1	4	1	6	100	2.5 weeks	1	--	1.0	6	100
Cover Soil Placement/Grading	1	4	1	6	500	12.5 weeks	1	--	1.0	6	500
Restoration/Revegetation/Fencing	1	1	--	2	140	3.5 weeks	1	--	1.0	2	140
Maintenance & Monitoring				1.9	484	Total Maintenance and Monitoring	1	--	1.0	1.9	484
Year 1 to 5	*1*	--	*1*	*2*	*200*	*40 hr/yr for 5 yrs*	*1*	--	*1*	*2*	*200*
Years 6 to 30	*1*	--	*1*	*2*	*225*	*9 hr/yr for 25 yrs*	*1*	--	*1*	*2*	*225*
Years 31 to 100	*1*	--	--	*1*	*70*	*1 hr/yr for 70 yrs*	*1*	--	*1*	*1*	*70*
Estimated Duration of Exposure [person-hrs]				**6,540**						**6,651**	

Table L-2

Crew Size and Task Duration Assumptions
Clarifier Materials

On-site Phosphorus Recovery (Mud Still)

	Baseline Worker Scenario						Protected Worker Scenario				
	Crew			Crew Size (persons)	Task Duration (hours)	Duration Assumption	Assumed Level of Protection	Incremental Addition to:		Crew Size (persons)	Task Duration (hours)
Risk - Contributing Exposure	Forman	Operator	Laborer					Crew Size (persons)	Task Duration Factor		
A	B	C	D	E=(B+C+D)	F	G	H	I	J	K = (E + I)	L = (F X J)
Removal Operations											
Site Preparation	1	1	1	3	20	1/2 week	1	--	1.0	3	20
Mud Still Preparation											
Construct/Test Feed System	2	4	10	16	500	1/4 year	1	1	1.0	17	500
Contruct/Test Mud Still	2	4	10	16	2000	1/2 year	1	1	1.0	17	2,000
Construct/Test Offgas System	2	4	10	16	1000	1/2 year	1	1	1.0	17	1,000
Test Burn	2	2	4	8	24	24 hr	1	1	1.0	9	24
Mud Still Operations (24 hr/day; 7 days/wk; 5 batches/wk; 71% Onstream time)											
Excavate CP and Load Skips	2	2	2	6	4,760	4 hr/day; 7 days/wk; 170 wks	3	1	1.4	7	6,664
Water Cap Control/Maintenance	--	--	1	1	595	1/2 hr/day,7 days/wk, 170 wks	2	0.5	1.1	1.5	655
Open Skip and Remove Residue	2	2	2	6	2,380	2 hr/day; 7 days/wk; 170 wks	3	1	1.4	7	3,332
Transfer P4 product	2	2	2	6	2,380	2 hr/day; 7 days/wk; 170 wks	3	1	1.4	7	3,332
System Maintenance	2	2	2	6	3,600	40 hr/week; 90 weeks	1	0	1.0	6	3,600
Transport (via truck) to P4 facility *	--	1	--	1	1,120	38 - 20 Tons loads	1	--	1.0	1	1,120
Transport (Truck returns to site) *	--	1	--	1	1,120	38 return trips	1	--	1.0	1	1,120
Transfer P4 product to P4 facility tanks	1	1	1	3	76	2 hr/load	3	1	1.0	4	76
P4 use at P4 facility	1	1	1	3	76	2 hr/load	3	1	1.0	4	76
Closure Operations											
Decontaminate & Decommission Facilities	1	2	6	9	320	8 - 40 hr weeks	3	1	1.4	10	448
Place Residue in Clarifier	1	1	1	3	16	2 days	1	1	1.4	4	22
Backfill/ Compaction	1	4	1	6	40	1 week	1	--	1.0	6	40
Evapotranspiration Cap	--	--	--	--	2,620	Table L-4	--	--	--	--	2,731
Maintenance & Monitoring				1.9	484	Total Maintenance and Monitoring	1	--	1.0	1.9	484
Year 1 to 5	*1*	--	*1*	*2*	*200*	*40 hr/yr for 5 yrs*	*1*	--	*1*	*2*	*200*
Years 6 to 30	*1*	--	*1*	*2*	*225*	*9 hr/yr for 25 yrs*	*1*	--	*1*	*2*	*225*
Years 31 to 100	*1*	--	--	*1*	*70*	*1 hr/yr for 70 yrs*	*1*	--	*1*	*1*	*70*
Estimated Duration of Exposure [person-hrs]				**123,370**						**165,362**	

Table L-3

Crew Size and Task Duration Assumptions
Clarifier Materials

Off-site Incineration

	Baseline Worker Scenario						Protected Worker Scenario				
	Crew			Crew Size (persons)	Task Duration (hours)		Assumed Level of Protection	Incremental Addition to:		Crew Size (persons)	Task Duration (hours)
Risk - Contributing Exposure	Forman	Operator	Laborer			Duration Assumption		Crew Size (persons)	Task Duration Factor		
A	B	C	D	E=(B+C+D)	F	G	H	I	J	K = (E + I)	L = (F X J)
Removal Operations											
Site Preparation	1	1	1	3	20	1/2 week	1	--	1.0	3	20
Water Cap Control/Maintenance	--	--	1	1	360	1/2 hr / day	2	0.5	1.1	1.5	396
Removal Operations (Clarifier to Drum)	1	4	3	8	5,750	Removal rate is 16 drums / 8 hr (day)	1	1	1.4	9	8,050
Drum Transfer to Storage	1	1	1	3	720	1 hr/day	3	1	1.4	4	1,008
Drum Inspection and pH adjustment	--	1	--	1	11,680	2 hr /day; 16 yrs	1	--	1.0	1	11,680
Transportation Operations											
Drum Transfer (Storage to Truck)	1	1	--	2	288	2 hrs / load	1	--	1.0	2	288
Transport (via truck) to TSD facility *	--	1	--	1	4,320	Sauget, IL	1	--	1.0	1	4,320
Transport (Truck returns to site) *	--	1	--	1	4,320		1	--	1.0	1	4,320
Incineration Operations											
Receive/unload truck at TSD facility	1	1	--	2	288	2 hrs / load	1	1	1.4	3	403
Transfer to Incinerator Unit	--	1	--	1	2,920	0.5 hr / day; 16 yrs	3	1	1.4	2	4,088
Stabilize ash and waste residue from air cleaning system for final landfill disposal	1	1	--	2	1600	2 hr/wk; 50 wks/yr; 16 yrs	1	--	1.0	2	1,600
Closure Operations											
Backfill/ Compaction	1	4	1	6	40	1 week	1	--	1.0	6	40
Evapotranspiration Cap	--	--	--	--	2,620	Table J-4	--	--	--	--	2,731
Maintenance & Monitoring				1.9	484	Total Maintenance and Monitoring	1	--	1.0	1.9	484
Estimated Duration of Exposure [person-hrs]				**79,951**						**114,508**	

Table L-4

Crew Size and Task Duration Assumptions
Clarifier Materials

Evapotranspiration Cap

	Baseline Worker Scenario						Protected Worker Scenario				
	Crew							Incremental Addition to:			
Risk - Contributing Exposure	Forman	Operator	Laborer	Crew Size (persons)	Task Duration (hours)	Duration Assumption	Assumed Level of Protection	Crew Size (persons)	Task Duration Factor	Crew Size (persons)	Task Duration (hours)
A	B	C	D	E=(B+C+D)	F	G	H	I	J	K = (E + I)	L = (F X J)
Site Preparation	1	1	1	3	20	1/2 week	1	--	1.0	3	20
Subgrade Placement	1	4	1	6	80	2 weeks	2	0.5	1.1	6.5	88
Surcharge Placement/Removal	1	4	1	6	40	1 week	1	--	1.0	6	40
Consolidation Monitoring	1	--	1	2	20	1 hr/ week for 20 weeks	1	--	1.0	2	20
Gas Collection System Installation	1	1	2	4	20	1/2 week	2	0.5	1.1	4.5	22
Subgrade Regrading	1	1	--	2	20	1/2 week	1	--	1.0	2	20
Cover Soil Placement/Grading	1	4	1	6	120	3 weeks	1	--	1.0	6	120
Restoration/Revegetation	1	1	--	2	20	1/2 week	1	--	1.0	2	20
Maintenance & Monitoring				1.9	484	Total Maintenance and Monitoring	1	--	1.0	1.9	484
Year 1 to 5	*1*	--	*1*	*2*	*200*	*40 hr/yr for 5 yrs*	*1*	--	*1*	*2*	*200*
Years 6 to 30	*1*	--	*1*	*2*	*225*	*9 hr/yr for 25 yrs*	*1*	--	*1*	*2*	*225*
Years 31 to 100	*1*	--	--	*1*	*70*	*1 hr/yr for 70 yrs*	*1*	--	*1*	*1*	*70*
Estimated Duration of Exposure [person-hrs]				**2,620**						**2,731**	

Appendix M

Risk Calculations for Short-term Risk Scenarios

Table M-1

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Baseline Worker Scenario
Clarifier Materials

Enhanced RCRA Cap

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	
Site Preparation	3	20	60	4.7E-08	1	4.7E-08	2.8E-06	
Subgrade Placement	6	80	480	4.7E-08	3	1.4E-07	6.8E-05	
Surcharge Placement/Removal	6	80	480	4.7E-08	1	4.7E-08	2.3E-05	
Consolidation Monitoring	2	20	40	4.7E-08	1	4.7E-08	1.9E-06	
Gas Collection System Installation	4	20	80	4.7E-08	3	1.4E-07	1.1E-05	
Subgrade Placement	12	40	480	4.7E-08	1	4.7E-08	2.3E-05	
Subgrade Regrading	2	60	120	4.7E-08	1	4.7E-08	5.6E-06	
Liner Placement	6	100	600	4.7E-08	1	4.7E-08	2.8E-05	
Cover Soil Placement/Grading	6	500	3,000	4.7E-08	1	4.7E-08	1.4E-04	
Restoration/Revegetation/Fencing	2	140	280	1.1E-07	1	1.1E-07	3.1E-05	
Maintenance & Monitoring	1.9	484	920	5.9E-09	1	5.9E-09	5.4E-06	
TOTAL (Sum of column)			**6,540**				**3.4E-04**	**Low**
Probability of Worker Fatality							**0.0007%**	

[1] See Appendix L for estimated crew size and task duration.

Table M-2

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Protected Worker Scenario
Clarifier Materials

Enhanced RCRA Cap

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D	E = (C X D)	F	G	H = (F + G)	I = (E X H)	
Site Preparation	1	3	20	60	4.7E-08	1.6E-09	4.9E-08	2.9E-06	
Subgrade Placement	2	6.5	88	572	4.7E-08	1.6E-09	4.9E-08	2.8E-05	
Surcharge Placement/Removal	1	6	80	480	4.7E-08	1.6E-09	4.9E-08	2.3E-05	
Consolidation Monitoring	1	2	20	40	4.7E-08	1.6E-09	4.9E-08	1.9E-06	
Gas Collection System Installation	2	4.5	22	99	4.7E-08	1.6E-09	4.9E-08	4.8E-06	
Subgrade Placement	1	12	40	480	4.7E-08	1.6E-09	4.9E-08	2.3E-05	
Subgrade Regrading	1	2	60	120	4.7E-08	1.6E-09	4.9E-08	5.8E-06	
Liner Placement	1	6	100	600	4.7E-08	1.6E-09	4.9E-08	2.9E-05	
Cover Soil Placement/Grading	1	6	500	3,000	4.7E-08	1.6E-09	4.9E-08	1.5E-04	
Restoration/Revegetation/Fencing	1	2	140	280	1.1E-07	1.6E-09	1.1E-07	3.1E-05	
Maintenance and Monitoring	1	1.9	484	920	5.9E-09	--	5.9E-09	5.4E-06	
TOTAL (Sum of column)				**6,651**				**3.0E-04**	**Low**
Probability of Worker Fatality								**0.0006%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

Table M-3

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Baseline Worker Scenario
Clarifier Materials

Enhdanced RCRA Cap

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	**B**	**C**	**D = (B X C)**	**E**	**F**	**G = (E X F)**	**H = (D X G)**	
Site Preparation	3	20	60	1.6E-06	1	1.6E-06	9.3E-05	
Subgrade Placement	6	80	480	1.6E-06	3	4.7E-06	2.2E-03	
Surcharge Placement/Removal	6	80	480	1.6E-06	1	1.6E-06	7.4E-04	
Consolidation Monitoring	2	20	40	1.6E-06	1	1.6E-06	6.2E-05	
Gas Collection System Installation	4	20	80	1.6E-06	3	4.7E-06	3.7E-04	
Subgrade Placement	12	40	480	1.6E-06	1	1.6E-06	7.4E-04	
Subgrade Regrading	2	60	120	1.6E-06	1	1.6E-06	1.9E-04	
Liner Placement	6	100	600	1.6E-06	1	1.6E-06	9.3E-04	
Cover Soil Placement/Grading	6	500	3,000	1.6E-06	1	1.6E-06	4.7E-03	
Restoration/Revegetation/Fencing	2	140	280	2.6E-06	1	2.6E-06	7.3E-04	
Maintenance and Monitoring	1.9	484	920	4.0E-07	1	4.0E-07	3.7E-04	
TOTAL (Sum of column)			**6,540**				1.1E-02	**Medium**
Probability of Serious Injury							**0.02%**	

[1] See Appendix L for estimated crew size and task duration.

Table M-4

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Protected Worker Scenario
Clarifier Materials

Enhanced RCRA Cap

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D	E = (D X E)	F	G	H = (F + G)	I = (E X H)	
Site Preparation	1	3	20	60	1.6E-06	2.6E-07	1.8E-06	1.1E-04	
Subgrade Placement	2	6.5	88	572	1.6E-06	2.6E-07	1.8E-06	1.0E-03	
Surcharge Placement/Removal	1	6	80	480	1.6E-06	2.6E-07	1.8E-06	8.7E-04	
Consolidation Monitoring	1	2	20	40	1.6E-06	2.6E-07	1.8E-06	7.2E-05	
Gas Collection System Installation	2	4.5	22	99	1.6E-06	2.6E-07	1.8E-06	1.8E-04	
Subgrade Placement	1	12	40	480	1.6E-06	2.6E-07	1.8E-06	8.7E-04	
Subgrade Regrading	1	2	60	120	1.6E-06	2.6E-07	1.8E-06	2.2E-04	
Liner Placement	1	6	100	600	1.6E-06	2.6E-07	1.8E-06	1.1E-03	
Cover Soil Placement/Grading	1	6	500	3,000	1.6E-06	2.6E-07	1.8E-06	5.4E-03	
Restoration/Revegetation/Fencing	1	2	140	280	2.6E-06	2.6E-07	2.9E-06	8.0E-04	
Maintenance and Monitoring	1	1.9	484	920	4.0E-07	2.6E-07	6.6E-07	6.1E-04	
TOTAL (Sum of column)				**6,651**				**1.1E-02**	**Medium**
Probability of Serious Injury								**0.02%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

Table M-5

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Baseline Worker Scenario
Clarifier Materials

On-site Phosphorus Recovery (Mud Still)

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	
Removal Operations								
Site Preparation	3	20	60	4.7E-08	1	4.7E-08	2.8E-06	
Mud Still Preparation								
Construct/Test Feed System	16	500	8,000	4.7E-08	1	4.7E-08	3.8E-04	
Construct/Test Mud Still	16	2,000	32,000	4.7E-08	1	4.7E-08	1.5E-03	
Construct/Test Offgas System	16	1,000	16,000	4.7E-08	1	4.7E-08	7.5E-04	
Test Burn	8	24	192	4.7E-08	1	4.7E-08	9.0E-06	
Mud Still Operations (24 hr/day; 7 days/wk; 5 batches/wk; 71% Onstream time)								
Transfer Operations (Clarifier to Skip)	6	4,760	28,560	7.0E-09	10	7.0E-08	2.0E-03	
Water Cap Control/Maintenance	1	595	595	7.0E-09	1	7.0E-09	4.1E-06	
Open Skip and Remove Residue	6	2,380	14,280	7.0E-09	1	7.0E-09	9.9E-05	
Transfer P4 product to ISO containers	6	2,380	14,280	7.0E-09	1	7.0E-09	9.9E-05	
System Maintenance	6	3,600	21,600	7.0E-09	1	7.0E-09	1.5E-04	
Transport (via truck) to P4 facility [2]	1	1,120	1,120	1.3E-07	1	1.3E-07	1.4E-04	
Transport (Truck returns to site) [2]	1	1,120	1,120	1.3E-07	1	1.3E-07	1.4E-04	
Transfer P4 product to P4 facility tanks	3	76	228	7.0E-09	1	7.0E-09	1.6E-06	
P4 use at P4 facility	3	76	228	7.0E-09	1	7.0E-09	1.6E-06	
Closure Operations								
Decontaminate & Decommission Facilities	9	320	2,880	7.0E-09	10	7.0E-08	2.0E-04	
Place Residue in Clarifier	3	16	48	7.0E-09	1	7.0E-09	3.3E-07	
Backfill/ Compaction	6	40	240	7.0E-09	1	7.0E-09	1.7E-06	
Evapotranspiration Cap (see Table M-13)	--	--	2,620	--	--	--	1.4E-04	
Maintenance & Monitoring	1.9	484	920	5.9E-09	1	5.9E-09	5.4E-06	
TOTAL (Sum of column)			**144,970**				**5.6E-03**	**Medium**
Probability of Worker Fatality							**0.005%**	

[1] See Appendix L for estimated crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-6

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Protected Worker Scenario
Clarifier Materials

On-site Phosphorus Recovery (Mud Still)

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D	E = (C X D)	F	G	H = (F + G)	I = (E X H)	
Removal Operations									
Site Preparation	1	3	20	60	4.7E-08	1.6E-09	4.9E-08	2.9E-06	
Mud Still Preparation									
Construct/Test Feed System	1	17	500	8,500	4.7E-08	1.6E-09	4.9E-08	4.1E-04	
Construct/Test Mud Still	1	17	2,000	34,000	4.7E-08	1.6E-09	4.9E-08	1.6E-03	
Construct/Test Offgas System	1	17	1,000	17,000	4.7E-08	1.6E-09	4.9E-08	8.2E-04	
Test Burn	1	9	24	216	4.7E-08	1.6E-09	4.9E-08	1.0E-05	
Mud Still Operations (24 hr/day; 7 days/wk; 5 batches/wk; 71% Onstream time)									
Transfer Operations (Clarifier to Skip)	3	7	6,664	46,648	7.0E-09	1.6E-09	8.6E-09	4.0E-04	
Water Cap Control/Maintenance	2	1.5	655	982	7.0E-09	1.6E-09	8.6E-09	8.4E-06	
Open Skip and Remove Residue	3	7	3,332	23,324	7.0E-09	1.6E-09	8.6E-09	2.0E-04	
Transfer P4 product	3	7	3,332	23,324	7.0E-09	1.6E-09	8.6E-09	2.0E-04	
System Maintenance	1	6	3,600	21,600	7.0E-09	1.6E-09	8.6E-09	1.8E-04	
Transport (via truck) to P4 facility [2]	1	1	1,120	1,120	1.3E-07	--	1.3E-07	1.4E-04	
Transport (Truck returns to site) [2]	1	1	1,120	1,120	1.3E-07	--	1.3E-07	1.4E-04	
Transfer P4 product to P4 facility tanks	3	4	76	304	7.0E-09	1.6E-09	8.6E-09	2.6E-06	
P4 use at P4 facility	3	4	76	304	7.0E-09	1.6E-09	8.6E-09	2.6E-06	
Closure Operations									
Decontaminate & Decommission Facilities	3	10	448	4,480	7.0E-09	1.6E-09	8.6E-09	3.8E-05	
Place Residue in Clarifier	1	4	22	90	7.0E-09	1.6E-09	8.6E-09	7.7E-07	
Backfill/ Compaction	1	6	40	240	7.0E-09	1.6E-09	8.6E-09	2.1E-06	
Evapotranspiration Cap (see Table M-14)	--	0	0	2,731	--	--	--	9.6E-05	
Maintenance & Monitoring	1	1.9	484	920	5.9E-09	--	5.9E-09	5.4E-06	
TOTAL (Sum of column)				**186,962**				**4.3E-03**	**Medium**
Probability of Worker Fatality								**0.003%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-7

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Baseline Worker Scenario
Clarifier Materials

On-site Phosphorus Recovery (Mud Still)

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	
Removal Operations								
Site Preparation	3	20	60	1.6E-06	1	1.6E-06	9.3E-05	
Mud Still Preparation								
Construct/Test Feed System	16	500	8,000	1.6E-06	1	1.6E-06	1.2E-02	
Contruct/Test Mud Still	16	2,000	32,000	1.6E-06	1	1.6E-06	5.0E-02	
Construct/Test Offgas System	16	1,000	16,000	1.6E-06	1	1.6E-06	2.5E-02	
Test Burn	8	24	192	1.6E-06	1	1.6E-06	3.0E-04	
Mud Still Operations (24 hr/day; 7 days/wk; 5 batches/wk; 71% Onstream time)								
Excavate CP and Load Skips	6	4,760	28,560	7.0E-07	10	7.0E-06	2.0E-01	
Water Cap Control/Maintenance	1	595	595	7.0E-07	1	7.0E-07	4.2E-04	
Open Skip and Remove Residue	6	2,380	14,280	7.0E-07	1	7.0E-07	1.0E-02	
Transfer P4 product to ISO containers	6	2,380	14,280	7.0E-07	1	7.0E-07	1.0E-02	
System Maintenance	6	3,600	21,600	7.0E-07	1	7.0E-07	1.5E-02	
Transport (via truck) to P4 facility [2]	1	1,120	1,120	3.8E-06	1	3.8E-06	4.2E-03	
Transport (Truck returns to site) [2]	1	1,120	1,120	3.8E-06	1	3.8E-06	4.2E-03	
Transfer P4 product to P4 facility tanks	3	76	228	7.0E-07	1	7.0E-07	1.6E-04	
P4 use at P4 facility	3	76	228	7.0E-07	1	7.0E-07	1.6E-04	
Closure Operations								
Decontaminate & Decommission Facilities	9	320	2,880	1.6E-06	10	1.6E-05	4.5E-02	
Place Residue in Clarifier	3	16	48	1.6E-06	1	1.6E-06	7.4E-05	
Backfill/ Compaction	6	40	240	1.6E-06	1	1.6E-06	3.7E-04	
Evapotranspiration Cap (see Table M-15)	--	--	2,620	--	--	--	4.8E-03	
Maintenance & Monitoring	1.9	484	920	4.0E-07	1	4.0E-07	3.7E-04	
TOTAL (Sum of column)			**144,970**				**3.8E-01**	**High**
Probability of Serious Injury							**0.34%**	

[1] See Appendix L for estimated crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-8

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Protected Worker Scenario
Clarifier Materials

On-site Phosphorus Recovery (Mud Still)

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D	E = (D X E)	F	G	H = (F + G)	I = (E X H)	
Removal Operations									
Site Preparation	1	3	20	60	1.6E-06	2.6E-07	1.8E-06	1.1E-04	
Mud Still Preparation									
Construct/Test Feed System	1	17	500	8,500	1.6E-06	2.6E-07	1.8E-06	1.5E-02	
Contruct/Test Mud Still	1	17	2,000	34,000	1.6E-06	2.6E-07	1.8E-06	6.2E-02	
Construct/Test Offgas System	1	17	1,000	17,000	1.6E-06	2.6E-07	1.8E-06	3.1E-02	
Test Burn	1	9	24	216	1.6E-06	2.6E-07	1.8E-06	3.9E-04	
Mud Still Operations (24 hr/day; 7 days/wk; 5 batches/wk; 71% Onstream time)									
Excavate CP and Load Skips	3	7	6,664	46,648	7.0E-07	2.6E-07	9.6E-07	4.5E-02	
Water Cap Control/Maintenance	2	1.5	655	982	7.0E-07	2.6E-07	9.6E-07	9.4E-04	
Open Skip and Remove Residue	3	7	3,332	23,324	7.0E-07	2.6E-07	9.6E-07	2.2E-02	
Transfer P4 product to ISO containers	3	7	3,332	23,324	7.0E-07	2.6E-07	9.6E-07	2.2E-02	
System Maintenance	1	6	3,600	21,600	7.0E-07	2.6E-07	9.6E-07	2.1E-02	
Transport (via truck) to P4 facility *	1	1	1,120	1,120	3.8E-06	--	3.8E-06	4.2E-03	
Transport (Truck returns to site) *	1	1	1,120	1,120	3.8E-06	--	3.8E-06	4.2E-03	
Transfer P4 product to P4 facility tanks	3	4	76	304	7.0E-07	2.6E-07	9.6E-07	2.9E-04	
P4 use at P4 facility	3	4	76	304	7.0E-07	2.6E-07	9.6E-07	2.9E-04	
Closure Operations									
Decontaminate & Decommission Facilities	3	10	448	4,480	1.6E-06	2.6E-07	1.8E-06	8.1E-03	
Package removable materials in drums	1	4	22	90	1.6E-06	2.6E-07	1.8E-06	1.6E-04	
Backfill/ Compaction	1	6	40	240	1.6E-06	2.6E-07	1.8E-06	4.3E-04	
Evapotranspiration Cap (see Table M-16)	--	--	--	2730.6	--	--	--	3.7E-03	
Maintenance & Monitoring	1	1.9	484	920	4.0E-07	--	4.0E-07	3.7E-04	
TOTAL (Sum of column)				**186,962**				**2.4E-01**	**High**
Probability of Serious Injury								**0.2%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5×10^{-9} / mile (assuming 50 mi/hr)

Table M-9

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Baseline Worker Scenario
Clarifier Materials

Off-site Incineration

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	
Removal Operations								
Site Preparation	3	20	60	4.7E-08	1	4.7E-08	2.8E-06	
Water Cap Control/Maintenance	1	360	360	7.0E-09	1	7.0E-09	2.5E-06	
Removal Operations (Clarifier to Drums)	8	5750	46,000	7.0E-09	10	7.0E-08	3.2E-03	
Drum Transfer to Storage	3	720	2,160	7.0E-09	1	7.0E-09	1.5E-05	
Drum Inspection and pH adjustment	1	11680	11,680	7.0E-09	1	7.0E-09	8.1E-05	
Transportation Operations								
Drum Transfer (Storage to Truck)	2	288	576	7.0E-09	1	7.0E-09	4.0E-06	
Transport (via truck) to TSD facility [2]	1	4320	4,320	1.3E-07	1	1.3E-07	5.4E-04	
Transport (Truck returns to site) [2]	1	4320	4,320	1.3E-07	1	1.3E-07	5.4E-04	
Incineration Operations								
Receive/unload truck at TSD facility	2	288	576	5.4E-08	1	5.4E-08	3.1E-05	
Transfer to Incinerator Unit	1	2920	2,920	5.4E-08	10	5.4E-07	1.6E-03	
Stabilize ash and waste residue from air cleaning system for final landfill disposal	2	1600	3,200	5.4E-08	1	5.4E-08	1.7E-04	
Closure Operations								
Backfill/ Compaction	6	40	240	4.7E-08	1	4.7E-08	1.1E-05	
Evapotranspiration Cap (see Table M-13)	--	--	2,620	--	--	--	1.4E-04	
Maintenance and Monitoring	1.9	484	920	5.9E-09	1	5.9E-09	5.4E-06	
TOTAL (Sum of column)			**79,951**				**6.3E-03**	**Medium**
Probability of Worker Fatality							**0.02%**	

[1] See Appendix L for estimated crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-10

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Protected Worker Scenario
Clarifier Materials

Off-site Incineration

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	**B**	**C**	**D**	**E = (C X D)**	**F**	**G**	**H = (F + G)**	**I = (E X H)**	
Removal Operations									
Site Preparation	1	3	20	60	4.7E-08	1.6E-09	4.9E-08	2.9E-06	
Water Cap Control/Maintenance	2	1.5	396	594	7.0E-09	1.6E-09	8.6E-09	5.1E-06	
Removal Operations (Clarifier to Drums)	1	9	8,050	72,450	7.0E-09	1.6E-09	8.6E-09	6.2E-04	
Drum Transfer to Storage	3	4	1,008	4,032	7.0E-09	1.6E-09	8.6E-09	3.4E-05	
Drum Inspection and pH adjustment	1	1	11,680	11,680	7.0E-09	1.6E-09	8.6E-09	1.0E-04	
Transportation Operations									
Drum Transfer (Storage to Truck)	1	2	288	576	7.0E-09	1.6E-09	8.6E-09	4.9E-06	
Transport (via truck) to TSD facility [2]	1	1	4,320	4,320	1.3E-07	--	1.3E-07	5.4E-04	
Transport (Truck returns to site) [2]	1	1	4,320	4,320	1.3E-07	--	1.3E-07	5.4E-04	
Incineration Operations									
Receive/unload truck at TSD facility	1	3	403	1,210	5.4E-08	1.6E-09	5.5E-08	6.7E-05	
Transfer to Incinerator Unit	3	2	4,088	8,176	5.4E-08	1.6E-09	5.5E-08	4.5E-04	
Stabilize ash and waste residue from air cleaning system for final landfill disposal	1	2	1,600	3,200	5.4E-08	1.6E-09	5.5E-08	1.8E-04	
Closure Operations									
Backfill/ Compaction	1	6	40	240	4.7E-08	1.6E-09	4.9E-08	1.2E-05	
Evapotranspiration Cap (see Table M-14)	1	1	1	2,731	--	--	--	9.6E-05	
Maintenance and Monitoring	1	1.9	484	920	5.9E-09	--	5.9E-09	5.4E-06	
TOTAL (Sum of column)				**114,508**				**2.7E-03**	**Medium**
Probability of Worker Fatality								**0.007%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-11

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Baseline Worker Scenario
Clarifier Materials

Off-site Incineration

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	
Removal Operations								
Site Preparation	3	20	60	1.6E-06	1	1.6E-06	9.3E-05	
Water Cap Control/Maintenance	1	360	360	7.0E-07	1	7.0E-07	2.5E-04	
Removal Operations (Clarifier to Drum)	8	5750	46,000	7.0E-07	10	7.0E-06	3.2E-01	
Drum Transfer to Storage	3	720	2,160	7.0E-07	1	7.0E-07	1.5E-03	
Drum Inspection & pH adjustment	1	11680	11,680	7.0E-07	1	7.0E-07	8.2E-03	
Transportation Operations								
Drum Transfer (Storage to Truck)	2	288	576	7.0E-07	1	7.0E-07	4.0E-04	
Transport (via truck) to TSD facility [2]	1	4320	4,320	3.8E-06	1	3.8E-06	1.6E-02	
Transport (Truck returns to site) [2]	1	4320	4,320	3.8E-06	1	3.8E-06	1.6E-02	
Incineration Operations								
Receive/unload truck at TSD facility	2	288	576	8.0E-07	1	8.0E-07	4.6E-04	
Transfer to Incinerator Unit	1	2920	2,920	8.0E-07	10	8.0E-06	2.3E-02	
Stabilize ash and waste residue from air cleaning system for final landfill disposal	2	1600	3,200	8.0E-07	1	8.0E-07	2.6E-03	
Closure Operations								
Backfill/ Compaction	6	40	240	1.6E-06	1	1.6E-06	3.7E-04	
Evapotranspiration Cap (see Table M-15)	--	--	2,620	--	--	--	4.8E-03	
Maintenance and Monitoring	1.9	484	920	4.0E-07	1	4.0E-07	3.7E-04	
TOTAL (Sum of column)			**79,951**				**4.0E-01**	**High**
Probability of Serious Injury							**1.2%**	

[1] See Appendix L for estimated crew size and task duration.

[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-12

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Protected Worker Scenario
Clarifier Materials

Off-site Incineration

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D	E = (D X E)	F	G	H = (F + G)	I = (E X H)	
Removal Operations									
Site Preparation	1	3	20	60	1.6E-06	2.6E-07	1.8E-06	1.1E-04	
Water Cap Control/Maintenance	2	1.5	396	594	7.0E-07	2.6E-07	9.6E-07	5.7E-04	
Removal Operations (Clarifier to Drum)	1	9	8,050	72,450	7.0E-07	2.6E-07	9.6E-07	7.0E-02	
Drum Transfer to Storage	3	4	1,008	4,032	7.0E-07	2.6E-07	9.6E-07	3.9E-03	
Drum Inspection and pH adjustment	1	1	11,680	11,680	7.0E-07	2.6E-07	9.6E-07	1.1E-02	
Transportation Operations									
Drum Transfer (Storage to Truck)	1	2	288	576	7.0E-07	2.6E-07	9.6E-07	5.5E-04	
Transport (via truck) to TSD facility [2]	1	1	4,320	4,320	3.8E-06	--	3.8E-06	1.6E-02	
Transport (Truck returns to site) [2]	1	1	4,320	4,320	3.8E-06	--	3.8E-06	1.6E-02	
Incineration Operations									
Receive/unload truck at TSD facility	1	3	403	1,210	8.0E-07	2.6E-07	1.1E-06	1.3E-03	
Transfer to Incinerator Unit	3	2	4,088	8,176	8.0E-07	2.6E-07	1.1E-06	8.7E-03	
Stabilize ash and waste residue from air cleaning system for final landfill disposal	1	2	1,600	3,200	8.0E-07	2.6E-07	1.1E-06	3.4E-03	
Closure Operations									
Backfill/ Compaction	1	6	40	240	1.6E-06	2.6E-07	1.8E-06	4.3E-04	
Evapotranspiration Cap (see Table M-16)	--	--	--	2,731	--	--	--	3.7E-03	
Maintenance and Monitoring	1	1.9	484	920	4.0E-07	--	4.0E-07	3.7E-04	
TOTAL (Sum of column)				**114,508**				**1.4E-01**	**High**
Probability of Serious Injury								**0.4%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.
[2] Truck transport fatality risk calculated from risk/mile rate of 2.5 x 10^{-9} / mile (assuming 50 mi/hr)

Table M-13

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Baseline Worker Scenario
Clarifier Materials

Evapotranspiration Cap

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	(Total Risk)
Site Preparation	3	20	60	4.7E-08	1	4.7E-08	2.8E-06	
Subgrade Placement	6	80	480	4.7E-08	3	1.4E-07	6.8E-05	
Surcharge Placement/Removal	6	40	240	4.7E-08	1	4.7E-08	1.1E-05	
Consolidation Monitoring	2	20	40	4.7E-08	1	4.7E-08	1.9E-06	
Gas Collection System Installation	4	20	80	4.7E-08	3	1.4E-07	1.1E-05	
Subgrade Regrading	2	20	40	4.7E-08	1	4.7E-08	1.9E-06	
Cover Soil Placement/Grading	6	120	720	4.7E-08	1	4.7E-08	3.4E-05	
Restoration/Revegetation	2	20	40	1.1E-07	1	1.1E-07	4.4E-06	
Maintenance & Monitoring	1.9	484	920	5.9E-09	1	5.9E-09	5.4E-06	
TOTAL (Sum of column)			**2,620**				**1.4E-04**	**Low**
Probability of Worker Fatality							**0.0004%**	

[1] See Appendix L for estimated crew size and task duration.

Table M-14

Short term Worker Risk Scenarios and Estimated Probability of Fatality
Protected Worker Scenario
Clarifier Materials

Evapotranspiration Cap

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	**B**	**C**	**D**	**E = (C X D)**	**F**	**G**	**H = (F + G)**	**I = (E X H)**	
Site Preparation	1	3	20	60	4.7E-08	1.60E-09	4.85E-08	2.91E-06	
Subgrade Placement	2	6.5	88	572	4.7E-08	1.60E-09	4.85E-08	2.77E-05	
Surcharge Placement/Removal	1	6	40	240	4.7E-08	1.60E-09	4.85E-08	1.16E-05	
Consolidation Monitoring	1	2	20	40	4.7E-08	1.60E-09	4.85E-08	1.94E-06	
Gas Collection System Installation	2	4.5	22	99	4.7E-08	1.60E-09	4.85E-08	4.80E-06	
Subgrade Regrading	1	2	20	40	4.7E-08	1.60E-09	4.85E-08	1.94E-06	
Cover Soil Placement/Grading	1	6	120	720	4.7E-08	1.60E-09	4.85E-08	3.49E-05	
Restoration/Revegetation	1	2	20	40	1.1E-07	1.60E-09	1.12E-07	4.49E-06	
Maintenance and Monitoring	1	1.9	484	920	5.9E-09	--	5.90E-09	5.43E-06	
TOTAL (Sum of column)				**2,731**				**9.6E-05**	**Very Low**
Probability of Worker Fatality								**0.0003%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

Table M-15

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Baseline Worker Scenario
Clarifier Materials

Evapotranspiration Cap

Risk - Contributing Exposure	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Risk Factor	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D = (B X C)	E	F	G = (E X F)	H = (D X G)	
Site Preparation	3	20	60	1.6E-06	1	1.6E-06	9.30E-05	
Subgrade Placement	6	80	480	1.6E-06	3	4.7E-06	2.23E-03	
Surcharge Placement/Removal	6	40	240	1.6E-06	1	1.6E-06	3.72E-04	
Consolidation Monitoring	2	20	40	1.6E-06	1	1.6E-06	6.20E-05	
Gas Collection System Installation	4	20	80	1.6E-06	3	4.7E-06	3.72E-04	
Subgrade Regrading	2	20	40	1.6E-06	1	1.6E-06	6.20E-05	
Cover Soil Placement/Grading	6	120	720	1.6E-06	1	1.6E-06	1.12E-03	
Restoration/Revegetation	2	20	40	2.6E-06	1	2.6E-06	1.04E-04	
Maintenance and Monitoring	1.9	484	920	4.0E-07	1	4.0E-07	3.68E-04	
TOTAL (Sum of Column)			**2,620**				**4.8E-03**	
Probability of Serious Injury							**0.01%**	

[1] See Appendix L for estimated crew size and task duration.

Table M-16

Short term Worker Risk Scenarios and Estimated Probability of Serious Injury
Protected Worker Scenario
Clarifier Materials

Evapotranspiration Cap (Options 2 & 3)

Risk - Contributing Exposure	Assumed Level of Protection[1]	Crew Size[1] (persons)	Task Duration[1] (hours)	Duration of Exposure to risk (person-hrs)	Baseline Risk Rate (risk/hr)	Heat Stress Risk Rate (risk/hr)	Estimated Risk Rate (risk/hr)	Risk Product Due to Element (risk)	Qualitative (Total Risk)
A	B	C	D	E = (D X E)	F	G	H = (F + G)	I = (E X H)	
Site Preparation	1	3	20	60	1.6E-06	2.6E-07	1.8E-06	1.1E-04	
Subgrade Placement	2	6.5	88	572	1.6E-06	2.6E-07	1.8E-06	1.0E-03	
Surcharge Placement/Removal	1	6	40	240	1.6E-06	2.6E-07	1.8E-06	4.3E-04	
Consolidation Monitoring	1	2	20	40	1.6E-06	2.6E-07	1.8E-06	7.2E-05	
Gas Collection System Installation	2	4.5	22	99	1.6E-06	2.6E-07	1.8E-06	1.8E-04	
Subgrade Regrading	1	2	20	40	1.6E-06	2.6E-07	1.8E-06	7.2E-05	
Cover Soil Placement/Grading	1	6	120	720	1.6E-06	2.6E-07	1.8E-06	1.3E-03	
Restoration/Revegetation	1	2	20	40	2.6E-06	2.6E-07	2.9E-06	1.1E-04	
Maintenance and Monitoring	1	1.9	484	920	4.0E-07	--	4.0E-07	3.7E-04	
TOTAL (Sum of column)				**2,731**				**3.7E-03**	
Probability of Serious Injury								**0.01%**	

[1] See Appendix L for assumed level of protection, crew size and task duration.

Appendix N

Cost Estimates for Retained Alternatives

"Representative" Cost Estimate Summary
Supplemental Waste Plan - Clarifier
Silver Bow Plant

	Closure						Post-closure Financial Assurance	
Alternatives	Estimated Capital Cost	Contingency	Estimated Engineering/ Administration	30 Years Present Worth OMR[4]	Total Estimated Relative Cost	Cost of Financial Assurance	30 Years Post-Closure Cost (no discount)	100 Years Post-Closure Cost (no discount)
Enhanced RCRA Cap[1]	$2,400,000	$480,000	$640,000	$1,500,000	$5,000,000	$430,000	$1,500,000	$3,500,000
Off-site Incineration[2]	$36,000,000	$7,800,000	$3,800,000	$1,500,000	$49,000,000	$5,300,000	$1,500,000	$3,500,000

Alternative	Estimated Mud Still Capital, Contingency & Engineering/ Administration Cost	Estimated Evapotranspiration Cap Cost	30 Years Present Worth OMR	Total Estimated Relative Cost	Cost of Financial Assurance	30 Years Post-Closure (no discount) Cost	100 Years Post-Closure (no discount) Cost
Mud Still [3]	$21,000,000	$1,000,000	$1,500,000	$24,000,000	$1,400,000	$1,500,000	$3,500,000

Cost Estimate Details

1 - Estimated costs from 2003 Astaris Cap proposal, multiplied by CCI index (see Appendix E for cost estimate methodology)

2 - Estimated capital, contingency, and engineering/admin costs from original waste plan, multiplied by CCI index (see Appendix E for cost estimate methodology).

3 - Estimated capital construction, contingency, engineering, administration and operation costs provided by Solvay. Estimated evapotranspiration cap costs from original waste plan, adjusted for size, multiplied by CCI index (see Appendix E for cost estimate methodology).

4 - OMR and post-closure costs assumed to be the same for each alternative (costs based on 2003 Astaris Cap proposal; see Appendix E for cost estimate methodology).

DRAFT

Enhanced RCRA Cap
Representative Cost Estimate
Silver Bow Plant

ENHANCED RCRA CAP

ITEM	2003 ORIGINAL ESTIMATED QUANTITY	UNIT	UNIT COST [1]	ITEM TOTAL COST 2003	ITEM ADJUSTED FOR INFLATION 2013	
SOIL SAMPLING						
Sampling and Analysis	24	SAMPLE	$2,500	$60,000	$85,400	*
Reporting	1	LS	$15,000	$15,000	$21,300	*
				2003 Cost	2013 Cost	
SUBTOTAL SOIL SAMPLING				$75,000	$106,700	
GENERAL REQUIREMENTS						
Mobilization/Demob./Submittals	1	LS	$155,000	$155,000	$220,500	*
Health & Safety	1	LS	$50,000	$50,000	$71,100	*
Equipment and Personnel Decon. Facilities	7	MO	$10,000	$70,000	$99,600	*
Sitework						
Clear and Grade	5	ACRE	$2,000	$10,000	$14,200	*
Fence Removal	800	LF	$2	$1,600	$2,300	*
SUBTOTAL GENERAL REQUIREMENTS				$286,600	$407,700	
CAP CONSTRUCTION						
Geofabric Filter	15,000	SF	$1.50	$22,500	$32,000	*
Sand (Granulated Slag) Subgrade	1,500	CY	$6	$9,000	$12,800	*
Geoweb	30,000	SF	$1.00	$30,000	$42,700	*
Gas Collection System	1	LS	$4,000	$4,000	$5,700	*
Gas Treatment System	1	LS	$4,500	$4,500	$6,400	*
Placement and Grading - Coarse & Granulated Slag	14,800	CY	$3	$44,400	$63,200	*
Sand (Granulated Slag) Surcharge	15,000	CY	$5	$75,000	$106,700	*
Sand (Granulated Slag)	1,900	CY	$3	$5,700	$8,100	*
Sand Filter - Rounded to Subrounded	1,900	CY	$20	$38,000	$54,100	*
Geosynthetic Clay Liner (GCL)	100,000	SF	$2	$200,000	$284,500	*
HDPE - 60 mil	100,000	SF	$1.60	$160,000	$227,600	*
Drainage Layer - Geonet	100,000	SF	$1.00	$100,000	$142,300	*
Geofabric Filter	100,000	SF	$0.50	$50,000	$71,100	*
Sand Filter - Rounded to Subrounded	3,700	CY	$20	$74,000	$105,300	*
Sand (Granulated Slag)	6,700	CY	$3	$20,100	$28,600	*
Biotic Protection Layer - Coarse Slag	16,700	CY	$6	$100,200	$142,600	*
Sand (Granulated Slag)	6,700	CY	$3	$20,100	$28,600	*
Geofabric Filter	180,000	SF	$0.50	$90,000	$128,000	*
Topsoil	16,700	CY	$8	$133,600	$190,100	*
Pea Gravel for Topsoil Mixing	1,000	CY	$20	$20,000	$28,500	*
Topsoil for Pea Gravel	5,700	CY	$12	$68,400	$97,300	*
				2003 Cost	2013 Cost	
SUBTOTAL CAP CONSTRUCTION				$1,269,500	$1,806,200	
SITE RESTORATION						
Site Restoration/Revegetation	10	ACRE	$5,000	$50,000	$71,100	
Install Perimeter Fence	1,900	LF	$12	$22,800	$32,400	
				2003 Cost	2013 Cost	
SUBTOTAL SITE RESTORATION				$72,800	$103,500	
ESTIMATED TOTAL FIELD COST				$1,703,900	$2,424,100	
Contingency (20%) [2]				$340,780	$484,820	
Engineering/Administration	9	MO	$50,000	$450,000	$640,200	
			Year	2003 Cost	2013 Cost	
ESTIMATED TOTAL CONSTRUCTION COST				$2,494,700	**$3,550,000**	

NOTES:

[1] Unit cost includes labor, materials, equipment, overhead, and profit.

[2] Calculated as Contingency Multiplier times Estimated Total Field Cost.

Mud Still
Representative Cost Estimate
Silver Bow Plant

MUD STILL

ITEM	MATERIAL	LABOR	TOTAL
MUD STILL CONSTRUCTION (MATERIAL AND LABOR)			
Primary Equipment	$2,858,000	$574,400	$3,432,400
Piping	$458,500	$851,500	$1,310,000
Instrumentation	$792,180	$674,820	$1,467,000
Electrical	$507,750	$1,015,500	$1,523,250
Site Development	$65,000	$325,000	$390,000
Fire Protection	$20,000	$200,000	$220,000
Concrete	$66,600	$321,900	$388,500
Structural Steel	$200,100	$147,900	$348,000
Buildings	$162,000	$243,000	$405,000
Insulation	$235,000	$141,000	$376,000
Painting	$53,000	$79,500	$132,500
Demolition	$28,500	$190,000	$218,500
Indirect Costs (Engineering, Supervision)	$0	$2,518,682	$2,518,682
SUBTOTAL MUD STILL CONSTRUCTION (MATERIAL AND LABOR)	$5,446,630	$7,283,202	$12,729,832

	ESTIMATED QUANTITY	UNIT	UNIT COST [1]	ITEM TOTAL COST
MUD STILL OPERATIONS				
Consumables	5,674,232	lb. crude P4	$0.40	$2,269,693
Electric	5,674,232	lb. crude P4	$0.11	$612,817
Labor	5,674,232	lb. crude P4	$0.91	$5,140,708
Residue Disposal	5,674,232	lb. crude P4	$0.25	$422,497
SUBTOTAL MUD STILL OPERATIONS				$8,445,714

	ESTIMATED QUANTITY	UNIT	UNIT COST [1]	ITEM TOTAL COST
P4 PRODUCT VALUE				
P4 Product Value	1,418,558	lb. P4 Product	$1.70	$2,411,549
SUBTOTAL MUD STILL COSTS				**$21,200,000**

EVAPOTRANSPIRATION CAP

ITEM	2003 ESTIMATED ORIGINAL QUANTITY	CAP SIZE QUANTITY (FOR 2013)	UNIT	UNIT DIRECT COST [1]	ITEM TOTAL COST 2003	ITEM ADJUSTED FOR CAP SIZE + INFLATION 2013
SOIL SAMPLING						
Sampling and Analysis	24	36	SAMPLE	$2,500	$60,000	$128,000
Reporting	1	1	LS	$15,000	$15,000	$21,300
SUBTOTAL SOIL SAMPLING					$75,000	$149,300
GENERAL REQUIREMENTS						
Mobilization/Demob./Submittals	1	1	LS	$20,280	$20,280	$28,900
Health & Safety	1	1	LS	$40,000	$40,000	$56,900
Equipment and Personnel Decon. Facilities	4	4	MO	$10,000	$40,000	$56,900
Sitework						
Clear and Grade	1	1	ACRE	$2,000	$2,000	$2,800
Fence Removal	800	800	LF	$2	$1,600	$2,300
SUBTOTAL GENERAL REQUIREMENTS					$103,880	$147,800
CAP CONSTRUCTION						
Demolition	1	1	LS	$10,000	$10,000	$14,200
Geotextile	20,000	20,000	SF	$1.50	$30,000	$42,700
Granular Slag Fill	3,000	3,000	CY	$3	$9,000	$12,800
Sand/Granular Slag Subgrade	700	3,200	CY	$3	$2,100	$13,700
Borrow Soil - Clay	2,200	1,600	CY	$7	$15,400	$15,900
Topsoil	700	500	CY	$8	$5,600	$5,700
SUBTOTAL CAP CONSTRUCTION					$72,100	$105,000
SITE RESTORATION						
Site Restoration/Revegetation	5	10	ACRE	$5,000	$25,000	$71,100
Install Perimeter Fence	1,600	800	LF	$8	$12,800	$9,100
SUBTOTAL SITE RESTORATION					$37,800	$80,200
ESTIMATED TOTAL FIELD COST					$288,780	$482,300
Contingency (20%) [2]					$57,756	$96,460
Engineering/Administration	5	6	MO	$50,000	$250,000	$426,800
SUBTOTAL CAP COSTS					**$600,000**	**$1,010,000**

TOTAL ESTIMATED COST (MUD STILL + CAP)	**$22,210,000**

Estimated Mud Still Construction Costs (Equipment and Labor)

Prepared by Solvay

10' Dia Skip-Scrubber Building option

REV. 4 1/14/2012

Description	Cost Each	Qty	Usual factor Fraction of Equipment Material	Labor	Total
Direct Costs					
Equipmen 2118000	20		2,118,000	706,000	2,824,000
Skip Bottom vessels (10' D x 2.5'H)	25,000	6	150,000	1,000	151,000
Skip Top (weather cover) 10' D x1')	10,000	6	60,000	1,000	61,000
Still (Oven) with top	750,000	1	750,000	225,000	975,000
Condensor SS, 39" D X 18' H	70,000	1	70,000	21,000	91,000
SS Sump Tank w/jacket heater	21,000	1	21,000	6,300	27,300
Recirc. Pump	10,000	2	20,000	6,000	26,000
Sump Level Buffer Tank	12,000	1	12,000	3,600	15,600
Waste Water collection tank	10,000	1	10,000	3,000	13,000
Sump Transfer Pump	10,000	1	10,000	3,000	13,000
Hot water Distrib.Pump	10,000	1	10,000	3,000	13,000
Recirc. Air cooler	50,000	1	50,000	15,000	65,000
P4 Collection tank, CS 6K gal	60,000	1	60,000	18,000	78,000
Truck scale (w/output to control system)	60,000	1	60,000	18,000	78,000
ISO access platform	30,000	1	30,000	9,000	39,000
Vapor Combustor	150,000	1	150,000	45,000	195,000
Scrubber- 4,000 cfm, FRP	60,000	1	60,000	18,000	78,000
Scrubber Recirc Pump	10,000	2	20,000	6,000	26,000
Scrubber Fan	15,000	1	15,000	4,500	19,500
Bridge Crane (15 Ton)	100,000	1	100,000	30,000	130,000
Evaporator pond (dam and line)	200,000	1	200,000		200,000
Waste water transfer pump	10,000	1	10,000	3,000	13,000
N2 TK (rented cryo/vaporizer) 120K scf	25,000	1	25,000	7,500	32,500
Hot water heater system	250,000	1	250,000	75,000	325,000
Hot Water Tank	8,000	1	8,000	2,400	10,400
Hot water recirc pump	6,000	2	12,000	3,600	15,600
Water conditioning/softener	25,000	1	25,000	7,500	32,500
Caustic tank-SS 300 gal	8,000	1	8,000	2,400	10,400
Caustic pump	10,000	1	10,000	3,000	13,000
Spill pan	10,000	1	10,000	3,000	13,000
Phossy Water Buffer tank-850gal	7,000	1	7,000	2,100	9,100
Phossy Water Trans. Pump	10,000	1	10,000	3,000	13,000
Residual silo Cyclone Separator	10,000	1	10,000	3,000	13,000
Silo Baghouse	10,000	1	10,000	3,000	13,000
Residual material silo 200 ft3	15,000	1	15,000	4,500	19,500
Vacuum system water separator	10,000	1	10,000	3,000	13,000
Vacuum system Demister	5,000	1	5,000	1,500	6,500
Vacuum system Fan	10,000	1	10,000	3,000	13,000
Fork truck (min 24K lbs)	20,000	1	20,000	-	20,000
Flatbed truck	20,000	1	20,000		20,000
Track Hoe-50 ft reach	80,000	1	80,000	-	80,000
ISO Containers	70,000	6	420,000	-	420,000
Jump Tank (heated)	10,000	1	10,000	3,000	13,000
Supersack Feeder	15,000	1	15,000	4,500	19,500
Subtotal			**2,858,000**	**574,400**	**3,432,400**

Piping 60-160	100		741,300	1,835,600	2,576,900
Vent piping from Still	80	18" X 10'	28,000	52,000	80,000
N2 lines to Still	70	1" X 100'	24,500	45,500	70,000
Recirc to condenser thru cooler (4"-CS)	65	4" X 200'	22,750	42,250	65,000
Phossy water to piping system	150	1"X 175'	52,500	97,500	150,000
P4 Piping to Reciever Tank	14	3" X 3'	4,900	9,100	14,000
Phossy water to P4 collection tank	50	2" X 75'	17,500	32,500	50,000
P4 from tank to Truck (jacketed)	150	1.5" 75'	52,500	97,500	150,000
Phossy H2O, ISO to Buffer, P4 recov'y Tk	60	2"X 100'	21,000	39,000	60,000
Vents for system	30	2"X 100'	10,500	19,500	30,000
Phossy H2O to/from sump level buffer tank	20	2" X 40'	7,000	13,000	20,000
Transfer piping for residual skip mat'l	25	6" X 25'	8,750	16,250	25,000
Overflow to waste water tank	10	2" X 70'	3,500	6,500	10,000
Blowdown to Evap Pond (e traced)	25	1.5" X 200	8,750	16,250	25,000
Waste water Tank to Clarifyer (SS)	25	1.5" X 200	8,750	16,250	25,000
Sump vent to FA and combuster (SS)	25	6" X 40'	8,750	16,250	25,000
Combuster to Scrubber (SS)	15	6" X 25'	5,250	9,750	15,000
Scrubber to fan (FRP)	10	6" X 25'	3,500	6,500	10,000
Residual vacuum line-skip to cyclone-SS Duct	11	3" X 50'	3,850	7,150	11,000
Liquid vacuum line-skip to separator-SS Duct	11	3" X 50'	3,850	7,150	11,000
Blower inlet-SS Duct	12	4" X 60'	4,200	7,800	12,000
Blower discharge-SS Duct	12	4" X 60'	4,200	7,800	12,000
Water within process area-CS	45	2" X 400'	15,750	29,250	45,000
Misc Process lines	50		17,500	32,500	50,000
Utilities			-	-	-
Process Water tie In	20	6" X 150'	7,000	13,000	20,000
Process water to clarifier (SS) e-traced	10	1.5" X 200	3,500	6,500	10,000
Hot water system	80	2" X 200'	28,000	52,000	80,000
N2 for instruments	50	1" X 200'	17,500	32,500	50,000
Gas to combuster,Boiler and heaters	85	1" X 800'	29,750	55,250	85,000
Misc, steam water, Safety showers etc	100		35,000	65,000	100,000
Subtotal			**458,500**	**851,500**	**1,310,000**

Instrumen 20-70	40		571,860	367,120	938,980
Skip Bottom vessels (10' D x 2.5'H)			-	-	-
Skip Top (weather cover) 10' D x1')			-	-	-
Still (Oven) with top	300	1	81,000	69,000	150,000
Condensor SS, 39" D X 18' H	300	1	81,000	69,000	150,000
SS Sump Tank w/jacket heater	100	1	27,000	23,000	50,000
Recirc. Pump	50	2	27,000	23,000	50,000
Sump Level Buffer Tank	50	1	13,500	11,500	25,000
Waste Water collection tank	70	1	18,900	16,100	35,000
Sump Transfer Pump	50	1	13,500	11,500	25,000
Hot water Distrib.Pump	50	1	13,500	11,500	25,000
Recirc. Air cooler	100	1	27,000	23,000	50,000
P4 Collection tank, CS 6K gal	200	1	54,000	46,000	100,000
Truck scale (w/output to control system)	150	1	40,500	34,500	75,000
ISO access platform	-	1	-	-	-
Vapor Combustor	200	1	54,000	46,000	100,000
Scrubber- 4,000 cfm, FRP	200	1	54,000	46,000	100,000
Scrubber Recirc Pump	50	2	27,000	23,000	50,000
Scrubber Fan	50	1	13,500	11,500	25,000
Bridge Crane (15 Ton)		1	-	-	-
Evaporator pond (dam and line)		1	-	-	-
Waste water transfer pump	50	1	13,500	11,500	25,000
N2 TK (rented cryo/vaporizer) 120K scf		1	-	-	-
Hot water heater system	100	1	27,000	23,000	50,000
Hot Water Tank	70	1	18,900	16,100	35,000
Hot water recirc pump	25	2	13,500	11,500	25,000
Water conditioning/softener	100	1	27,000	23,000	50,000
Caustic tank-SS 300 gal	70	1	18,900	16,100	35,000
Caustic pump	25	1	6,750	5,750	12,500
Spill pan		1	-	-	
Phossy Water Buffer tank-850gal	70	1	18,900	16,100	35,000
Phossy Water Trans. Pump	25	1	6,750	5,750	12,500
Residual silo Cyclone Separator	15	1	4,050	3,450	7,500
Silo Baghouse	10	1	2,700	2,300	5,000
Residual material silo 200 ft3	20	1	5,400	4,600	10,000
Vacuum system water separator	10	1	2,700	2,300	5,000
Vacuum system Demister	5	1	1,350	1,150	2,500
Vacuum system Fan	10	1	2,700	2,300	5,000
Fork truck (min 24K lbs)		1	-	-	-
Flatbed truck		1	-	-	-
Track Hoe-50 ft reach		1	-	-	-
ISO Containers		6	-	-	-
Jump Tank (heated)	30	1	8,100	6,900	15,000
Supersack Feeder	30	1	8,100	6,900	15,000
Autovalves for P4 and steam coils	80	1	21,600	18,400	40,000
Phosphine monitoring- 12 units	12	12	38,880	33,120	72,000
Subtotal			**792,180**	**674,820**	**1,467,000**

Electrical 25-60	40		317,700	706,000	1,023,700
Skip Bottom vessels (10' D x 2.5'H)	-	6	-	-	-
Skip Top (weather cover) 10' D x1')		6	-	-	-
Still (Oven) with top	600	1	90,000	180,000	270,000
Condensor SS, 39" D X 18' H	-	1	-	-	-
SS Sump Tank w/jacket heater	-	1	-	-	-
Recirc. Pump	30	2	9,000	18,000	27,000
Sump Level Buffer Tank		1	-	-	-
Waste Water collection tank		1	-	-	-
Sump Transfer Pump	30	1	4,500	9,000	13,500
Hot water Distrib.Pump	30	1	4,500	9,000	13,500
Recirc. Air cooler	100	1	15,000	30,000	45,000
P4 Collection tank, CS 6K gal		1	-	-	-
Truck scale (w/output to control system)	30	1	4,500	9,000	13,500
ISO access platform		1	-	-	-
Vapor Combustor	75	1	11,250	22,500	33,750
Scrubber- 4,000 cfm, FRP	75	1	11,250	22,500	33,750
Scrubber Recirc Pump	30	2	9,000	18,000	27,000
Scrubber Fan	75	1	11,250	22,500	33,750
Bridge Crane (15 Ton)	150	1	22,500	45,000	67,500
Evaporator pond (dam and line)	-	1	-	-	-
Waste water transfer pump	30	1	4,500	9,000	13,500
MCC Sections and feed wiring	550	1	82,500	165,000	247,500
N2 TK (rented cryo/vaporizer) 120K scf	50	1	7,500	15,000	22,500
Hot water heater system	125	1	18,750	37,500	56,250
Water conditioning/softener	50	1	7,500	15,000	22,500
Caustic tank-SS 300 gal	-	1	-	-	-
Caustic pump	30	1	4,500	9,000	13,500
Spill pan		1	-	-	-
Phossy Water Buffer tank-850gal		1	-	-	-
Phossy Water Trans. Pump	30	1	4,500	9,000	13,500
Residual silo Cyclone Separator		1	-	-	-
Silo Baghouse	75	1	11,250	22,500	33,750
Residual material silo 200 ft3	10	1	1,500	3,000	4,500
Vacuum system water separator		1	-	-	
Vacuum system Demister		1	-	-	
Vacuum system Fan	25	1	3,750	7,500	11,250
Fork truck (min 24K lbs)		1	-	-	-
Flatbed truck		1	-	-	-
Track Hoe-50 ft reach		1	-	-	-
ISO Containers		6	-	-	-
Jump Tank (heated)	10	1	1,500	3,000	4,500
Supersack Feeder	10	1	1,500	3,000	4,500
Electric Tracing	500	1	75,000	150,000	225,000
Oven Building- lighting, misc	150	1	22,500	45,000	67,500
ISO Loading Building- lighting, misc	50	1	7,500	15,000	22,500
Utility Building- lighting, misc	70	1	10,500	21,000	31,500
MCC Building- lighting, misc	25	1	3,750	7,500	11,250
Outside and Clarifier	300	1	45,000	90,000	135,000
Subtotal			**507,750**	**1,015,500**	**1,523,250**
Site Devel 4-8	6		21,180	141,200	162,380
Roads/paving (14,000 sf asphalt)	6,000	1	60,000	300,000	360,000
Fencing misc repairs	100	1	1,000	5,000	6,000
Excavation for lines to remote area	250	1	2,500	12,500	15,000
Misc gravel drives etc	150	1	1,500	7,500	9,000
Subtotal			**65,000**	**325,000**	**390,000**

Fire Protec 5-15	10		105,900	141,200	247,100
Building Fire Protection	300	1	15,000	150,000	165,000
Tie in to main lines	100	1	5,000	50,000	55,000
Subtotal			**20,000**	**200,000**	**220,000**
Concrete 12-55	35		127,080	818,960	946,040
Skip Staging Building (25' X 26' X 40'H)	220	1	13,200	63,800	77,000
ISO Loading Building (14' X 28' X 18'H)	120	1	7,200	34,800	42,000
Utility Bldg extension (24' X 28' X 30'H)	240	1	14,400	69,600	84,000
Scrubber pad-12' X 30' open	80	1	4,800	23,200	28,000
Residual Bin/fan found 12' X 12' open	60	1	3,600	17,400	21,000
N2 Tank Foundation 12' X12' open	60	1	3,600	17,400	21,000
Over Foundation (Fire Brick)	200	1	12,000	58,000	70,000
Misc	130	1	7,800	37,700	45,500
Subtotal			**66,600**	**321,900**	**388,500**
Structural 25-50	40		487,140	480,080	967,220
Oven Level platform-25 'X 25' X 11'H	240	1	55,200	40,800	96,000
Condensor structure-12' X 8' X 20'H	120	1	27,600	20,400	48,000
Oven Support platform-12'X 12' X 8'H	80	1	18,400	13,600	32,000
Silo access platform-3 'X 15' X 16'H	100	1	23,000	17,000	40,000
Silo Baghouse platform-6 'X 10' X 26'H	80	1	18,400	13,600	32,000
Pipe supports bridges	100	1	23,000	17,000	40,000
Misc walkways, stairs etc	150	1	34,500	25,500	60,000
Subtotal			**200,100**	**147,900**	**348,000**
Buildings 1-15	10		84,720	169,440	254,160
Break room (Prefab indust. unit.)	700	1	28,000	42,000	70,000
Revamp Change House facilities	500	1	20,000	30,000	50,000
Control room in Skip staging area (6' X 12')	200	1	8,000	12,000	20,000
MCC Building repairs	150	1	6,000	9,000	15,000
Skip staging extension-25' X 26' X 40'	800	1	32,000	48,000	80,000
Utility extension-25' X 26' X 30' H	750	1	30,000	45,000	75,000
ISO Loading building-14' X 28' X 18' H	450	1	18,000	27,000	45,000
Misc	500	1	20,000	30,000	50,000
Subtotal			**162,000**	**243,000**	**405,000**
Insulation 5-15	8		105,900	84,720	190,620
P4 piping	650	1	32,500	19,500	52,000
Sump Tank	400	1	20,000	12,000	32,000
Scrubber piping	300	1	15,000	9,000	24,000
P4 Recovery Tank	800	1	40,000	24,000	64,000
Lines to clarifier(2) and evap pond(1)	1,000	1	50,000	30,000	80,000
Hot water tank and piping	800	1	40,000	24,000	64,000
Misc heating	750	1	37,500	22,500	60,000
Subtotal			**235,000**	**141,000**	**376,000**
Painting 3-8	5		42,360	84,720	127,080
Structure	1,900	1	38,000	57,000	95,000
Misc	750	1	15,000	22,500	37,500
Subtotal			**53,000**	**79,500**	**132,500**
Demolitior 5-15	8		-	-	-
East Tower (crane cost in Mt'l)	900	1	13,500	90,000	103,500
Water distr. Building	200	1	3,000	20,000	23,000
Interior structures (crane cost in Mt'l)	600	1	9,000	60,000	69,000
Misc around clarifyer	200	1	3,000	20,000	23,000
Subtotal			**28,500**	**190,000**	**218,500**
			5,446,630	**4,764,520**	**10,211,150**

Indirect Costs

	766	Eng. Days ($100/hr)	612,669
	1,489	Eng. Days ($120/hr)	1,429,561
	794	Constr. Supervision ($65/hr)	476,452
Total Indirect Costs (X 1.21)		19.8% of total project	**2,518,682**
TOTAL INSTALLED COST (X 5.35)	11,331,300	REF only (standard factors)	**12,729,832**

Proj Range: $ 8,910,882 to approx. $ 16,548,782

Desired field rate: 75

Estimated Operating Costs-Full Scale Mud Still

Prepared by Solvay

Assumptions

Electricity Cost ($/Kw-Hr)	$	0.12
Labor Cost (Including Fringes-$/Hr)	$	60.00
Oven Primary Heat- Kw-Hr/# Batch		0.6
Auxilliary Equipment - Kw-Hr/# Batch		0.3
Estimated Consumables ($/# Batch)	$	0.40
Estimated P4 %		25.0%
Estimated Residue %		30.0%
Estimated Residue Disposal ($/#)	$	0.25
Labor	3 man crews operating 2 - 12 hour shifts	
Operating Time	24 Hours/Batch	
Operating Batch Size(lbs)		6,676
Total Material in Clarifier (gallons)		500,000
Total Material in Clarifier (lbs)		5,674,232
Skip Capacity (10' Diam x 1') (gallons)		588.25
Batches per week (71% Onstream Time)		5
Time to empty clarifier (Weeks)		170.00

Heated Area	Diameter (feet)	Wall Height (ft) (feet)	Top Area (sq. feet)	Walls Area (sq. feet)	Bottom Area (sq. feet)	Total Area (sq. feet)	KW per Square Foot	Furnace Size KW
Pilot Still	2	1.25	3.1415	3.926875	3.1415	10.209875	3.134	32
10' Diameter Still	10	1.25	78.5375	19.634375	78.5375	176.709375	3.134	554

Total Gallons Per Batch	Total Batch Weight (lbs)	Hours Per Batch	Processed lbs.Per Hour	Estimated Aux. Equip. Kw-Hr/lb of Batch	Estimated Aux. Equip. Total KW-Hr Used/Batch	Primary Heat Kw-Hr/lb of Batch	Primary Heat Total KW-Hr Used/Batch	Total KW-Hr Used/Batch
668	6676	24.00	278	0.30	2002.71	0.60	4005	6008

Total P4 Produced lbs/batch	Estimated Labor-Per Week Man-Hrs	Total Labor Cost - Inc. Fringes ($/Hr)	Total Labor Cost - Inc. Fringes ($/Week)	Total Labor Cost - Inc. Fringes ($/Year)	Total Residue Produced lbs/batch	Residue Disposal $/batch
1669	504	$60	$30,240	$1,572,480	2003	$ 497

Estimated consumables $/lb of Batch	Total Electric Costs $/lb of Batch	Total Labor Cost 5 Batches Per Week $/lb of Batch	Residue Disposal $/lb of Batch	Total Cost $/lb of Batch	Total P4 Revenue @ $2/lb Per Batch	Total P4 Revenue @ $2/lb $/lb of Batch	Net Cost $/lb of Batch
$0.40	$0.11	$0.91	$ 0.07	$1.49	$3,337.84	$0.50	$0.99

Residue Disposal Costs - Using Heritage Environmental Estimates
Assumptions

Supersack - Disposal Cost	150
Local Landfill Surcharge	0.12
Freight Charge per Load	2400
Fuel Surcharge per Load	0.22
Supersack Capacity - Cubic Feet	27
Bulk Density of residue - #/Cubic Foot	35
Supersacks Per Load	44

Pound of Residue Per Truck Load	Disposal Cost ($/#)	Landfill Surcharge ($/#)	Freight Cost ($/#)	Fuel Surcharge ($/#)	Total Cost ($/#)
41580	$ 0.16	$ 0.02	$ 0.06	$ 0.01	$ 0.25

***Need to add ISO leasing costs and diesel fuel costs

- Consumables
- Natural Gas
- Heating
- Process
- Nitrogen
- Fuel
- Supplies

Utilities Usage Estimate **and Estimated Cost**

Based on lbs/batch of: 6,715 # mud and 2,155 lb P4
and 24 hrs/batch

Electricity:

This is based on the Portishead process energy balance, 1976 report.
It shows that about 50% of energy was used to make-up for losses (other than needed for distillation).

6,000	kWh per batch or per day for 24 hr cycle.	Cost per same:	$ 720
1.01	kWh/lb P4 @32% weight P4 in mud (average of 2011 pilot run)		$0.121
0.32	kWh/lb mud		$0.038
		Monthly cost:	**$21,600.00**

Nitrogen: Gas cost estimated at 20% higher than UP costs. Lease about 46.7% as UP

UP N2 cost $0.335 per 100scf plus $1,500/mo on a 13,000 gal tank
$0.402 per 100 scf Use a 6,000 gal tank: $900 est/month
UP usage is estimated to 12,000,000 scf / month. SB rated monthly usage: 890,000 scf/mo
That means tank size of 1,500 gal would be adequate. 86.4 scf/gal liquid 5,127 gal/mo
SB monthly costs expected about: $1,781 for gas. Gas + lease = **$2,681** /month
14,766 scf/batch or per day for 24 hr cycle. Monthly usage, scf = 442,980 scf/mo
6.85 scf/lb P4 @32% weight P4 in mud (average of 2011 pilot run) $0.041 /lb P4
2.20 scf/lb mud $0.013 /lb mud

Natural Gas (space heat excluded). Assumes non-insulated Condenser and top of Sump

Heat losses to make-up, BTU/h 97,000 based on 120°F differential air to jackets and 1½" insulation. Includes condenser losses
2,328,000 BTU/day or BTU/24hr-batch
82% Boiler efficiency (Miura Specs)
2,839,024 BTU fuel needed
100,000 BTU/therm. 1 therm = 100 cuft nat gas.

28.39	therms/day or per 24 hr batch	Cost per same:	$14.20	/day
0.01317	therms/lb P4		$398	/lb P4
0.00423	therms/lb mud		$128	/lb mud
		Monthly:	**$425.85**	

Space Heating

100.0	therms/day or per 24 hr batch	Cost per same:	$50.00	/day
		Monthly:	**$1,500.00**	

Utilities Rates

Electricity:	$0.12	per kWh - (Dec 2011 NW Energy rates Montana)
Natural Gas:	$0.50	per therm --- per Dan Bersanti
Nitrogen		See estimate above, based on UP rates

Totalutilities (operating): **$26,207** Note, $900/mo lease applies also for winter
Utility Costs - $/#Batch **$ 0.18**

Capping Alternatives
Operation, Maintenance, and Repair Costs
Cost Estimate Details

ITEM	ESTIMATED QUANTITY	UNIT	UNIT DIRECT COST [1]	2003 ANNUAL ITEM TOTAL DIRECT COST	2013 ADJUSTED ANNUAL ITEM DIRECT COST	30 YEAR PRESENT WORTH OF DIRECT COST [2] 2013	30 YEAR POST-CLOSURE (NO DISCOUNT) 2013	100 YEAR POST-CLOSURE COST 2003	100 YEAR POST-CLOSURE COST 2013	COMMENTS
Admin., Inspection, Reporting (Years 1 to 5)	1	LS	$25,000	$25,000	$ 35,600.00	$ 150,000.00	$178,000	$125,000	$178,000	
Admin., Inspection, Reporting (Years 6 to 10)	1	LS	$15,000	$15,000	$ 21,300.00	$ 260,000.00	$106,500	$75,000	$106,500	
Admin., Inspection, Reporting (Years 11 to 100)	1	LS	$10,000	$10,000	$ 14,200.00	$ 330,000.00	$284,000	$900,000	$1,278,000	
Groundwater Monitoring (Years 1 to 5)	1	YR	$6,250	$6,250	$ 8,900.00	$ 40,000.00	$44,500	$31,250	$44,500	1 upgradient, 4 downgradient wells
Groundwater Monitoring (Years 6 to 30)	1	YR	$6,250	$6,250	$ 8,900.00	$ 180,000.00	$222,500	$156,250	$222,500	1 upgradient, 4 downgradient wells
Cap Maintenance (Years 1 to 30)	1	LS	$6,000	$6,000	$ 8,500.00	$ 130,000.00	$255,000	$180,000	$255,000	
Cap Maintenance (Years 31 to 100)	1	LS	$5,000	$5,000	$ 7,100.00	$ -	$0	$350,000	$497,000	
Phosphine Monitoring (Years 1 to 30)	1	LS	$5,000	$5,000	$ 7,100.00	$ 110,000.00	$71,000	$150,000	$213,000	
Phosphine Collection/Treatment System Maintenance (Years 1 to 30)	1	LS	$2,500	$2,500	$ 3,600.00	$ 60,000.00	$18,000	$75,000	$108,000	120 lbs of Centaur Carbon per year, includes labor for change-out, piping and blower repair
SUBTOTAL OMR COSTS						$1,260,000	$1,179,500	$2,042,500	$2,902,500	
Contingency (20%) [2]						$252,000	$235,900	$408,500	$580,500	
ESTIMATED TOTAL OMR COSTS						$1,512,000	$1,415,400	$2,451,000	$3,483,000	

NOTES:

[1] Lump sum costs include labor, materials, equipment, profit and overhead. Costs in 2003 dollars.

[2] Calculated as Contingency Multiplier times subtotal OMR costs.

[3] Groundwater compliance monitoring is not included in this estimate.

Silver Bow Plant
Off-site Incineration - Clarifier
Cost Estimate Details

ITEM	ESTIMATED QUANTITY	REDUCED CAP SIZE QUANTITY (FOR 2013)	UNIT	UNIT DIRECT COST [1]	2003 ITEM TOTAL DIRECT COST	**2013 ITEM TOTAL DIRECT COST**	ITEM ADJUSTED FOR CAP SIZE + INFLATION 2013	SOURCE	COMMENTS
GENERAL REQUIREMENTS									
Mobilization/Demob./Submittals	1	1	LS	$519,650	$519,650	$739,300	$739,300	Barr	10% of total field cost, excluding T& D
Health & Safety	1	1	LS	$100,000	$100,000	$142,300	$142,300	Barr	Training, refresher training, and field support
Equipment and Personnel Decon. Facilities	24	24	MO	$10,000	$240,000	$341,500	$341,500	Barr	
Sitework									
Clear and Grade	1	5	ACRE	$2,000	$2,000	$2,800	$14,200	Barr	
Fence Removal	800	800	LF	$2	$1,600	$2,300	$2,300	Barr	
SUBTOTAL GENERAL REQUIREMENTS					$863,250	$1,228,200	$1,239,600		
PHOSPHORUS REMOVAL, TREATMENT, AND DISPOSAL									
Phosphorus Removal Operations									
Agitation Chamber	650	650	VLF	$1,500	$975,000	$1,387,200	$1,387,200	Means	Means (1999) (I.e. Caisson drill and operator)
Backhoe and Operator	104	104	WK	$6,000	$624,000	$887,800	$887,800	Barr	$150/hr @ 40 h/wk
Transfer pump and screen	1	1	LS	$20,000	$20,000	$28,500	$28,500	Master Sales	Master Sales
Double Walled Stainless Steel Tank	1	1	LS	$250,000	$250,000	$355,700	$355,700	Tanks Direct	30,000 gallon capacity tank + $7000 transportation, Tanks Direct
Steam Sparge and Steam Plant	1	1	LS	$400,000	$400,000	$569,100	$569,100	Barr	
Additional Labor and operators	104	104	WK	$7,200	$748,800	$1,065,300	$1,065,300	Barr	4 people, 40h/wk @ $45/h, for 2 years
Phosphorus Packing System	1	1	LS	$1,000,000	$1,000,000	$1,422,700	$1,422,700	Barr	
Drums for packing and transportation	11,500	11,500	DRUM	$100		$1,150,000	$1,150,000	Barr	55 gallon steel drum (UN1A2/X400/S), as advertised on www.newpig.com 1/20/2014
Drum Storage Building	9,600	9,600	SF	$42	$403,200	$573,600	$573,600	Means	60' x 160' building w/plumbing, HVAC, and electrical, Means (1998)
Concrete Slab for Drum Storage Building	600	600	CY	$120	$72,000	$102,400	$102,400	Means	6 inch slab with 2 ft curbed edges to contain water, 15,000 square feet, Means (1999)
Decommission/Decon	1	1	LS	$250,000	$250,000	$355,700	$355,700	Barr	Decommissioning and decontamination of phosphorus removal and packing system
Transportation	437,000	437,000	MI	$5	$2,185,000	$3,108,700	$3,108,700	Barr	assume 50 drums per load; total of 230 loads X 1900 miles @ $5 / loaded mile
Incineration/Disposal	11,500	11,500	DRUM	$1,455	$16,736,000	$23,811,000	$23,811,000	TWI	TWI at $3.15/lb, 462 lbs crude phosphorus/drum
SUBTOTAL PHOSPHORUS REMOVAL, TREATMENT, AND DISPOSAL					$23,664,000	$34,817,700	$34,817,700		
CLARIFIER DEMOLITION AND CAP CONSTRUCTION									
Demolition	1	1	LS	$10,000	$10,000	$14,200	$14,200	Barr	Demolition of above-ground concrete clarifier wall, misc.
Geotextile	20,000	20,000	SF	$1.50	$30,000	$42,700	$42,700	Barr	Cover the clarifier contents
Granular Slag Fill	3,000	3,000	CY	$3	$9,000	$12,800	$12,800	Barr	Subgrade fill
Sand/Granular Slag Subgrade	700	3,200	CY	$3	$2,100	$3,000	$13,700	Barr	Fill up to top of clarifier: 3 ft over 29,000 sq ft area; assumes on-site source
Borrow Soil - Clay	2,200	1,600	CY	$7	$15,400	$21,900	$15,900	Barr	1.5 ft over 29,000 sq ft area; assume on-site source
Topsoil	700	500	CY	$8	$5,600	$8,000	$5,700	Barr	0.5 ft over 29,000 sq ft area; assume off-site source
SUBTOTAL CLARIFIER DEMOLITION AND CAP CONSTRUCTION					$72,100	$102,600	$105,000		
SITE RESTORATION									
Site Restoration/Revegetation	5	10	ACRE	$5,000	$25,000	$35,600	$71,100	Barr	Includes seeding, mulching, fertilizing
Install Perimeter Fence	1,600	800	LF	$8	$12,800	$18,200	$9,100	Barr	
SUBTOTAL SITE RESTORATION					$37,800	$53,800	$80,200		
ESTIMATED TOTAL FIELD COST					$24,637,150	$36,202,300	$36,242,500		
Contingency (40%) [2]					$2,286,460	$3,713,040	$3,800,000		40% of Estimated Total Field Cost (minus Treatment and Disposal)
					$2,838,150	$4,037,955	$4,037,955		15% of Treatment and Disposal
Engineering/Administration					$2,286,460	$3,713,040	$3,800,000	Barr	40% of Estimated Total Field Cost, excluding T & D
ESTIMATED TOTAL CONSTRUCTION COST					$33,000,000	$48,000,000	**$47,900,000**		

NOTES:
[1] Unit direct cost includes labor, materials, equipment, overhead, and profit.
[2] Calculated as Contingency Multiplier times Estimated Total Field Cost.

Cost of Financial Assurance
Enhanced RCRA Cap

Activity	Year	Annual Expense	Total Amount of Financial Assurance	Typical Cost	Annual Cost
Cap Construction	2015	$2,000,000	$5,240,000	1.35%	$70,740
	2016	$1,520,000	$3,240,000	1.35%	$43,740
30 Year Post Closure Care	2017	$91,000	$1,720,000	1.35%	$23,220
	2018	$91,000	$1,629,000	1.35%	$21,992
	2019	$91,000	$1,538,000	1.35%	$20,763
	2020	$91,000	$1,447,000	1.35%	$19,535
	2021	$91,000	$1,356,000	1.35%	$18,306
	2022	$57,000	$1,265,000	1.35%	$17,078
	2023	$57,000	$1,208,000	1.35%	$16,308
	2024	$57,000	$1,151,000	1.35%	$15,539
	2025	$57,000	$1,094,000	1.35%	$14,769
	2026	$57,000	$1,037,000	1.35%	$14,000
	2027	$49,000	$980,000	1.35%	$13,230
	2028	$49,000	$931,000	1.35%	$12,569
	2029	$49,000	$882,000	1.35%	$11,907
	2030	$49,000	$833,000	1.35%	$11,246
	2031	$49,000	$784,000	1.35%	$10,584
	2032	$49,000	$735,000	1.35%	$9,923
	2033	$49,000	$686,000	1.35%	$9,261
	2034	$49,000	$637,000	1.35%	$8,600
	2035	$49,000	$588,000	1.35%	$7,938
	2036	$49,000	$539,000	1.35%	$7,277
	2037	$49,000	$490,000	1.35%	$6,615
	2038	$49,000	$441,000	1.35%	$5,954
	2039	$49,000	$392,000	1.35%	$5,292
	2040	$49,000	$343,000	1.35%	$4,631
	2041	$49,000	$294,000	1.35%	$3,969
	2042	$49,000	$245,000	1.35%	$3,308
	2043	$49,000	$196,000	1.35%	$2,646
	2044	$49,000	$147,000	1.35%	$1,985
	2045	$49,000	$98,000	1.35%	$1,323
	2046	$49,000	$49,000	1.35%	$662
Cost of Financial Assurance					**$430,000**

Cost of Financial Assurance
On-site Phosphorus Recovery

Activity	Year	Annual Expense	Total Amount of Financial Assurance	Typical Cost	Annual Cost
Mud Still Constuction	2015	$8,000,000	$24,020,000	1.35%	$324,270
	2016	$4,800,000	$16,020,000	1.35%	$216,270
Mud Still Operation	2017	$1,700,000	$11,220,000	1.35%	$151,470
	2018	$1,700,000	$9,520,000	1.35%	$128,520
	2019	$1,700,000	$7,820,000	1.35%	$105,570
	2020	$1,700,000	$6,120,000	1.35%	$82,620
	2021	$1,700,000	$4,420,000	1.35%	$59,670
Cap Construction	2022	$1,000,000	$2,720,000	1.35%	$36,720
30 Year Post Closure Care	2023	$91,000	$1,720,000	1.35%	$23,220
	2024	$91,000	$1,629,000	1.35%	$21,992
	2025	$91,000	$1,538,000	1.35%	$20,763
	2026	$91,000	$1,447,000	1.35%	$19,535
	2027	$91,000	$1,356,000	1.35%	$18,306
	2028	$57,000	$1,265,000	1.35%	$17,078
	2029	$57,000	$1,208,000	1.35%	$16,308
	2030	$57,000	$1,151,000	1.35%	$15,539
	2031	$57,000	$1,094,000	1.35%	$14,769
	2032	$57,000	$1,037,000	1.35%	$14,000
	2033	$49,000	$980,000	1.35%	$13,230
	2034	$49,000	$931,000	1.35%	$12,569
	2035	$49,000	$882,000	1.35%	$11,907
	2036	$49,000	$833,000	1.35%	$11,246
	2037	$49,000	$784,000	1.35%	$10,584
	2038	$49,000	$735,000	1.35%	$9,923
	2039	$49,000	$686,000	1.35%	$9,261
	2040	$49,000	$637,000	1.35%	$8,600
	2041	$49,000	$588,000	1.35%	$7,938
	2042	$49,000	$539,000	1.35%	$7,277
	2043	$49,000	$490,000	1.35%	$6,615
	2044	$49,000	$441,000	1.35%	$5,954
	2045	$49,000	$392,000	1.35%	$5,292
	2046	$49,000	$343,000	1.35%	$4,631
	2047	$49,000	$294,000	1.35%	$3,969
	2048	$49,000	$245,000	1.35%	$3,308
	2049	$49,000	$196,000	1.35%	$2,646
	2050	$49,000	$147,000	1.35%	$1,985
	2051	$49,000	$98,000	1.35%	$1,323
	2052	$49,000	$49,000	1.35%	$662
Cost of Financial Assurance					**$1,400,000**

Cost of Financial Assurance
Off-site Incineration

Activity	Year	Annual Expense	Total Amount of Financial Assurance	Typical Cost	Annual Cost
Site Construction	2015	$11,000,000	$46,020,000	1.35%	$621,270
Packaging and Incineration Operations	2016	$2,018,750	$35,020,000	1.35%	$472,770
	2017	$2,018,750	$33,001,250	1.35%	$445,517
	2018	$2,018,750	$30,982,500	1.35%	$418,264
	2019	$2,018,750	$28,963,750	1.35%	$391,011
	2020	$2,018,750	$26,945,000	1.35%	$363,758
	2021	$2,018,750	$24,926,250	1.35%	$336,504
	2022	$2,018,750	$22,907,500	1.35%	$309,251
	2023	$2,018,750	$20,888,750	1.35%	$281,998
	2024	$2,018,750	$18,870,000	1.35%	$254,745
	2025	$2,018,750	$16,851,250	1.35%	$227,492
	2026	$2,018,750	$14,832,500	1.35%	$200,239
	2027	$2,018,750	$12,813,750	1.35%	$172,986
	2028	$2,018,750	$10,795,000	1.35%	$145,733
	2029	$2,018,750	$8,776,250	1.35%	$118,479
	2030	$2,018,750	$6,757,500	1.35%	$91,226
	2031	$2,018,750	$4,738,750	1.35%	$63,973
Cap Construction	2032	$1,000,000	$2,720,000	1.35%	$36,720
30 Year Post Closure Care	2033	$91,000	$1,720,000	1.35%	$23,220
	2034	$91,000	$1,629,000	1.35%	$21,992
	2035	$91,000	$1,538,000	1.35%	$20,763
	2036	$91,000	$1,447,000	1.35%	$19,535
	2037	$91,000	$1,356,000	1.35%	$18,306
	2038	$57,000	$1,265,000	1.35%	$17,078
	2039	$57,000	$1,208,000	1.35%	$16,308
	2040	$57,000	$1,151,000	1.35%	$15,539
	2041	$57,000	$1,094,000	1.35%	$14,769
	2042	$57,000	$1,037,000	1.35%	$14,000
	2043	$49,000	$980,000	1.35%	$13,230
	2044	$49,000	$931,000	1.35%	$12,569
	2045	$49,000	$882,000	1.35%	$11,907
	2046	$49,000	$833,000	1.35%	$11,246
	2047	$49,000	$784,000	1.35%	$10,584
	2048	$49,000	$735,000	1.35%	$9,923
	2049	$49,000	$686,000	1.35%	$9,261
	2050	$49,000	$637,000	1.35%	$8,600
	2051	$49,000	$588,000	1.35%	$7,938
	2052	$49,000	$539,000	1.35%	$7,277
	2053	$49,000	$490,000	1.35%	$6,615
	2054	$49,000	$441,000	1.35%	$5,954
	2055	$49,000	$392,000	1.35%	$5,292
	2056	$49,000	$343,000	1.35%	$4,631
	2057	$49,000	$294,000	1.35%	$3,969
	2058	$49,000	$245,000	1.35%	$3,308
	2059	$49,000	$196,000	1.35%	$2,646
	2060	$49,000	$147,000	1.35%	$1,985
	2061	$49,000	$98,000	1.35%	$1,323
	2062	$49,000	$49,000	1.35%	$662
Cost of Financial Assurance					**$5,300,000**

Appendix O

History of Operation of Mud Distillation Units within A&W/Rhodia

History of Operation of Mud Distillation Units within A&W/Rhodia

By Kevin Ryan, former Manager of Phosphorus Technology, Rhodia, October 8, 2014

Introduction: In the early 1970s, particularly at two Albright and Wilson locations in Canada (Long Harbour, Newfoundland and Varennes, Quebec) it had become an increasing priority to address the generation and accumulation of large volumes of materials containing residual elemental phosphorus. These residues were defined either as a phosphorus/water/solids emulsion (typically containing approximately 30% elemental phosphorus) called Phosphorus Mud, or a more dilute residue stream typically containing 1-3% elemental phosphorus called Phosphorus Sludge.

To address the significant accumulations of these materials especially at the two phosphorus manufacturing sites in Canada, key Albright and Wilson (A&W) corporate phosphorus technology personnel, based in the company's technical headquarters in the UK, were assigned to assess alternative means of treating and/or recovering the elemental phosphorus from these streams. As a result of this technical activity a new mud distillation process was developed and patented. Over time, and based upon the success of this process development, a total of nine distillation trains were built and successfully operated at two separate locations in the UK, at two different locations in Canada, and at one location in the US. Below is a listing of the operating experience at these various sites as well as a general description of the process.

Description of the process: The A&W distillation process, which was patented in 1978, provided a distillation apparatus comprising a furnace adapted to receive a skip containing phosphorus mud or sludge. The furnace top was provided with an aperture through which the skips could be inserted or removed as well as a means for closing the aperture with a vapor tight seal. A pool of molten lead, capable of transferring heat from the inner surface of the furnace to the base of the skip, was provided within the furnace. A means of heating the furnace electrically was also provided, as well as ductwork designed to carry the phosphorus vapor from the furnace to the condensing stream. A means of removing the recovered elemental phosphorus, as well as a means of disposing of the residual phosphorus free solids left in the bottom of the skips at the end of each distillation batch were also provided. A key advantage of the process was that it permitted the skip of phosphorus mud residue to be removed quickly from the furnace as soon as the distillation had been completed, without the need to allow the furnace to cool. This capability converted what was essentially a batch process into a semi-continuous process.

Over a period of approximately twenty years, nine individual distillation trains were constructed at five separate sites. The two initial installations were smaller trains, which were constructed at two separate locations in the UK, where the process was piloted and developed. Later, at three different locations in North America, seven trains were constructed and successfully and safely operated. Below is a listing of the operations of these various plants.

3. The Three Foot Diameter Pilot Plant – Oldbury, UK (~1974/1975): The initial pilot plant for the process was constructed at Oldbury in the UK, the location of A&W's process development facility. A total of 74 batches were run in this unit of several different charge materials and the operating parameters were varied in order to determine the limitations and capability of the process. At the end of the development, the Oldbury pilot plant demonstrated the practical feasibility of mud distillation as a method of recovery of phosphorus of useful quality from a variety of muds with the formation of a residue that can be disposed of safely. The pilot activity also demonstrated there were limitations to the amount or depth of charge that could be processed. Too large a charge resulted in either too long a distillation time or incomplete removal of phosphorus from the charge.

However, encouraged by the overall success of this unit, a larger seven foot diameter plant was constructed at Portishead in the UK.

4. The Seven Foot Diameter Prototype Plant – Portishead UK (~1975-1979): The larger seven foot diameter unit also operated successfully for over 400 runs during the process development stage and for a period of time after the development work was completed to recover phosphorus from contaminated residues in the UK. Based upon the success of this prototype plant, construction was begun on a larger plant at the A&W phosphorus manufacturing plant in Long Harbour, Newfoundland, Canada,

5. Two Ten Foot Diameter Mud Still Trains in Long Harbour, Newfoundland, Canada (1978-~1993): Prior to the construction of the mud processing plant in

1978, P4 mud produced at Long Harbour was stored in tanks or in P4 mud storage holes. From 1978 until the closure of the plant in 1989, most of the P4 mud produced was successfully processed in the two ten foot diameter mud still trains.

After the Long Harbour phosphorus plant had been shut down, the mud stills continued to operate for ~three-four years in an attempt to recover mud from various large storage tanks on the site. The operation of the mud plants at a shutdown site proved much more difficult than at a fully operational site. Especially in winter and in part because the utility plants (steam etc) were not designed to operate at such a lower requirement, numerous facility breakdowns etc. rendered the continued operation of this process unfeasible. Hence in ~1993 the plants were shut down and decommissioned and the remaining mud was disposed of in a landfill at the site.

6. Four Ten Foot Diameter Mud Still Trains Varennes, Quebec (~ 1981 and 1983 to ~1993): Based upon the success of the Long Harbour units, and compelled by the need to treat the mud and sludge generations at the Varennes plant, initially two mud stills were installed in ~1981 and later two additional still trains were installed in ~1983. All four of these units operated safely and successfully and recovered all the fresh arisings of mud and sludge at the Varennes site until the closure of that phosphorus plant in 1993. In 1993, when the Varennes plant was shut down, these units were also shut down and decommissioned as part of that site's remediation program.

7. Single ten foot diameter still, Colombia, Tennessee (~1987 - ~1992): In 1987 or thereabouts a seventh ten foot diameter phosphorus mud distillation system of similar design was constructed and installed at the Monsanto former elemental phosphorus manufacturing site in Colombia, Tennessee, USA. Monsanto entered an agreement with A&W to purchase and utilize this technology to process and treat the mud remaining at the Colombia Tennessee phosphorus manufacturing site after the shutdown of this facility. This plant also operated successfully for ~5-6 years into the early 1990s and recovered elemental phosphorus from the P4 rich residues at that site. After successful completion of the remediation activity at that site, the distillation plant was also shut down and decommissioned.

8. Summary: In summary, a total of nine P4 mud distillation plants were constructed and successfully operated over ~20 years from 1974 – ~1993. The first two of these plants were smaller (three and seven foot diameter) and used to pilot and develop the process. The next seven plants were all ten foot diameter units that were successfully operated at three different sites in North America. All seven plants have since been shut down and decommissioned. The units are more difficult to operate in winter conditions, and especially as standalone operations, where the potential for freezing of mud and phosphorus lines and also water and steam lines is greater.

Appendix P

Residue Testing Summary – Clarifier Material Treatability Study, Phase 3 Report

Rhodia Phosphorus Recovery Pilot Plant
2011 Residue Summary

Residue Collection Date	Test Number	Drum Number	A/B Sample	Field Flammability Test	Field Test for PH3 Generation	EPA 1030 Ignitability Test	Burn Rate Test	Residue Density	TCLP Sample to Lab	TCLP Results	Sample Residue Disposal Location
6/15/2011	Test 1	12	A	Negative	Negative	Negative	Not Reqd.	30.41	6/28/2011	Failed for Cadmium - 2.69 mg/L	Clarifer
6/22/2011	Test 2	5	B	Negative	Negative	Negative	Not Reqd.	30.76	6/28/2011	Passed all TCLP analysis	Clarifer
6/22/2011	Test 2 Re-run	5	B	Negative	Negative	Negative	Not Reqd.	30.76	7/22/2011	Failed for Cadmium - 1.86 mg/L	Clarifer
6/24/2011	Test 3	5	B	Negative	Negative	Negative	Not Reqd.	30.76	7/7/2011	Failed for Cadmium - 2.03 mg/L	Residue Drum 1
6/24/2011	Test 3 Re-run	5	B	Negative	Negative	Negative	Not Reqd.	30.76	7/22/2011	Failed for Cadmium - 3.06 mg/L	Residue Drum 1
6/29/2011	Test 4	7	A	Negative	Negative	Negative	Not Reqd.	31.69	7/7/2011	Passed all TCLP analysis	Residue Drum 2
7/13/2011	Test 5	8	A	Negative	Negative	Negative	Not Reqd.	34.05	7/22/2011	Failed for Cadmium - 1.86 mg/L	Residue Drum 3
7/20/2011	Test 6	10	A	Negative	Negative	Negative	Not Reqd.	31.49	7/22/2011	Failed for Cadmium - 2.53 mg/L	Residue Drum 4
	Test 7	7	A	Negative	Negative	Negative	Not Reqd.	33.47		Residue contaminated - No TCLP Analysis	Clarifer
	Test 8	11	A	Residue contaminated with RAP. Unable to obtain samples.						Residue contaminated - No TCLP Analysis	Clarifer
8/10/2011	Test 9	1	A	Negative	Negative	Negative	Not Reqd.	34.00	8/19/2011	Failed for Cadmium - 2.65 mg/L	Clarifier
8/16/2011	Test 10	9	A	Negative	Negative	Negative	Not Reqd.	30.87	8/19/2011	Failed for Cadmium - 1.45 mg/L	Clarifier
8/24/2011	Test 11	3	A	Negative	Negative	Negative	Not Reqd.	30.95	8/19/2011	Passed all TCLP analysis	Residue Drum 5
	Test 12	2	A	Negative	Negative	Negative	Not Reqd.	31.56		Residue contaminated - No TCLP Analysis	Clarifier

Appendix Q

HELP Modeling for Evapotranspiration Cap

HELP Modeling
Soil Cap

Introduction

The HELP (Hydrologic Evaluation of Landfill Performance) model (Version 3.07, U.S. Army Corps of Engineers, November 1997) was used to project long-term infiltration through the soil cap system.

The HELP model tracks the water budget for the cap system. The water enters as precipitation (including snowmelt) less the runoff, and exits via evapotranspiration (ET), percolation, and drainage, or it is held in storage in the pore spaces. The amount of water percolating through the capped material is of particular interest because it can leach contaminants and may impact the underlying groundwater.

The summary model output for the soil cap system is attached. It includes data inputs and summary results for 30 years of model simulation.

Input

The input values used were those recommended in the HELP guidance and documentation for this climate and this type of application. Site-specific parameters such as soil characteristics were used to select a reasonably similar HELP soil textures. The inputs and rationales for their selection are explained below.

Climate Data: 30 years of precipitation data were synthetically generated from monthly total precipitation data from the Butte, Montana airport and the Helena, Montana coefficients. The Helena coefficients are a default data set available with the HELP model. The average annual precipitation at Helena and Butte and the monthly distribution of precipitation were nearly identical, so the Helena coefficients were considered suitable for this model. The attached table of weather information for Butte and Helena illustrate the similarities in their climates. Temperature data were generated synthetically by the HELP model using Helena coefficients and monthly averages for Butte. The latitude was adjusted to 45.8° for the solar radiation and the Helena values were used for the relative humidity. The growing season for Helena was used: 128 days.

Cover Design: The layers that comprise the cover are 6 inches of topsoil, 18 inches of native soil borrow, and a cushion of granulated slag over the crude phosphorus. The corresponding HELP soil types are Texture 9 for the topsoil, Texture 12 for the native soil borrow, and Texture 1 for the granulated slag. This cover assumes that the topsoil and common fill will be obtained locally. The attached soil test data is for a borrow source available at the Silver Bow Plant property. The soil was compacted to approximately 90 percent of standard proctor maximum density for the permeability testing. The borrow soil is expected to function similarly to HELP soil Texture 12, based on the similar soil type (silty clay loam) and identical hydraulic conductivities (4.2×10^{-5} cm/s). The borrow soil may have an ability to store more water than the HELP Texture 12 soil, which would only improve the effectiveness of the cap. The granulated slag available at the plant would be used for the granular subgrade for the cap.

General Design and Evapotranspiration Parameters: The input and HELP-computed parameters for runoff and evapotranspiration are as follows:

Cover slope:	3%
Cover slope length:	50 feet
SCS runoff curve number:	83.50 (computed by HELP)
Evaporative zone depth:	24.0 inches
Maximum leaf area index:	2.00

Results

Summary output for the HELP model is attached.

The annual average values for the 30-year simulation are as follows:

Precipitation:	12.55 inches
Runoff:	0.475 inches
Evapotranspiration:	12.074 inches
Percolation through cap:	0.01272 inches

Model Sensitivity

Model sensitivity was tested on 2 parameters:

1. Evaporative zone depth
2. Leaf index

The summary outputs for the HELP model runs are attached. The effect on average annual percolation for this sensitivity case is summarized in the following table. The representative case using the inputs described earlier is listed first, followed by the sensitivity cases where one or more parameters were varied.

Sensitivity Cases

Parameter	Representative	Deep Evap. Zone	Shallow Evap. Zone	High Leaf Area
Evaporative zone depth (in)	24	42	14	24
Maximum leaf area index	2	2	2	3
Acreage annual percolation through cap (in/yr)	0.013	0.070	0.089	0.015

The range of annual average percolation is 0.013 inches to 0.089 inches for the representative and sensitivity cases, as shown in the last line of the above table. This result suggests that this form of cap is sensitive to variations in the cover vegetation and the depth of the evaporative zone, although the estimated percolation is still small, less than 0.1 inches per year. Based on these sensitivity results the soil cap design may benefit from optimization of the cap thickness, assuming a slightly thicker cap would reduce the variability in percolation due to these sensitivity factors.

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
                    DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
                      USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      P:\26\46\004\HELPMODE\HELP307\data4-3.D4
TEMPERATURE DATA FILE:        p:\26\46\004\Helpmode\help307\data7-3.D7
SOLAR RADIATION DATA FILE:    p:\26\46\004\helpmode\help307\data13-3.D13
EVAPOTRANSPIRATION DATA:      p:\26\46\004\helpmode\help307\DATA11-3.D11
SOIL AND DESIGN DATA FILE:    p:\26\46\004\helpmode\help307\soilcap2.D10
OUTPUT DATA FILE:             p:\26\46\004\helpmode\help307\slcap2a.OUT


TIME:  11: 2     DATE:  11/ 7/2001


******************************************************************************

     TITLE:  Silver Bow - Soil Cap (24" soil cover, 2' E.Z. Depth)

******************************************************************************


       NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
                WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
            THICKNESS                      =      6.00   INCHES
            POROSITY                       =      0.5010 VOL/VOL
            FIELD CAPACITY                 =      0.2840 VOL/VOL
            WILTING POINT                  =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT     =      0.2840 VOL/VOL
            EFFECTIVE SAT. HYD. COND.      =  0.190000006000E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                   FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
            THICKNESS                      =     18.00   INCHES
            POROSITY                       =      0.4710 VOL/VOL
            FIELD CAPACITY                 =      0.3420 VOL/VOL
            WILTING POINT                  =      0.2100 VOL/VOL
            INITIAL SOIL WATER CONTENT     =      0.3420 VOL/VOL
            EFFECTIVE SAT. HYD. COND.      =  0.419999997000E-04 CM/SEC
```

```
                              LAYER  3
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   1
        THICKNESS                      =     72.00   INCHES
        POROSITY                       =      0.4170 VOL/VOL
        FIELD CAPACITY                 =      0.0450 VOL/VOL
        WILTING POINT                  =      0.0180 VOL/VOL
        INITIAL SOIL WATER CONTENT     =      0.0450 VOL/VOL
        EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC




               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

       NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
                FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
                AND A SLOPE LENGTH OF   50. FEET.

      SCS RUNOFF CURVE NUMBER                =      83.50
      FRACTION OF AREA ALLOWING RUNOFF       =     100.0     PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE     =       0.180   ACRES
      EVAPORATIVE ZONE DEPTH                 =      24.0     INCHES
      INITIAL WATER IN EVAPORATIVE ZONE      =       7.860   INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE     =      11.484   INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE     =       4.590   INCHES
      INITIAL SNOW WATER                     =       0.000   INCHES
      INITIAL WATER IN LAYER MATERIALS       =      11.100   INCHES
      TOTAL INITIAL WATER                    =      11.100   INCHES
      TOTAL SUBSURFACE INFLOW                =       0.00    INCHES/YEAR




                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                HELENA                    MONTANA

          STATION LATITUDE                          =  45.82 DEGREES
          MAXIMUM LEAF AREA INDEX                   =   2.00
          START OF GROWING SEASON (JULIAN DATE)     =    138
          END OF GROWING SEASON (JULIAN DATE)       =    266
          EVAPORATIVE ZONE DEPTH                    =  24.0  INCHES
          AVERAGE ANNUAL WIND SPEED                 =   7.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  63.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  54.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  49.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  63.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     HELENA                MONTANA

                NORMAL MEAN MONTHLY PRECIPITATION  (INCHES)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
     0.61         0.56         0.81         1.03         1.89         2.27
     1.30         1.11         1.12         0.80         0.62         0.59


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     HELENA                MONTANA

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
```

```
     -------        -------        -------        -------        -------        -------
      18.60          22.60          29.20          39.10          47.70          55.70
      63.30          61.70          51.90          42.10          29.40          20.90


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    HELENA              MONTANA
                   AND STATION LATITUDE  =  45.82 DEGREES




*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                  0.65     0.48     0.85     1.11     1.92     2.04
                            1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS         0.36     0.31     0.46     0.58     0.84     0.73
                            0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.021    0.068    0.145    0.171    0.040    0.000
                           0.000    0.000    0.000    0.000    0.024    0.005

    STD. DEVIATIONS        0.063    0.141    0.224    0.195    0.102    0.000
                           0.001    0.000    0.001    0.000    0.053    0.015

   VAPOTRANSPIRATION
  ------------------
    TOTALS                 0.460    0.401    0.456    0.841    2.286    2.510
                           2.092    0.969    0.857    0.547    0.322    0.333

    STD. DEVIATIONS        0.182    0.192    0.159    0.293    0.397    0.554
                           0.996    0.433    0.315    0.223    0.141    0.161

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                0.0011   0.0009   0.0010   0.0010   0.0010   0.0011
                          0.0012   0.0012   0.0011   0.0011   0.0011   0.0011

    STD. DEVIATIONS       0.0007   0.0006   0.0007   0.0007   0.0007   0.0007
                          0.0008   0.0008   0.0007   0.0007   0.0007   0.0007
*******************************************************************************


*******************************************************************************

      AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                    INCHES            CU. FEET       PERCENT
                              -------------------   -------------   ---------
  PRECIPITATION                 12.55   (   1.640)      8200.6       100.00

  RUNOFF                         0.475  (  0.2803)       310.31        3.784

  EVAPOTRANSPIRATION            12.074  (  1.4376)      7889.23       96.203

   COLATION/LEAKAGE THROUGH      0.01272 (  0.00818)        8.311      0.10135
    LAYER  3

  CHANGE IN WATER STORAGE       -0.011  (  0.9869)        -7.25       -0.088
*******************************************************************************
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          PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------   -------------
    PRECIPITATION                                1.15          751.410

    RUNOFF                                       0.705         460.7727

    PERCOLATION/LEAKAGE THROUGH LAYER  3         0.000070        0.04546

    SNOW WATER                                   1.84         1201.1409

    MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3614

    MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1912

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******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR   30
     ----------------------------------------------------------------------
               LAYER          (INCHES)        (VOL/VOL)
               -----          --------        ---------
                 1             2.3158          0.3860

                 2             4.9099          0.2728

                 3             3.5412          0.0492

             SNOW WATER        0.000

******************************************************************************
******************************************************************************
```

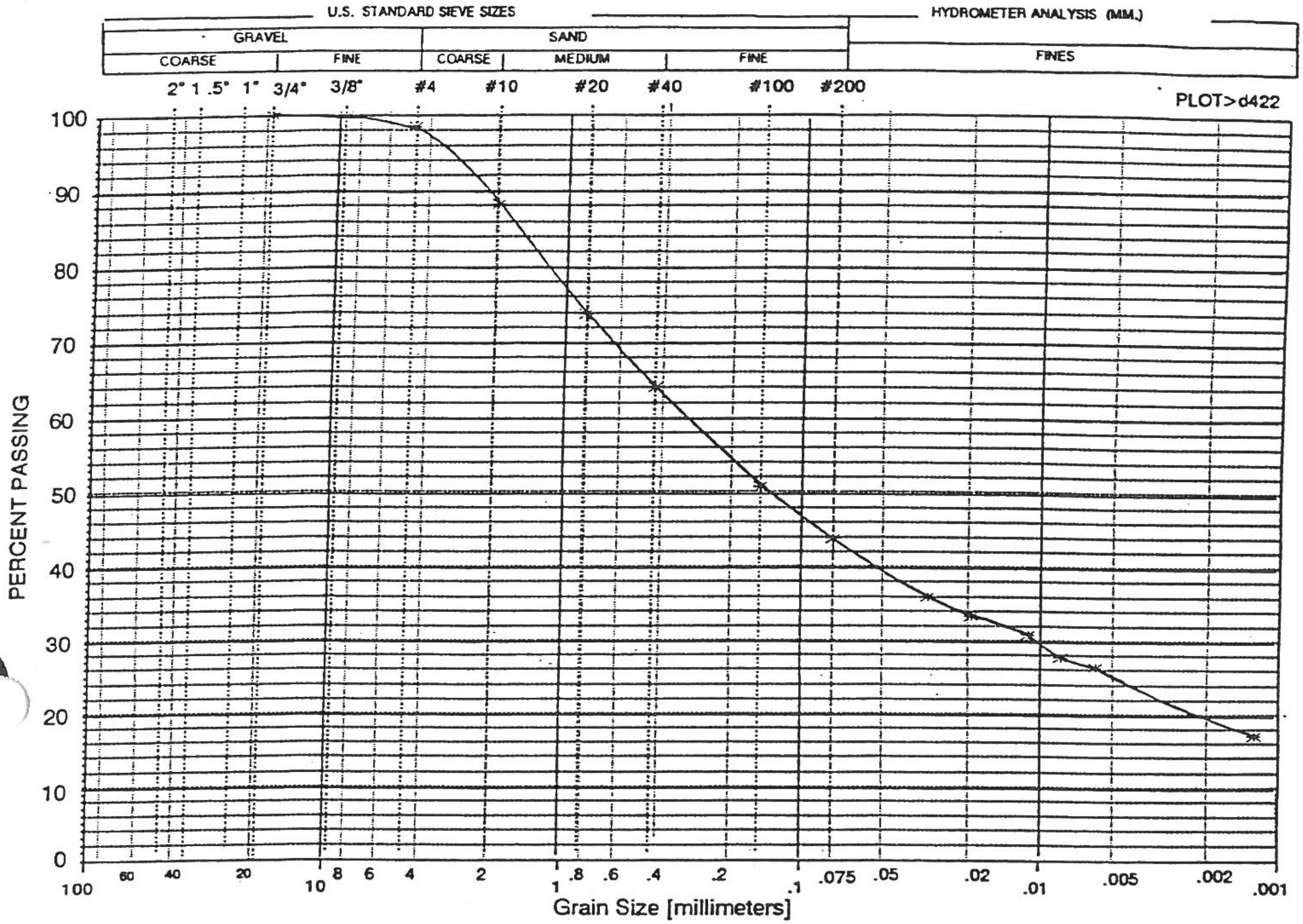
Monthly Climate Summary
Butte FAA Airport, Montana: (Weather Station 241318)
Compared to HELP Helena Climate Data

Month	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Butte Average Maximum Temperature, °F	29.8	34.3	40.6	51.1	60.5	69.3	79.5	78.0	66.9	55.5	40.5	31.7	53.2
Butte Average Minimum Temperature, °F	7.4	10.9	17.7	27.0	34.9	42.0	47.1	45.3	36.9	28.7	18.2	10.0	27.2
Butte Average Total Precipitation, inches	0.61	0.56	0.81	1.03	1.89	2.27	1.30	1.11	1.12	0.80	0.62	0.59	12.71
Butte Average Total Snowfall, inches	8.6	7.7	10.3	7.5	3.7	0.5	0.0	0.1	1.1	3.6	6.6	8.3	57.9
Butte Average Snow Depth, inches	4.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0
Butte Average Wind Speed, mph **	14.9	14.1	3.6	0.8	2.3	2.6	5.1	4.3	6.5	5.9	15.5	2.5	6.3
Helena Average Mean Temperature, °F	18.1	26.0	31.6	42.3	52.2	60.1	67.9	65.9	55.6	45.1	31.4	23.5	43.3
Helena Average Total Precipitation, inches	0.66	0.44	0.69	1.01	1.72	2.01	1.04	1.18	0.83	0.65	0.54	0.60	11.4
Helena Average Wind Speed, mph													7.8

Notes: Data were based on a record period of 104 years, 1894 to 1998, for Butte FAA Airport unless noted otherwise
* Indicates data are based on a record period of 1 year, 1996, from onsite weather station

REPORTED TO: Rhodia Silver Bow | Date: 7-19-99

	Boring Number	Sample Number	Depth (feet)	Type of Sample	Soil Classification
x	99-10		0.5-6.0	Bulk	Clayey sand w/a trace of gravel (SC)



	OTHER TESTS x	+	◻
Liquid Limit (%)	46.5		
Plastic Limit (%)	20.1		
Plasticity Index	26.4		
Water Content (%)	12.3		
Dry Density [pcf]			
Specific Gravity (*)	2.67*		
Porosity			
Organic Content (%)			
pH			
Shrinkage Limit [SL]			
Penetrometer [tsf]			
Qu [psf]			

* Assumed Value

	PERCENT PASSING x	+	◻
Mass [gm]			
2"			
1-1/2"			
1"			
3/4"	100.0		
3/8"	99.7		
#4	98.5		
#10	88.3		
#20	73.8		
#40	64.1		
#100	50.7		
#200	43.9		

ASTM: D422 Sieve Set

	x	+	◻
D_{60}			
D_{30}			
D_{10}			
C_u			
C_c			

Remarks:

ARS

MOISTURE - DENSITY CURVE

Project RHODIA SILVER BOW - #26/46-004 JSL 200 Date 7-16-99

Reported To BARR ENGINEERING COMPANY Job No. 3604

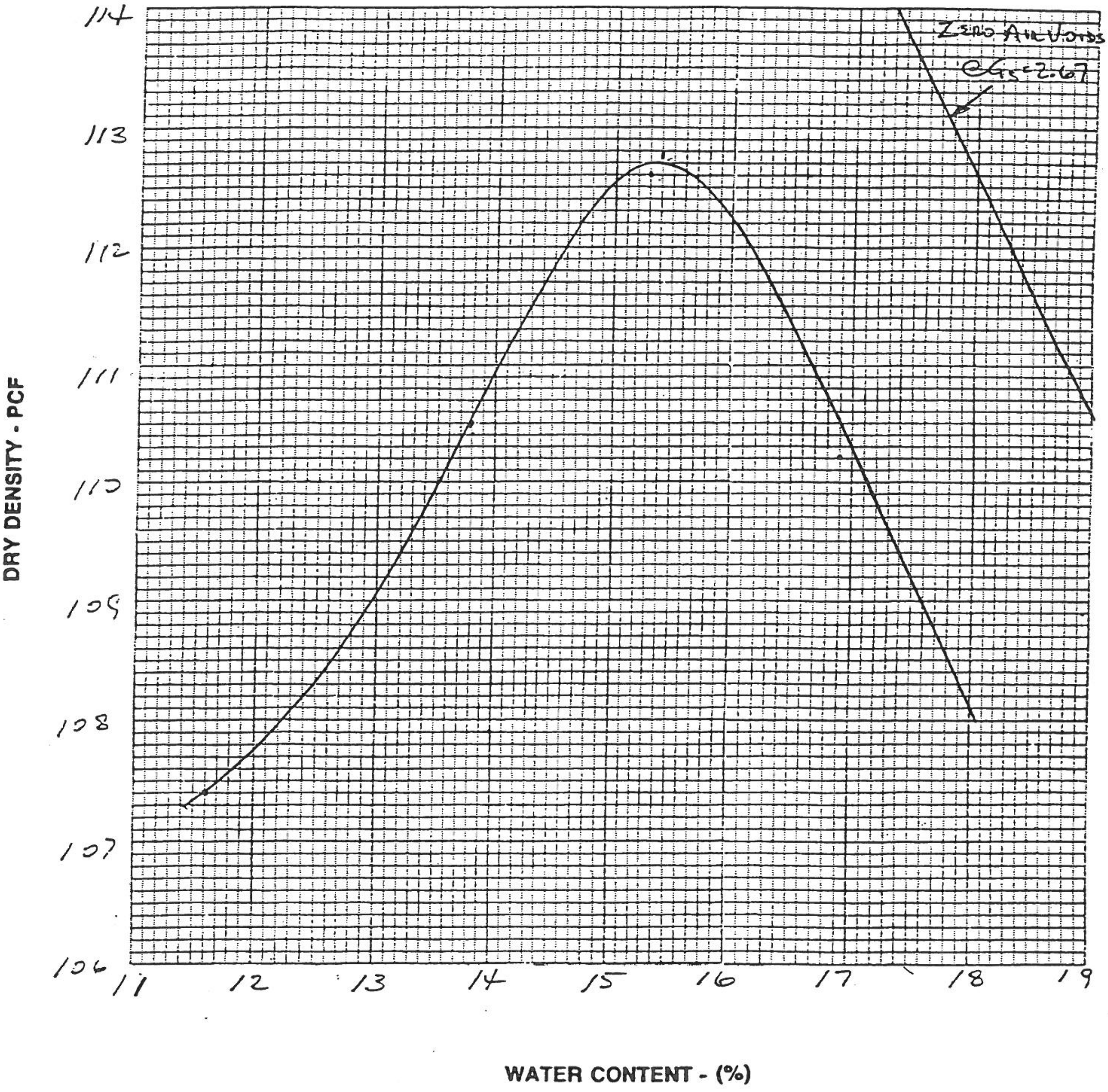
Boring No. 99-10 Sample No. ______ Depth (ft.) 1/2 - 6 Location ______

Test Method ASTM: D698, PROCEDURE B

Soil Description CLAYEY SAND W/A TRACE OF GRAVEL (SC)

AS RECEIVED WATER CONTENT: 12.3% LL=46.5%, PL=20.1%, PI=26.4

Maximum Dry Density 112.7 pcf Optimum Water Content 15.4 %



Project: RHODIA SILVER BOW - # 26/46-004 JSL200 Date: 7-30-99

Reported To: BARR ENGINEERING COMPANY Job No.: 3604

oring No.	99-10	99-10	99-10		
Sample No.					
Depth (Ft)	1/2 -6	1/2 -6	6-12		
Type of Sample	BULK	BULK	BULK		
Soil Classification (ASTM: D2487/2488)	CLAYEY SAND W/A TRACE OF GRAVEL (SC)	→			
Mechanical Analysis Dry Weight (Grams)					
Percent Passing					
Gravel 3"					
2"					
1"					
3/4"					
Sand #4					
#10					
#40					
#100					
#200					
Atterberg Limits					
Liquid Limit					
Plastic Limit					
Plasticity Index					
Moisture - Density					
Water Content (%)	3.6 *	25.8 **	33.2		
Dry Density (PCF)		100.6 #			
Unconfined Compression					
Maximum Load (psf)			*AIR DRIED TO CONSTANT WEIGHT		
Hand Penetrometer (tsf)			FOR TWO WEEKS		
Organic Content (%)					
pH (Meter Method)			** WATER HOLDING CAPACITY		
c Gravity			# INITIAL DRY DENSITY AT 12.4% W.C.		
Resistivity (ohm-cm)			BEFORE SOAKING & GRAVITY DRAINING		

Permeability Test Data (Compacted Specimens)

Project: RHODIA SILVER BOW - # 26/46-004 JSL200 Date: 7-23-99

Reported To: BARR ENGINEERING COMPANY Job No.: 3604

Sample No./Designation	99-10					
Sample Type, Location Elevation or Depth	@½'-6'					
Soil Classification	CLAYEY SAND W/A TRACE OF GRAVEL (SC)					
In-Place Water Content (%)	12.3					
Moisture - Density Relation						
(ASTM: D698)						
Max Dry Density (PCF)	112.7					
Opt. Water Content (%)	15.4					
Atterberg Limits						
Liquid Limit	46.5					
Plastic Limit	20.1					
Plasticity Index	26.4					
Permeability Test						
% Saturation (After Test)	87.5*					
Specimen Height (Inches)	3.00					
Specimen Diameter (Inches)	2.86					
Dry Density (PCF)	101.9					
% of Max. Density	90.4					
Water Content (%)	12.3					
Type of Test (Head)	Falling					
Max. Head Differential (Ft)	1.1					
Confining Pressure (Effective-PSI)	2.0					
Trial No.	12-16					
Water Temp. (°C)	23					
Co-efficient of Permeability						
K @ 20°C (Cm/Sec)	4.2×10^{-5}					
K @ 20°C (Ft/Min)	8.3×10^{-5}					

* LOST WATER AFTER DISSAMBLING DUE TO GRAVITY DRAINAGE

```
****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
*                 DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
*                   USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:     P:\26\46\004\HELPMODE\HELP307\data4-3.D4
TEMPERATURE DATA FILE:       p:\26\46\004\Helpmode\help307\data7-3.D7
SOLAR RADIATION DATA FILE:   p:\26\46\004\helpmode\help307\data13-3.D13
EVAPOTRANSPIRATION DATA:     p:\26\46\004\helpmode\help307\DATA11-4.D11
SOIL AND DESIGN DATA FILE:   p:\26\46\004\helpmode\help307\soilcap2.D10
OUTPUT DATA FILE:            p:\26\46\004\helpmode\help307\slcap2b.OUT


TIME:  11: 2     DATE:  11/ 7/2001


****************************************************************************

    TITLE:  Silver Bow - Soil Cap (24" soil cover,42″ E.Z. Depth)

****************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
             WERE SPECIFIED BY THE USER.


                                LAYER  1
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
           THICKNESS                      =       6.00    INCHES
           POROSITY                       =       0.5010 VOL/VOL
           FIELD CAPACITY                 =       0.2840 VOL/VOL
           WILTING POINT                  =       0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT     =       0.2840 VOL/VOL
           EFFECTIVE SAT. HYD. COND.      =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
           THICKNESS                      =      18.00    INCHES
           POROSITY                       =       0.4710 VOL/VOL
           FIELD CAPACITY                 =       0.3420 VOL/VOL
           WILTING POINT                  =       0.2100 VOL/VOL
           INITIAL SOIL WATER CONTENT     =       0.3420 VOL/VOL
           EFFECTIVE SAT. HYD. COND.      =  0.419999997000E-04 CM/SEC
```

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                         LAYER  3
                         --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   1
     THICKNESS                      =     72.00   INCHES
     POROSITY                       =       0.4170 VOL/VOL
     FIELD CAPACITY                 =       0.0450 VOL/VOL
     WILTING POINT                  =       0.0180 VOL/VOL
     INITIAL SOIL WATER CONTENT     =       0.0450 VOL/VOL
     EFFECTIVE SAT. HYD. COND.      =   0.999999978000E-02 CM/SEC




            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
           FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF   50. FEET.

    SCS RUNOFF CURVE NUMBER                 =      83.50
    FRACTION OF AREA ALLOWING RUNOFF        =     100.0     PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE      =       0.180   ACRES
    EVAPORATIVE ZONE DEPTH                  =      42.0     INCHES
    INITIAL WATER IN EVAPORATIVE ZONE       =       8.670   INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE      =      18.990   INCHES
    LOWER LIMIT OF EVAPORATIVE STORAGE      =       4.914   INCHES
    INITIAL SNOW WATER                      =       0.000   INCHES
    INITIAL WATER IN LAYER MATERIALS        =      11.100   INCHES
    TOTAL INITIAL WATER                     =      11.100   INCHES
    TOTAL SUBSURFACE INFLOW                 =       0.00    INCHES/YEAR




             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           HELENA                    MONTANA

        STATION LATITUDE                       =  45.82 DEGREES
        MAXIMUM LEAF AREA INDEX                =   2.00
        START OF GROWING SEASON (JULIAN DATE)  =    138
        END OF GROWING SEASON (JULIAN DATE)    =    266
        EVAPORATIVE ZONE DEPTH                 =  42.0   INCHES
        AVERAGE ANNUAL WIND SPEED              =   6.30 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  63.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  54.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  49.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  63.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    HELENA               MONTANA

           NORMAL MEAN MONTHLY PRECIPITATION  (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  0.61        0.56        0.81        1.03        1.89        2.27
  1.30        1.11        1.12        0.80        0.62        0.59


  NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    HELENA               MONTANA

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
```

```
     -------       -------       -------       -------       -------       -------
      18.60         22.60         29.20         39.10         47.70         55.70
      63.30         61.70         51.90         42.10         29.40         20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    HELENA                  MONTANA
                  AND STATION LATITUDE  =  45.82 DEGREES





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        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.023    0.084    0.143    0.144    0.034    0.000
                           0.000    0.000    0.000    0.000    0.024    0.007

    STD. DEVIATIONS        0.061    0.159    0.223    0.176    0.091    0.000
                           0.001    0.000    0.001    0.000    0.052    0.019

  VAPOTRANSPIRATION
  ------------------
    TOTALS                 0.414    0.370    0.432    0.844    2.280    2.554
                           2.063    0.986    0.919    0.565    0.301    0.300

    STD. DEVIATIONS        0.154    0.162    0.144    0.304    0.388    0.518
                           0.983    0.438    0.351    0.234    0.143    0.138

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                 0.0051   0.0045   0.0050   0.0050   0.0049   0.0049
                           0.0074   0.0082   0.0071   0.0067   0.0059   0.0056

    STD. DEVIATIONS        0.0046   0.0043   0.0045   0.0044   0.0044   0.0044
                           0.0054   0.0061   0.0052   0.0048   0.0042   0.0044

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       AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET      PERCENT
                               -------------------    -------------  ---------
  PRECIPITATION                  12.55   (   1.640)       8200.6     100.00

  RUNOFF                          0.459  (  0.2806)        299.96      3.658

  EVAPOTRANSPIRATION             12.027  (  1.4373)       7858.68     95.831

    COLATION/LEAKAGE THROUGH      0.07028 (  0.05110)        45.918     0.55994
    LAYER  3

  CHANGE IN WATER STORAGE        -0.006  (  0.9773)         -3.96     -0.048
*******************************************************************************
```

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******************************************************************************

           PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
    PRECIPITATION                               1.15           751.410

    RUNOFF                                      0.737          481.3681

    PERCOLATION/LEAKAGE THROUGH LAYER  3        0.000846         0.55257

    SNOW WATER                                  1.91          1248.5452

    MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2282

    MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1170

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```

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*******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR   30
      ----------------------------------------------------------------------
               LAYER          (INCHES)        (VOL/VOL)
               -----          --------        ---------
                 1             2.3220          0.3870

                 2             4.6315          0.2573

                 3             3.9646          0.0551

             SNOW WATER        0.000

*******************************************************************************
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```

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************************************************************************
************************************************************************
**                                                                    **
**                                                                    **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE         **
**                 HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)         **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY             **
**                    USAE WATERWAYS EXPERIMENT STATION               **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY        **
**                                                                    **
**                                                                    **
************************************************************************
************************************************************************


PRECIPITATION DATA FILE:      P:\26\46\004\HELPMODE\HELP307\data4-3.D4
TEMPERATURE DATA FILE:        p:\26\46\004\Helpmode\help307\data7-3.D7
SOLAR RADIATION DATA FILE:    p:\26\46\004\helpmode\help307\data13-3.D13
EVAPOTRANSPIRATION DATA:      p:\26\46\004\helpmode\help307\DATA11-5.D11
SOIL AND DESIGN DATA FILE:    p:\26\46\004\helpmode\help307\soilcap2.D10
OUTPUT DATA FILE:             p:\26\46\004\helpmode\help307\slcap2c.OUT


TIME:  11: 3     DATE:  11/ 7/2001


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TITLE: Silver Bow - Soil Cap (24" soil cover, ~~2"~~ 14" E.Z. Depth)

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************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   9
          THICKNESS                    =       6.00   INCHES
          POROSITY                     =       0.5010 VOL/VOL
          FIELD CAPACITY               =       0.2840 VOL/VOL
          WILTING POINT                =       0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.2840 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.190000006000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                 LAYER  2
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =      18.00   INCHES
          POROSITY                     =       0.4710 VOL/VOL
          FIELD CAPACITY               =       0.3420 VOL/VOL
          WILTING POINT                =       0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.3420 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.419999997000E-04 CM/SEC
```

```
                              LAYER  3
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   1
        THICKNESS                    =      72.00   INCHES
        POROSITY                     =       0.4170 VOL/VOL
        FIELD CAPACITY               =       0.0450 VOL/VOL
        WILTING POINT                =       0.0180 VOL/VOL
        INITIAL SOIL WATER CONTENT   =       0.0450 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

       NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
                FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
                AND A SLOPE LENGTH OF   50. FEET.

      SCS RUNOFF CURVE NUMBER              =     83.50
      FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE   =      0.180   ACRES
      EVAPORATIVE ZONE DEPTH               =     14.0     INCHES
      INITIAL WATER IN EVAPORATIVE ZONE    =      4.440   INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE   =      6.774   INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE   =      2.490   INCHES
      INITIAL SNOW WATER                   =      0.000   INCHES
      INITIAL WATER IN LAYER MATERIALS     =     11.100   INCHES
      TOTAL INITIAL WATER                  =     11.100   INCHES
      TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR


               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                HELENA               MONTANA

           STATION LATITUDE                        =  45.82 DEGREES
           MAXIMUM LEAF AREA INDEX                 =   2.00
           START OF GROWING SEASON (JULIAN DATE)   =    138
           END OF GROWING SEASON (JULIAN DATE)     =    266
           EVAPORATIVE ZONE DEPTH                  =  14.0  INCHES
           AVERAGE ANNUAL WIND SPEED               =   6.30 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  63.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  54.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  49.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  63.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    HELENA              MONTANA

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
     0.61        0.56        0.81        1.03        1.89        2.27
     1.30        1.11        1.12        0.80        0.62        0.59


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    HELENA              MONTANA

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
```

```
      -------       -------       -------       -------       -------       -------
       18.60         22.60         29.20         39.10         47.70         55.70
       63.30         61.70         51.90         42.10         29.40         20.90


          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    HELENA              MONTANA
                     AND STATION LATITUDE  =  45.82 DEGREES




*******************************************************************************

          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                0.030    0.106    0.176    0.227    0.051    0.000
                          0.001    0.000    0.000    0.000    0.028    0.009

    STD. DEVIATIONS       0.088    0.196    0.245    0.245    0.128    0.000
                          0.003    0.000    0.001    0.000    0.061    0.025

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                0.413    0.367    0.414    0.996    2.256    2.326
                          1.698    0.953    0.940    0.702    0.407    0.309

    STD. DEVIATIONS       0.155    0.161    0.145    0.459    0.583    0.629
                          0.811    0.497    0.472    0.314    0.121    0.137

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS               0.0072   0.0068   0.0075   0.0072   0.0082   0.0087
                         0.0085   0.0077   0.0071   0.0070   0.0065   0.0070

    STD. DEVIATIONS      0.0086   0.0087   0.0099   0.0096   0.0095   0.0094
                         0.0087   0.0082   0.0075   0.0075   0.0071   0.0072

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES             CU. FEET      PERCENT
                                 ------------------    -------------  ---------
 PRECIPITATION                    12.55     (   1.640)      8200.6      100.00

 RUNOFF                            0.627    (  0.3479)       409.90       4.998

 EVAPOTRANSPIRATION               11.779    (  1.4470)      7696.50      93.853

 PERCOLATION/LEAKAGE THROUGH       0.08947 (  0.09880)       58.463      0.71291
   LAYER  3

 CHANGE IN WATER STORAGE           0.055    (  0.8099)        35.75       0.436
*******************************************************************************
```

```
******************************************************************************

              PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
    ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
       PRECIPITATION                               1.15            751.410

       RUNOFF                                      0.832           543.4906

       PERCOLATION/LEAKAGE THROUGH LAYER  3        0.001477          0.96500

       SNOW WATER                                  1.91           1248.5452


       MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3768

       MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1779

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***************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
     -----------------------------------------------------------------
                    LAYER          (INCHES)        (VOL/VOL)
                    -----          --------        ---------
                      1             2.3083          0.3847

                      2             5.7103          0.3172

                      3             4.7227          0.0656

                  SNOW WATER        0.000

***************************************************************************
***************************************************************************
```

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     P:\26\46\004\HELPMODE\HELP307\data4-3.D4
TEMPERATURE DATA FILE:       p:\26\46\004\Helpmode\help307\data7-3.D7
SOLAR RADIATION DATA FILE:   p:\26\46\004\helpmode\help307\data13-3.D13
EVAPOTRANSPIRATION DATA:     p:\26\46\004\helpmode\help307\DATA11-6.D11
SOIL AND DESIGN DATA FILE:   p:\26\46\004\helpmode\help307\soilcap2.D10
OUTPUT DATA FILE:            p:\26\46\004\helpmode\help307\slcap2d.OUT


TIME:  11: 3     DATE:  11/ 7/2001


******************************************************************************

     TITLE:  Silver Bow - Soil Cap (24" soil cover, 2' E.Z. Depth)
                                                   Leaf Area Index 3.0
******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   9
          THICKNESS                    =      6.00   INCHES
          POROSITY                     =      0.5010 VOL/VOL
          FIELD CAPACITY               =      0.2840 VOL/VOL
          WILTING POINT                =      0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2840 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.190000006000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3420 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
```

```
                         LAYER  3
                         --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   1
      THICKNESS                      =     72.00    INCHES
      POROSITY                       =      0.4170 VOL/VOL
      FIELD CAPACITY                 =      0.0450 VOL/VOL
      WILTING POINT                  =      0.0180 VOL/VOL
      INITIAL SOIL WATER CONTENT     =      0.0450 VOL/VOL
      EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
            FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
            AND A SLOPE LENGTH OF   50. FEET.

    SCS RUNOFF CURVE NUMBER               =      83.50
    FRACTION OF AREA ALLOWING RUNOFF      =     100.0     PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE    =       0.180   ACRES
    EVAPORATIVE ZONE DEPTH                =      24.0     INCHES
    INITIAL WATER IN EVAPORATIVE ZONE     =       7.860   INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE    =      11.484   INCHES
    LOWER LIMIT OF EVAPORATIVE STORAGE    =       4.590   INCHES
    INITIAL SNOW WATER                    =       0.000   INCHES
    INITIAL WATER IN LAYER MATERIALS      =      11.100   INCHES
    TOTAL INITIAL WATER                   =      11.100   INCHES
    TOTAL SUBSURFACE INFLOW               =       0.00    INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

   NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            HELENA                     MONTANA

        STATION LATITUDE                          =  45.82 DEGREES
        MAXIMUM LEAF AREA INDEX                   =   3.00
        START OF GROWING SEASON (JULIAN DATE)     =    138
        END OF GROWING SEASON (JULIAN DATE)       =    266
        EVAPORATIVE ZONE DEPTH                    =  24.0  INCHES
        AVERAGE ANNUAL WIND SPEED                 =   6.30 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  63.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  54.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  49.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  63.00 %


   NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    HELENA              MONTANA

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
   0.61         0.56         0.81         1.03         1.89         2.27
   1.30         1.11         1.12         0.80         0.62         0.59


   NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    HELENA              MONTANA

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
```

```
    -------     -------     -------     -------     -------     -------
     18.60       22.60       29.20       39.10       47.70       55.70
     63.30       61.70       51.90       42.10       29.40       20.90


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    HELENA             MONTANA
                  AND STATION LATITUDE  =  45.82 DEGREES




*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.65     0.48     0.85     1.11     1.92     2.04
                           1.31     0.98     1.27     0.83     0.57     0.54

    STD. DEVIATIONS        0.36     0.31     0.46     0.58     0.84     0.73
                           0.67     0.47     0.68     0.42     0.35     0.36

  RUNOFF
  ------
    TOTALS                 0.027    0.095    0.162    0.182    0.042    0.000
                           0.000    0.000    0.000    0.000    0.026    0.008

    STD. DEVIATIONS        0.072    0.177    0.238    0.203    0.109    0.000
                           0.001    0.000    0.001    0.000    0.058    0.022

    APOTRANSPIRATION
  ------------------
    TOTALS                 0.414    0.370    0.433    0.829    2.300    2.889
                           1.842    0.977    0.843    0.514    0.283    0.300

    STD. DEVIATIONS        0.154    0.162    0.143    0.286    0.361    0.566
                           0.923    0.451    0.315    0.202    0.111    0.139

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                 0.0012   0.0011   0.0012   0.0012   0.0012   0.0013
                           0.0014   0.0013   0.0013   0.0013   0.0013   0.0013

    STD. DEVIATIONS        0.0009   0.0008   0.0009   0.0008   0.0008   0.0009
                           0.0010   0.0010   0.0009   0.0009   0.0009   0.0009

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES              CU. FEET     PERCENT
                                 -------------------    -------------  ---------
 PRECIPITATION                     12.55   (   1.640)       8200.6     100.00

 RUNOFF                             0.542  (  0.3122)        354.41      4.322

   POTRANSPIRATION                 11.994  (  1.4021)       7836.89     95.565

 PERCOLATION/LEAKAGE THROUGH        0.01517 (  0.01037)        9.915     0.12091
   LAYER  3

 CHANGE IN WATER STORAGE           -0.001  (  0.9566)         -0.61     -0.007

*******************************************************************************
```

```
******************************************************************************

             PEAK DAILY VALUES FOR YEARS     1 THROUGH    30
    --------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                               1.15           751.410

      RUNOFF                                      0.794          518.8820

      PERCOLATION/LEAKAGE THROUGH LAYER  3        0.000124         0.08134

      SNOW WATER                                  1.91          1248.5452

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3623

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1912

******************************************************************************
```

```
******************************************************************************

             FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
               LAYER         (INCHES)        (VOL/VOL)
               -----         --------        ---------
                 1            2.3246          0.3874

                 2            4.9748          0.2764

                 3            3.7727          0.0524

             SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

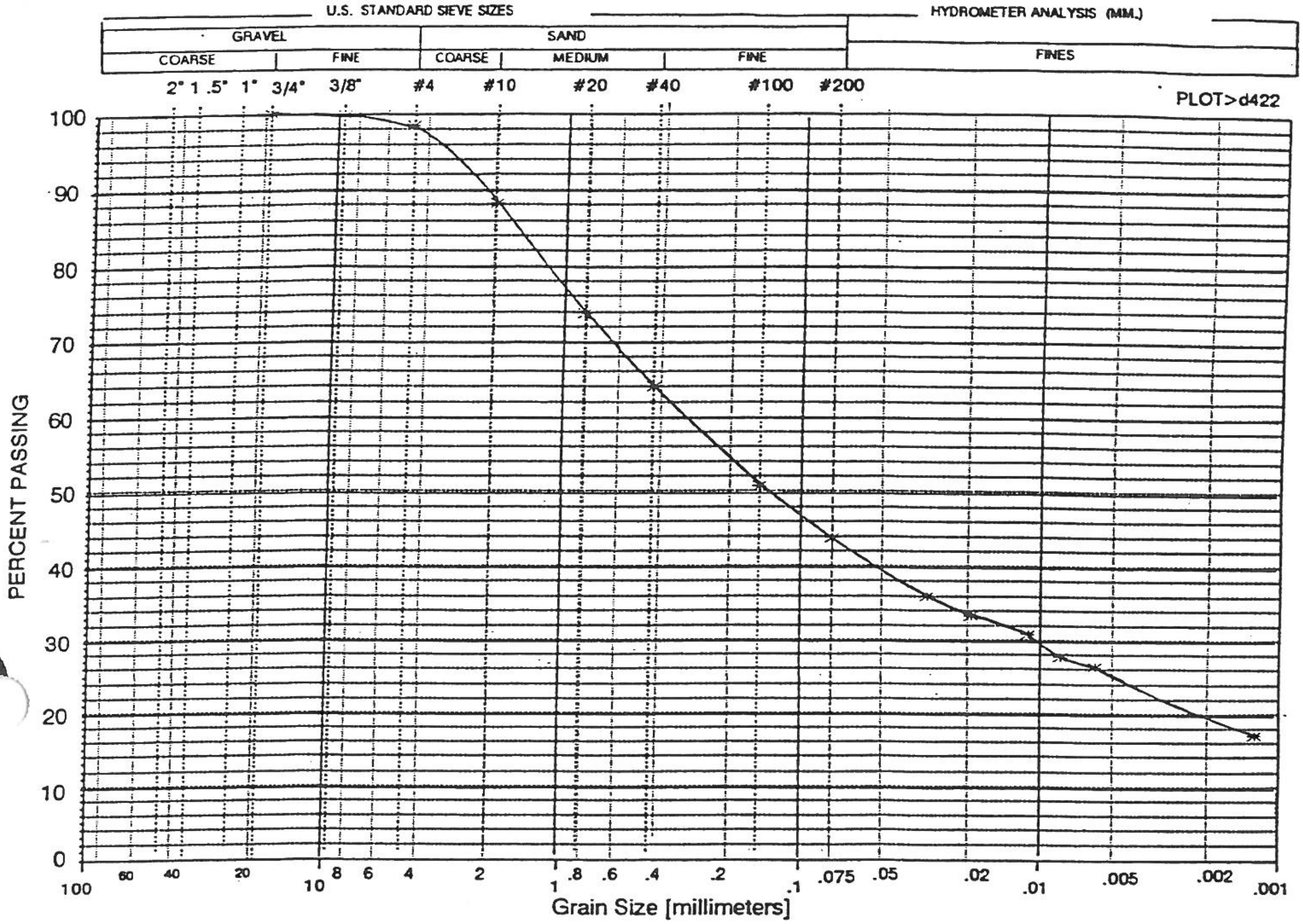
Appendix R

Soil Test Report

REPORTED TO: Rhodia Silver Bow

Date: 7-19-99

	Boring Number	Sample Number	Depth (feet)	Type of Sample	Soil Classification
x	99-10		0.5-6.0	Bulk	Clayey sand w/a trace of gravel (SC)



OTHER TESTS

	x	+	▯
Liquid Limit (%)	46.5		
Plastic Limit (%)	20.1		
Plasticity Index	26.4		
Water Content (%)	12.3		
Dry Density [pcf]			
Specific Gravity (*)	2.67*		
Porosity			
Organic Content (%)			
pH			
Shrinkage Limit [SL]			
Penetrometer [tsf]			
Qu [psf]			

* Assumed Value

PERCENT PASSING

	x	+	▯
Mass [gm]			
2"			
1-1/2"			
1"			
3/4"	100.0		
3/8"	99.7		
#4	98.5		
#10	88.3		
#20	73.8		
#40	64.1		
#100	50.7		
#200	43.9		

ASTM: D422 Sieve Set

	x	+	▯
D_{60}			
D_{30}			
D_{10}			
C_u			
C_c			

Remarks:

5'111

ARS

9301 Bryant Avenue South Suite 107

SOIL
ENGINEERING
TESTING, INC.

Bloomington, Minnesota 55420-3436

MOISTURE - DENSITY CURVE

Project RHODIA SILVER BOW -#26/46-004 JSL 200 Date 7-16-99

Reported To BARR ENGINEERING COMPANY Job No. 3604

Boring No. 99-10 Sample No. ______ Depth (ft.) 1/2-6 Location ______

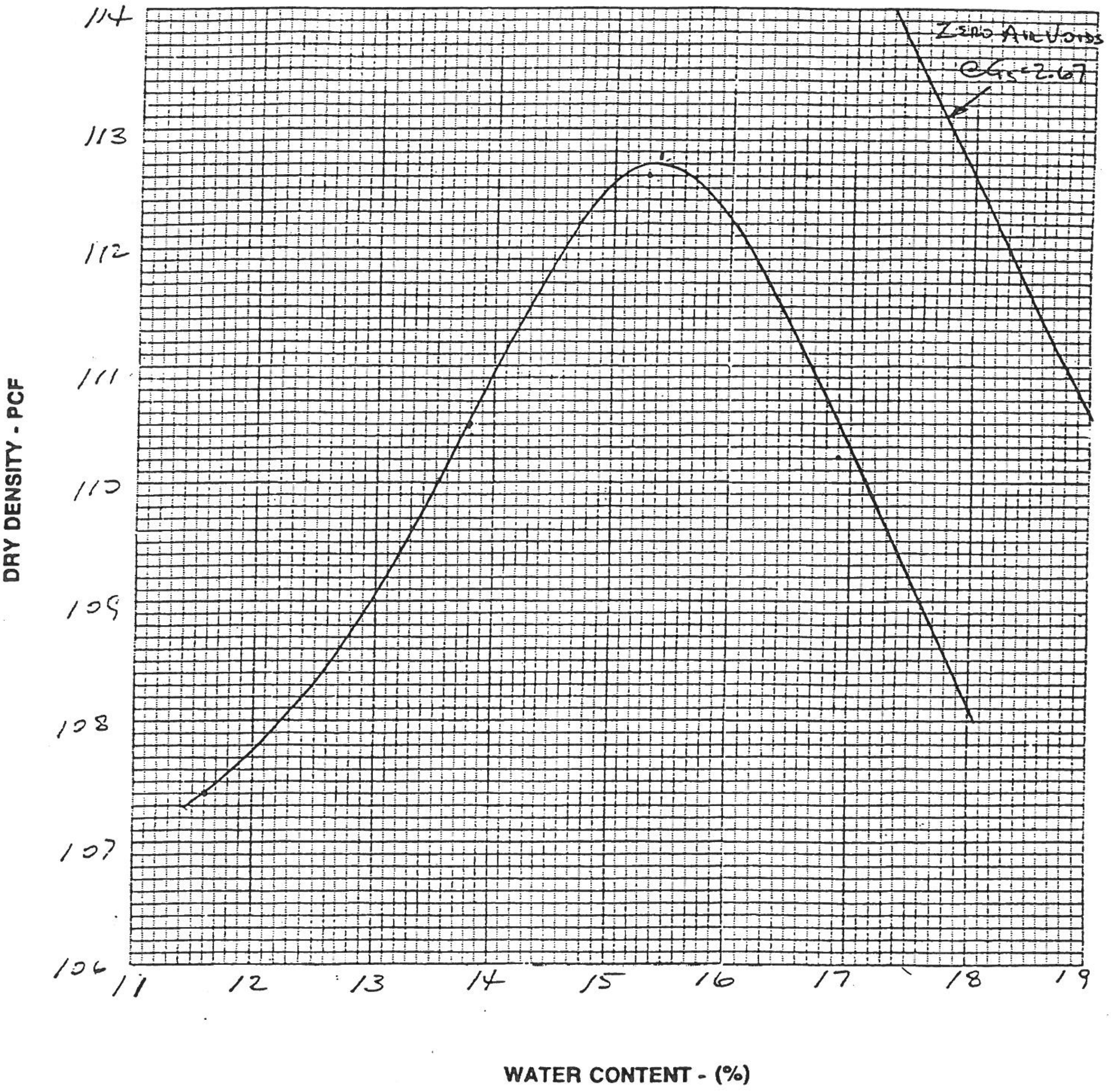
Test Method ASTM:D698, PROCEDURE B

Soil Description CLAYEY SAND w/A TRACE OF GRAVEL (SC)

AS RECEIVED WATER CONTENT: 12.3% LL=46.5%, PL=20.1%, PI=26.4

Maximum Dry Density 112.7 pcf

Optimum Water Content 15.4 %



Project: RHODIA SILVER BOW - # 26/46-004 JSL200 Date: 7-30-99

Reported To: BARR ENGINEERING COMPANY Job No.: 3604

oring No.	99-10	99-10	99-10		
Sample No.					
Depth (Ft)	½ -6	½ -6	6-12		
Type of Sample	BULK	BULK	BULK		
Soil Classification (ASTM: D2487/2488)	CLAYEY SAND W/A TRACE OF GRAVEL (SC) →				
Mechanical Analysis Dry Weight (Grams)					
Percent Passing					
Gravel 3"					
2"					
1"					
3/4"					
Sand #4					
#10					
#40					
#100					
#200					
Atterberg Limits Liquid Limit					
Plastic Limit					
Plasticity Index					
Moisture - Density Water Content (%)	3.6 *	25.8 **	33.2		
Dry Density (PCF)		100.6 #			
Unconfined Compression Maximum Load (psf)					
Hand Penetrometer (tsf)					
Organic Content (%)					
pH (Meter Method)					
c Gravity					
Resistivity (ohm-cm)					

* AIR DRIED TO CONSTANT WEIGHT FOR TWO WEEKS

** WATER HOLDING CAPACITY

INITIAL DRY DENSITY AT 12.4% W.C. BEFORE SOAKING & GRAVITY DRAINING

Permeability Test Data (Compacted Specimens)

Project: RHODIA SILVER BOW - # 26/46-004 JSL200 Date: 7-23-99

Reported To: BARR ENGINEERING COMPANY Job No.: 3604

Sample No./Designation	99-10					
Sample Type, Location Elevation or Depth	e½'-6'					
Soil Classification	CLAYEY SAND W/A TRACE OF GRAVEL (SC)					
In-Place Water Content (%)	12.3					
Moisture - Density Relation (ASTM: D698)						
Max Dry Density (PCF)	112.7					
Opt. Water Content (%)	15.4					
Atterberg Limits						
Liquid Limit	46.5					
Plastic Limit	20.1					
Plasticity Index	26.4					
Permeability Test						
% Saturation (After Test)	87.5*		* LOST WATER AFTER DISSAMBLING DUE			
Specimen Height (Inches)	3.00		TO GRAVITY DRAINAGE			
Specimen Diameter (Inches)	2.86					
Dry Density (PCF)	101.9					
% of Max. Density	90.4					
Water Content (%)	12.3					
Type of Test (Head)	Falling					
Max. Head Differential (Ft)	1.1					
Confining Pressure (Effective-PSI)	2.0					
Trial No.	12-16					
Water Temp. (°C)	23					
Co-efficient of Permeability						
K @ 20°C (Cm/Sec)	4.2×10^{-5}					
K @ 20°C (Ft/Min)	8.3×10^{-5}					

Appendix S

Required Permits and Rationale Document for Mud Still Technology

SOLVAY
asking more from chemistry®
Rhodia Inc., Member of the Solvay Group

Silver Bow Plant
P.O. Box 3146
Butte, MT 59702
406-782-1215
406-782-4498 (FAX)

June 18, 2013

Larry Kimmel
RCRA Project Manager
U.S. EPA Region 8
1595 Wynkoop Street
Mail Code: 8P-HW
Denver, CO 80202-1129

Re: Mud Still Recovery of Elemental Phosphorus–Required Permits and Rationale

Dear Mr. Kimmel:

As a result of our meeting in Denver on April 12, 2013, and consistent with the draft schedule I sent you on June 14, 2013, Rhodia has prepared a document that outlines the permit issues associated with the Mud Still Process and our interpretation of the Federal and State Regulations that would be relevant (Rationale Document - attached). The Rationale Document was prepared by Hogan Lovells US LLP at Rhodia's request and is being shared with EPA as a continuation of the dialogue that was started at the April meeting. Rhodia needs EPA's input and hopefully concurrence with our approach before a revision to the Waste Plan can be prepared and submitted, as the details in the Rationale Document impact the design and feasibility of the proposed Mud Still facility.

The attached Rationale Document contains much information about the proposed process and the applicability of Federal and State regulations. We realize a decision cannot be made quickly and another meeting may be required to more fully explain our rationale and discuss it with you. We would be happy to meet in Denver whenever you think it would be appropriate.

Thank you for your consideration of this document, and we look forward to achieving a mutual understanding on these important issues.

Sincerely,

Dan Bersanti

June 18, 2013

MUD STILL RECOVERY OF ELEMENTAL PHOSPHORUS
- - REQUIRED PERMITS AND RATIONALE - -

The purpose of this document is to identify and explain the rationale for the permits and other major regulatory programs that Rhodia, Inc. (Rhodia) believes will apply if a mud still is used to process and recover elemental phosphorus (P4) during remediation of the clarifier at Rhodia's Silver Bow, Montana site and during potential future commercial use of the mud still for P4-rich materials sent to Rhodia by other entities. Rhodia is presenting this information to continue the discussion with EPA and MDEQ on these issues that are critical to the feasibility of the mud still option, and to obtain EPA's concurrence with Rhodia's permitting and regulatory conclusions, all of which are summarized in the Conclusions Section 6 at the end of this document.

BACKGROUND

When Rhodia's elemental phosphorus plant at Silver Bow was actively producing P4, one step in the process involved placing material from the clarifier into a roaster. The roaster heated the material and produced P4 from it. When the roaster operation was ended in 1997, an estimated 500,000 gallons of this material rich in P4 was left in the clarifier under a water cap. This material has been referred to as the "clarifier sludge," and it is a D001 ignitable hazardous waste. This clarifier sludge on average has about 20% P4 and the remainder consists of wet solids, (*e.g.*, dirt, stones, grit, etc.) mostly from the phosphate rock, silica and coke that were the raw materials used to produce P4.

CONCEPTUAL PROCESS

One remediation option for the clarifier sludge would involve building a mud still facility on-site. About 500 gallons of clarifier sludge would be placed in the mud still on a batch basis, and the mud still would heat the clarifier sludge under pressure to the point where the P4 would be driven off as a vapor and then condensed into a marketable P4 product. The P4 recovery system would consist of three primary parts: (1) a stainless steel pan still with a separate electric furnace to heat the sludge and vaporize the phosphorus; (2) a stainless steel condenser to condense and accumulate the recovered phosphorus; and (3) a stainless steel recirculation tank and pump to capture the overflow water from the condenser and recirculate it back to the condenser. The process will result in a large amount (about 60% by volume of the initial mass) of solid residuals (*i.e.*, the dirt, stone, grit, etc.). The solid residuals will not spontaneously ignite because the P4 would have been removed, but they will contain some metals, including cadmium which will sometimes exceed the hazardous waste toxicity characteristic. After each batch, the residual solids would be removed and stockpiled near the clarifier. At the end of the entire phosphorus recovery operation using the mud still, which would take several years, the residual solids will be moved from the stockpile and placed into the clarifier for disposal. It is also expected that some sludge that is deep in the clarifier or embedded in cracks and corners of the clarifier cannot be safely removed from the clarifier. Such sludge, with EPA approval, would also be allowed to remain in the clarifier and disposed with the residual solids. After all residual solids have been placed back into the clarifier, the above ground portion on the clarifier walls would be pushed into the clarifier, the clarifier would be brought up to surface grade with a fill material, and finally capped using an EPA-approved cap design. The cap would extend beyond the clarifier and cover the adjacent areas where phosphorus sludge was buried pre-RCRA.

It is expected that the mud still operation will generate emissions with low concentrations of phosphorus pentoxide (P_2O_5) and phosphine (PH_3). The phosphine would be combusted in a flare-like unit, and the off gas from the combustion process and the vent gas from the mud still would be sent to a wet scrubber to remove the P_2O_5. Additionally, the physical process of removing material from the clarifier and placing this material into the mud still pans would generate some low level fugitive P_2O_5 emissions that would be released to the atmosphere.

The water that currently covers the clarifier sludge and the scrubber water will be reused in the recovery operations as cover water, clean-up water, and carrier water in the clarifier and in the process equipment, pipes, and any holding tanks or containers. Additional water will be added for these purposes from plant water wells. Any water that comes in contact with phosphorous-bearing material could pick-up small particles of P4, and therefore, is referred to as "phossy water." Phossy water should not flame, but occasionally it could smoke. We expect that all the phossy water will be used up in these processes, but if any is left at the end of the project, its pH, which usually ranges about 2.3 to 2.5, would be adjusted with lime in a tank and then the treated water would be evaporated on-site in a lined pond. There would be no discharge of the water, in any event. All wastewater should be nonhazardous both before and after the pH adjustment.

ANALYSIS OF PERMITTING/REGULATORY ISSUES

1. Hazardous Waste Permits and Regulation

A. The Mud Still

The mud still operation would be conducted pursuant to the RCRA Section 7003 Order, which was amended and issued to Rhodia on December 27, 2000 by EPA Region 8 (the "7003 Order"). See §VI.K of 7003 Order. In addition, certain selected sections of the RCRA Section 3000(h) Order issued to Rhodia by EPA Region 8 on December 2003 (the "3008(h) Order") apply to the management of the clarifier sludge. See Section VI.B. of 3008(h) Order. Most pertinent here is that Section XX of the 3008(h) Order—Other Applicable Laws—specifically will apply to work conducted under the 7003 Order, such as recovery of P4 from the clarifier. Section XX provides:

> *The Parties recognize and agree that the storage, treatment or disposal of any hazardous waste at the Facility may continue under this [3008(h)] Order and the 7003 Order without Respondent having to meet applicable hazardous waste management standards or obtain a hazardous waste management permit, and Respondent shall not be deemed out-of-compliance with any applicable law or regulation relating to hazardous waste, including the requirement to obtain a hazardous waste permit provided Respondent is otherwise in compliance with this [3008(h)] Order, which compliance will be determined pursuant to Section XXIII, and the 7003 Order, which compliance will be determined pursuant to Section XXIII.B. and C.*

This Section XX provides considerable flexibility to fashion a remedy for the clarifier that involves storage, treatment, and disposal of the sludge and its residue without a RCRA permit and other RCRA hazardous waste management requirements applying.

Although normal RCRA permitting and treatment, storage and disposal requirements would not apply based on this Section XX of the 3000(h) Order, Rhodia intends to conduct the mud still operation in an environmentally responsible manner. Material from the clarifier would be placed in the mud still pan using a long reach backhoe. While the mud still pans are being loaded and transported to the furnace, they would be placed in a larger containment pan that will collect any material that is spilled during loading and transport. Any material that is spilled can then be washed back into the clarifier for further processing.

Please note that these procedures that Rhodia will follow actually exceed the hazardous waste requirements that would otherwise apply if the mud still operation were not subject to Section XX of the 3008(h) Order. Specifically, the mud still would be a recycling process under 40 CFR §261.6(c) because it will recover a valuable product from the clarifier sludge, which is a hazardous waste recyclable material. See 40 CFR §261.6(a)(1). [1]/ Under 40 CFR §261.6(c)(1), the "recycling process itself," in this case the mud still, "is exempt from regulation except as provided in §261.6(d)." Note that 40 CFR §261.6(d) only imposes additional requirements on RCRA permitted facilities, and since the Silver Bow plant is not RCRA permitted, no additional requirements would apply. In summary, because the mud still is recovering valuable P4 from the clarifier sludge, we believe its operation would not be subject to hazardous waste management requirements.

B. The Solid Residuals from the Mud Still

We now turn to the hazardous waste regulatory issues associated with the solid residue that will remain after the P4 is recovered from the clarifier sludge. Based on the pilot test wherein the sampled solid residue regularly exhibited the toxicity characteristic for cadmium, it is expected that much of the solid residue will be hazardous due to its cadmium concentration. (The toxicity characteristic level for cadmium is 1.0 mg/l and the samples ranged from 0.43mg/l to 3.06 mg/l.) Although treatment of the solids that are hazardous to meet 40 CFR Part 268 land disposal restriction (LDR) standards prior to land disposal would normally be required under hazardous waste rules, disposal of the residual solids in the clarifier without further treatment is allowed under Section XX of the 3000(h) Order, which permits the treatment and disposal of hazardous waste from the clarifier without having to meet RCRA requirements.

---

[1]/ Montana incorporates by reference all of EPA's 40 CFR Part 261 regulations cited herein. See ARM 17.53.501.

In addition, such would also be allowed if the clarifier and its immediate surrounding area where P4 sludge had historically (pre-RCRA) been buried or released are designated by EPA as a corrective action management unit (CAMU). By designating the clarifier and its surrounding P4 sludge burial area as a CAMU, disposal of any hazardous waste residues can occur without the residue first having to be treated to meet the LDR treatment standards. See 40 CFR §264.552(a)(4). [2]/ Placement of any hazardous waste residue in a CAMU also does not trigger the requirement that the CAMU meet minimum technological requirements of a double liner and a leachate collection system. See 40 CFR §264.552(a)(5).

Designation of an area as a CAMU is expressly identified as an option for remediation in Section XII of the 3008(h) Order. ("Respondent may request designation of an area at the Facility to manage CAMU-eligible wastes.") In this case, designating the clarifier and its nearby P4 sludge burial area as a CAMU would be consistent with the applicable regulations and appropriate for the following reasons: First, the material that would be disposed in the CAMU would meet the requirements in Section XII of the 3008(h) Order and at 40 CFR 264.552(a) that it be "CAMU-eligible waste" in that it is the residue from the remedy for the clarifier. See 40 CFR §264.552(a)(1)(i). Second, the sample data indicate that the level of cadmium in the solid residue would not exceed a level that would cause the disposed material to have in it "principal hazards constituents" as defined in 40 CFR §264.552(e)(4)(i). [3]/ As such, additional treatment of the solid residue would not be required prior to its disposal in the clarifier at the end of the project. See 40 CFR §264.552(a)(4) and (e)(4)(i). Third, the CAMU would be capped in a manner that meets the standards specified in 40 CFR §552(e)(6)(iv). Fourth, groundwater monitoring would be placed around the CAMU in accordance with 40 CFR §552(e)(5). Finally, the CAMU would meet the closure and post-closure care standards in 40 CFR §552(e)(6).

---

[2]/ Montana has incorporated by reference most of the federal 40 CFR Part 264 rules, including the CAMU rule. See ARM 17.53.801.

[3]/ Carcinogens are generally to be identified as "principle hazardous constituents" if their risk level is at or above 10^{-3}. See 40 CFR § 264.552(e)(4)(i)(A)(1). The toxicity characteristic (TC) was set at a 10^{-5} risk level for carcinogens. See 55 Fed. Reg. at 11814 March 29, 1990). The 10^{-5} TC level for cadmium, a suspected carcinogen, is 1.0 mg/l. Therefore, cadmium would have to exceed 100 mg/l to be at or above the 10^{-3}risk level and be a "principle hazardous constituent." The sample results have never exceeded 3.06 mg/l. Thus, the cadmium in the solid residues will not be a "principle hazardous constituent."

In summary, either by relying on Section XX of the 3008(h) Order or by designating the clarifier and nearby P4 sludge burial area as a CAMU, the solid residues from the mud still operation could be disposed of on-site in the clarifier without additional treatment to meet LDR treatment standards.

2. Solid Waste Permits and Regulation

As noted earlier, the phossy water is not a hazardous wastewater, but it is a nonhazardous wastewater. If any wastewater remains after its use, it would be pH adjusted with lime in a tank and then conveyed into an earthen evaporation pond. There, the water would be completely evaporated, so there would be no need to discharge or dispose any water.

If evaporation of pH adjusted water in an earthen pond is needed, Rhodia proposes to apply for a solid waste management system license under ARM 17.50.508. Specifically, under ARM 17.50.508(1), Rhodia would need this license to construct and operate a solid waste management system. An earthen pond would likely be a “surface impoundment,” which is defined under Montana rules as “a natural topographic depression, human made excavation, or diked area formed primarily of earthen materials (although it may be lined with human made materials), that is designed to hold an accumulation of liquid wastes or wastes containing free liquids and is not an injection well. Examples of surface impoundments are holding, storage, settling, and aeration pits, ponds, and lagoons.” ARM 17.50.502(39). This surface impoundment/evaporation pond would also likely be a “solid waste management system” defined as “a system which controls the storage, treatment, recycling, recovery or disposal of solid waste.” ARM 17.50.502(37). “Solid wastes” include nonhazardous wastewaters that are not industrial wastewater effluents. See Montana Code Annotated, 75-10-103(7). In light of these state rules, it appears that a state solid waste management system license would be needed to construct and operate an evaporation pond for the phossy water, and Rhodia would obtain this license if any phossy water needs to be evaporated in a pond.

3. Air Permits and Regulation

Operation of the mud still will result in phosphorus pentoxide (P_2O_5), phosphine (PH_3), and nitrogen oxide (NOx) emissions. Specifically, PH_3 from the condenser would be sent to a controlled flare combustion unit that will flare combust the PH$_3$ .and destroy it. The off-gas from the combustion process as well as the vent gas from the mud still, which are almost entirely P$_2$O$_5$, would be sent to a wet scrubber. In addition, the physical process of removing material from the clarifier and placing the material into the mud still pans will generate some low level fugitive P$_2$0$_5$ emissions. Low levels of NOx will also be emitted from the combustion process.

As discussed in more detail below, under the federal Clean Air Act, a permit is not required for the construction and operation of the mud still because it is not a “major” source of air pollution and there are no applicable New Source Performance Standards (“NSPS”) or National Emissions Standards of Hazardous Air Pollutants (“NESHAPs”). In addition, no permit is required under Montana law because the mud still is not subject to the federal Clean Air Act requirements and the combustor is not an “incinerator.”

A. Federal Clean Air Act

Phosphine is listed as a hazardous air pollutant (“HAP”) under the federal Clean Air Act. 42 U.S.C. § 7412(b)(1). Phosphorus pentoxide is not a HAP. “Major” sources of HAPs must obtain a permit. In order to be a “major” source of HAPs, a source must emit ten tons per year of a single HAP or 25 tons per year of any HAPs combined. The maximum potential emissions of PH$_3$ from the operation of the mud still are well below these thresholds and, as a result, the mud still would not be a “major” source for HAPs.

NOx is a criteria pollutant. Emissions of NOx will be well below the major source threshold for criteria pollutants from this type of source (100 tons per year). 42 U.S.C. § 7602(j).

Minor sources of air pollutants may still be subject to regulation under the federal Clean Air Act if an NSPS or NESHAP applies to that source. Here, there are no applicable NSPS or NESHAPs. The phosphine is not a “contained gaseous material” because it is not in a container when combusted, and therefore, not a “solid waste” subject to regulation under the commercial and industrial solid waste incineration (CISWI) rule. See 42 U.S.C. § 7429(g)(6) (defining “solid waste” to include only “contained gaseous materials”). See 76 Fed. Reg. at 80,472-73 (Dec. 23, 2011) (“[B]urning of gaseous material, such as in fume incinerators (as well as other combustion units, including air pollution control devices that may combust gaseous material) does not involve treatment or other management of a solid waste."); 54 Fed. Reg. at 50,973, n. 5 (Dec. 11, 1989) (fume incinerators that are used to destroy gaseous emissions from various industrial processes are not subject to RCRA incinerator standards because the input (an uncontainerized gas) is not a solid waste). EPA made clear in its CISWI rule preamble discussion that combustion of uncontained gases is not subject to the CISWI rule. See 78 Fed. Reg. at 9,128 (Feb. 7, 2013). Similarly, because the uncontained gas that is combusted is not a solid waste, it cannot be a hazardous waste, and consequently, the NESHAP for hazardous waste combustors at 40 CFR Part 63, Subpart EEE does not apply.

B. State Air Permitting Program

A Montana air quality permit is required when, among other things, the source (1) is a "major" source under the federal Clean Air Act; (2) has the potential to emit 25 tons per year of any airborne pollutant; or (3) is regulated under sections 111, 112, or 129 of the federal Clean Air Act. See ARM § 17.8.743(1); ARM § 17.8.1204. As explained above, the mud still is not a "major" source because emissions of PH_3 and $P_2O_{5,}$ NOx from the operation of the mud still (including the combustion unit) are expected to be well below the relevant thresholds, and is also not subject to sections 111 (NSPS), 112 (NESHAPs), or 129 (CISWI) of the federal Clean Air Act.

In addition, an air permit would be required if the combustion unit is an incinerator that both (1) meets the definition of an incinerator under Montana's air law at 75-2-103(11) MCA, and (2) is subject to the requirements of 75-2-215 MCA, which in turn means that the combustion unit must be subject to the Montana hazardous waste provisions for incinerators at 75-2-406 MCA. See ARM §17.8.743(i)(c). The combustion unit meets neither of these criteria, (and both must be met for an air permit to be required). First, the combustion unit is not an incinerator as defined under the Montana air law at 75-2-103(11) MCA. That law defines "incinerator" as any single- or multiple-chambered combustion device that burns combustible material, alone or with a supplemental fuel or with catalytic combustion assistance, primarily for the purpose of removal, destruction, disposal, or volume reduction of any portion of the input material." MCA §75-2-103(11). Excluded from this definition, however, are "safety flares used to combust or dispose of hazardous or toxic gases at industrial facilities . . . .such as . . .

elemental phosphorus plants." Id. § 11(b)(i). The combustor functions as a safety flare and is used to combust hazardous toxic gases (here, PH_3) at an industrial facility. As such, it can be interpreted not to be an "incinerator" under Montana's air law. Second, the combustion unit is not the type of incinerator that is subject to regulation under Montana's hazardous waste law at 75-10-406 MCA. Fume incinerators that are used to destroy gaseous emissions from various industrial processes are not regulated under the hazardous waste law as incinerators because the input (an uncontainerized gas) is not a solid waste, and therefore, the gases cannot be a hazardous waste subject to regulation. See 54 Fed. Reg. at 50,973, n. 5 (Dec. 11, 1989). The combustion unit will only receive and destroy fumes, *i.e.*, off-gases from the mud still, and therefore, is not regulated as an incinerator under Montana's hazardous waste law. Because the combustion unit is not both an incinerator as defined under Montana's air law and as regulated under Montana's hazardous waste law, a state air quality permit is not required. See ARM § 17.8.743(1)(c).

In summary, after review of the relevant federal and state regulations, we believe that the construction and operation of the mud still does not require a construction or operating permit under the federal Clean Air Act or state air permitting program. Notwithstanding, the air emissions would be controlled through the proposed operation of the controlled flare combustion unit and the wet scrubber.

4. **Future Commercial Operation**

Construction and use of the mud still process to recover P4 from only the clarifier, by itself, would be cost–prohibitive and very difficult to justify. To garner support for the mud still internally within Rhodia, it is important that there be a reasonable regulatory path and supportive regulators that would enable Rhodia, after it completes processing of the clarifier sludge, to use the mud still to receive and recover P4 on a commercial basis from other generators and suppliers of phosphorus rich material. Potential customers might include other elemental phosphorus manufacturers who are dismantling and/or remediating their plants, some pursuant to EPA or state orders, and potentially other entities who generate or produce phosphorus rich solid streams. Our review of the applicable regulations for a commercial mud still operation follows, and we request EPA's confirmation of our conclusions.

With regard to air regulation and permits, there is no difference between Rhodia's non-commercial use of the mud still to process the clarifier sludge and Rhodia's use of the mud still commercially. No air permits are triggered by either the non-commercial or commercial operation.

Similarly, the handling of any remaining phossy wastewater would be subject to the same solid waste management system license whether the mud still is used non-commercially to recover P4 from the clarifier sludge or to recover P4 from other generators on a commercial basis. All remaining water, if any, from the non-commercial and commercial operations would be similarly pH adjusted with lime in tank units and then evaporated in a pond, and the evaporation pond would require a solid waste management system license under ARM 17.50.508(1).

The regulatory analysis regarding storage of the phosphorus-rich material prior to its processing in the mud still, however, would be different for the non-commercial versus the commercial operation of the mud still. This is because when Rhodia is recovering P4 non-commercially solely from the clarifier sludge, it is subject to Section XX of the 3008(h) Order, which expressly allows the storage, treatment or disposal of any hazardous waste to occur without meeting applicable hazardous waste management standards or obtaining a hazardous waste management permit. That flexibility is not available to Rhodia for commercial processing of P4-rich material from other generators.

The permit analysis will depend on whether the phosphorus rich material that is being brought to the Silver Bow site for P4 recovery is considered a hazardous waste recyclable material or an intermediate product that is being further processed to recover P4. If the material is an intermediate, it would not be subject to waste regulation at all. It could be brought to the Rhodia facility, stored in tanks, and processed in the mud still to recover P4 without a RCRA permit. If the material being sent to Rhodia for P4 recovery is a waste, and assuming it is hazardous due to its potential to ignite, Rhodia would also need to meet hazardous waste requirements for management of the incoming P4-rich hazardous waste prior to its P4 recovery. Specifically, if the incoming hazardous waste needs to be stored prior to being placed in the mud still for P4 recovery, such storage would require a hazardous waste permit. <u>See</u> 40 CFR

§261.6(c)(1). As discussed above, the mud still recovery operation itself would not be subject to RCRA permitting since it is an exempt recycling unit recovering P4 from, in this case, recyclable material, *i.e.*, a hazardous waste rich in P4. Id.

Regarding the solid residuals that remain after the mud still processing, they would need to be characterized to determine if they are hazardous whether the material brought to the Rhodia site for mud still processing is an intermediate product or a hazardous waste recyclable material. The solid residuals would be a solid waste, *i.e.*, a material intended for discard, in either case. If the solid residuals contain cadmium or some other RCRA metal above the hazardous waste toxicity characteristic level, the residues would have to be treated to meet LDR treatment standards prior to disposal, and they cannot be stored on Rhodia's site for more than 90 days without a RCRA permit. See 40 CFR §268.40(a) and §262.34(a). Further, the solid residues (treated or untreated) cannot be placed into an on-site CAMU since a CAMU at Rhodia's plant site cannot be used for disposal of residues from the processing of an off-site, third party's material. See 40 CFR §264.552(a) and 58 Fed. Reg. at 8664 (February 16, 1993).

Given these limitations, Rhodia's first option would be to collect the solid residuals, store them for up to 90 days in a tank, containers or a containment building, and send them off-site for LDR treatment and disposal, all of which could be done without Rhodia having to obtain a hazardous waste permit. Alternatively, Rhodia could obtain a hazardous waste permit that would allow it to store the solid residuals for more than 90 days and/or treat the residuals on-site to meet LDR treatment standards. Presumably the treatment would render the waste nonhazardous, and in that case, they could be disposed of in an on-site or off-site authorized nonhazardous waste landfill, which in Montana would require a state solid waste management system license under ARM 17.50.508.

In sum, the hazardous waste permit and LDR requirements for the commercial operation of the mud still would be more extensive than for non-commercial operations.

CONCLUSIONS

With regard to the non-commercial recovery of P4 from the clarifier sludge using the mud still, Rhodia believes, and requests EPA's concurrence, that:

- A hazardous waste permit is not required and other hazardous waste regulations will not apply to the operation of the mud still unit itself, although Rhodia plans to operate it to minimize and capture any releases;
- The storage and disposal of the solid residue from the mud still recovery operation that exhibits a hazardous waste characteristic, such as for cadmium, also would not be subject to hazardous waste permitting or other hazardous waste regulations based on Section XX of the 3008(h) Order. Alternatively, a CAMU would provide the same relief, and if EPA chooses not to rely on Section XX, we request EPA and MDEQ confirm that they will designate a CAMU covering the clarifier and the nearby P4 sludge pre-RCRA burial area;
- Any phossy water that remains after the mud still operation that is treated with lime in a tank-based system may be disposed into a pond for evaporation on-site if a solid waste management system license is obtained from the state; and
- No air permit is required for the phosphine and phosphorus pentoxide emissions from the mud still operation. Notwithstanding, Rhodia will control the, emissions through the controlled flare combustion unit and the wet scrubber.

With regard to commercial operation of the mud still to recover P4 from material brought to the site from other entities, Rhodia believes, and requests EPA's concurrence, that:

- The air permitting issues are the same for commercial versus non-commercial operations, *i.e.*, no air permits are required;
- The phossy water issues are the same for commercial and non-commercial operation of the mud still, *i.e.*, any remaining phossy water that is placed into a pond for evaporation will require a state solid waste management system license;
- All residual solids from commercial P4 recovery, assuming they have hazardous waste levels of cadmium or other constituents, will need to be treated to meet LDR treatment standards prior to disposal. Rhodia would need a hazardous waste permit to store or treat such residuals for more than 90 days. Assuming the solid residuals after treatment no longer exhibit a

hazardous waste characteristic, the treated solid residuals could be sent off-site for disposal in a nonhazardous waste landfill, or disposed on-site in a nonhazardous waste landfill if Rhodia obtains a state solid waste management system license;

- If the P4-rich material Rhodia receives from off-site entities is an intermediate product and not a solid or hazardous waste, Rhodia may receive it, store it prior to the mud still recovery, and use the mud still to recover the valuable P4, all without a hazardous waste permit. If, however, the P4 rich material is a solid and hazardous waste, it can only be received and stored by Rhodia if Rhodia has a hazardous waste permit. The mud still recovery operation, in any case however, would be a recycling unit that is exempt from permitting and other RCRA requirements; and
- Finally, Rhodia requests confirmation from MDEQ, and concurrence by EPA Region 8, that they will support the permitting and licensing required for commercial operation of a mud still at the Silver Bow plant.

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Rhodia Inc., Member of the Solvay Group

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July 3, 2013

Larry Kimmel
RCRA Project Manager
U.S. EPA Region 8
1595 Wynkoop Street
Mail Code: 8P-HW
Denver, CO 80202-1129

Re: Supplement to Mud Still Recovery of Elemental Phosphorus Required Permits and Rationale

Dear Mr. Kimmel:

In the Rationale Document that I sent you on June 21, 2013, we explained that there are two independent bases that support EPA fashioning a remedy for the clarifier that allows storage, treatment and disposal of the sludge and its residue without Rhodia having to obtain a RCRA permit or meet otherwise applicable hazardous waste management standards. The first basis is Section XX of the 3008(h) Order which expressly waives such RCRA requirements. The second basis is if EPA were to designate the clarifier and the surrounding area where P4 sludge has historically been buried as a corrective action management unit (CAMU) under the CAMU rules at 40 CFR § 264.552. There is a third independent basis for such flexibility, which we failed to mention in the Rationale Document.

Specifically, EPA has long recognized that "[u]nder Section 7003, EPA has the discretion to waive any RCRA requirements at a site where appropriate to implementing remedial actions." 58 Fed. Reg. at 8679 (Feb. 16, 1993). EPA further explained that when the remediation occurs under a 7003 Order, EPA can allow use of a CAMU without following its CAMU rules and regardless of the RCRA permit status of the facility. Id. EPA reiterated this authority in its October 1997 "Guidance on the Use of Section 7003 of RCRA" at page 4, where it said "persons complying with a RCRA Section 7003 Order under EPA's direction may treat, store, or dispose of waste without securing a RCRA permit for the actions required by that Order." As EPA explained in OSWER Policy Directive Number 9522.00-2 (November 16, 1987), such flexibility stems from the language of RCRA Section 7003, 42 USC §6973, which begins "Notwithstanding any other provision of this chapter,…".

In summary, even if there were no Section XX in the 3008(h) Order, and even if EPA does not want to go through the formal process of designating a CAMU at the site pursuant to 40 CFR § 264.552, because the clarifier remedy is being done under the 7003 Order, EPA can waive the hazardous waste storage, treatment and disposal requirements, including permits and land disposal restriction treatment standards, in connection with the mud still operation and disposal of the residues therefrom. Please let me know if you have any questions regarding this, or desire additional information.

Sincerely,

Dan Bersanti

Appendix T

Analysis of Air Quality Permitting Requirements for On-site Phosphorus Recovery

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Technical Memorandum

To: Montana Department of Environmental Quality – Air Resources Management Bureau (Department)

From: Barr Engineering Company

Subject: Analysis of Air Quality Permitting Requirements for On-site Phosphorus Recovery Alternative (i.e., Mud Still Operations)

Date: November 25, 2013

Project: 26460006

Solvay is evaluating alternatives for the management and final disposition of the contents of the Silver Bow facility's clarifier to fulfill the requirements of the Amended Administrative Order under RCRA § 7003 ("7003 Order") that was issued to Solvay's (f.k.a., Rhodia) Silver Bow facility near Butte, Montana by Environmental Protection Agency (EPA), Region 8 on June 29, 2000, and amended on December 27, 2000. One alternative involves on-site phosphorus recovery using the mud still technology that was the subject of the extensive treatability studies conducted at the Silver Bow Plant. The treatability studies included construction and operation of a pilot-scale mud still. The Department determined that the equipment associated with the pilot-scale mud still did not have the potential to emit more than 25 tons per year (TPY) of any regulated airborne pollutant, and the predicted emissions of phosphorus are expected to be less than 10 TPY. Therefore, the pilot-scale mud still did not require a Montana Air Quality Permit (MAQP) or a Title V Operating Permit. A copy of the Department's letter is provided in Attachment 1.

This memorandum evaluates the potential to emit from a production-scale mud still that would be constructed at the Silver Bow Plant, should EPA select this alterative for the final disposition of the clarifier contents and concludes that a MAQP or Title V Operating Permit would not be required for the same reasons identified above. Solvay is seeking concurrence from the Department as to the need for MAQP or Title V Operating Permit.

Process Description

A production-scale mud still would be constructed at the Silver Bow Plant to vaporize elemental phosphorus from the crude phosphorus and recover the phosphorus as a useable product. This alternative consists of excavation of the crude phosphorus and transfer to a metal skip (the metal skip would be placed in the furnace), an electric roasting furnace, a condenser, an oxidation chamber and a wet scrubber. The furnace would be continuously purged with nitrogen to maintain the necessary reducing atmosphere and to drive the water and phosphorus vapors through the process. Residues that remain in the skip after the phosphorus has been vaporized would be transferred to the residue silo via vacuum system with a cyclone separator and a bag filter to control particulate emissions. The conceptual process flow diagram is depicted on Figures 1 and 2.

The production-scale mud still would be designed to process five batches over seven days with continuous operations (i.e., 24-hours per day; 7-days per week). Each batch would process about 6,700 pounds of crude phosphorus (about 25 percent elemental phosphorus by weight). The condenser in the pilot-scale plant had an average phosphorus recovery rate of greater than 98 percent based on the batches that were run to completion (FEG 2012).

Potential Emission Sources

The MDEQ identified two potential sources of air pollutant emissions based on the Clarifier Waste Treatability Study Phase 2 Report – Pilot Plant Design and Testing (FEG 2011) (i.e., phosphorus vapors at the condenser vent and combustion emissions from the propane burner utilized in one of three potential still designs. Note: the propane burner option was not selected for the pilot-scale system). The production-scale mud still would have the same emission sources as the pilot-scale mud still (i.e., phosphorus vapors at the condenser vent). However, the production-scale plant would vent the condenser gases to an oxidation chamber. The oxidation chamber was considered integral to the process for safety reasons because it provides a controlled environment for oxidation of reduced phosphorus compounds that could be in the condenser exhaust. These reactions are spontaneous and would occur whether the condenser exhaust were vented directly to atmosphere or routed through the oxidation chamber; therefore, the oxidation chamber does not materially affect emissions to the atmosphere. A wet scrubber would be used to control particulate emissions; however, use of the wet scrubber was not considered in the permit applicability analysis.

Other sources of fugitive particulate emissions include residue management, and crude phosphorus excavation and handling. Mobile diesel-powered equipment would be used to excavate the crude phosphorus and transfer the skip to the furnace area. Particulate emissions from crude phosphorus excavation and handling would be negligible because the sludge would be maintained in a wet condition to prevent oxidation reactions. Some visible emissions may be present during crude phosphorus excavation and transfer to the skip. The skip would be covered once it is fully loaded and during transport to the mud still.

Potential to Emit Regulated Air Pollutants

On-site phosphorus recovery would result in emissions of regulated air pollutants. However, air emissions from the project would be less than any amount which would trigger requirements to obtain air quality construction and/or operating permits under Administrative Rules of Montana (ARM) 17.8.743, ARM 17.8.904 or ARM 17.8.1204.

Potential pollutants include elemental phosphorus (P_4), phosphine (PH_3), phosphorus pentoxide (P_4O_{10}) and lead (Pb). P_4 and PH_3 are classified as Hazardous Air Pollutants (HAPs). Emissions of these compounds would also be counted as particulate emissions. To be conservative in the particulate emissions calculation, it was assumed that all phosphorus compounds emitted were in the form of P_4O_{10}.

Calculated uncontrolled emissions from the proposed project at potential to emit are as follows:

Total Particulates (PM):	10.2 tons/yr
Particulates less than ten microns (PM_{10})	10.0 tons/yr
Particulates less than two point five microns ($PM_{2.5}$)	9.9 tons/yr
Lead	0.5 ton/yr
Hazardous Air Pollutants (HAPs)	4.8 tons/yr

No emissions of sulfur dioxide, nitrogen oxides, carbon monoxide, or volatile organic compounds are expected to occur.

Emission calculations are located in Attachment 2 to this technical memorandum.

Based on potential emissions, the requirements for a new source to obtain an air quality permit under the State of Montana regulations are summarized in Table 1 on the following page. In addition, the mud still

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does not meet the definitions of any of the source categories that are required to obtain permits. These regulations and conclusions are summarized in Attachment 3.

Table 1

MT Air Quality Permit Requirements by Emission Rate

Regulation	Applies To:	Applicable	Reason
17.8.743(a)	Construction of new sources with a potential to emit of more than 5 tons per year of lead.	No	The mud still would not emit more than 5 tons of lead per year. Maximum potential emissions of lead were estimated at 0.5 tons per year.
17.8.743(e)	Construction of sources with a potential to emit of more than 25 tons per year of any air pollutant, other than lead.	No	The mud still would be a source of particulate emissions, but potential emissions of particulates (PM, PM10 and PM2.5) were estimated to be $\leq$ 10.2 tons per year.
17.8.904	Major new stationary sources of air pollution	No	The mud still would not be a major new source of particulate emissions (>100 ton/yr any FCAA air pollutant or > 70 ton/yr PM_{10} in a non-attainment area) because potential emissions of particulates (PM, PM10 and PM2.5) were estimated to be $\leq$ 10.2 tons per year.
17.8.1204(1)(a)	An operating permit is required for major sources. A major source has the potential to emit 100 tons or more per year of any air pollutant.	No	The mud still would be a source of particulate emissions, but potential emissions of particulates (PM, PM_{10} and $PM_{2.5}$ were estimated to be $\leq$ 10.2 tons per year.
17.8.1204(1)(a)	An operating permit is required for a major source of hazardous air pollutants (HAPs) because it has potential emissions of more than 10 tons per year of a single HAP or the total of all HAPs emitted exceeds 25 tons per year.	No	The mud still would be a source of HAPs (e.g., P_4, PH_3). The potential emissions of P_4 and/or PH_3 as a single HAP or as total HAPs would be less than 4.8 tons per year. Potential emissions of PH_3 are based on the very conservative assumption that all elemental phosphorus would be emitted as PH_3.

The uncontrolled emission rates in the potential to emit calculations are based on the batch processing of the crude phosphorus with an average recovery rate of 98% and 6,670 lbs per batch of a sludge containing 25wt% elemental phosphorus. The potential to emit calculations assume continuous operations (24-hours per day; 7 days per week). The potential to emit calculations for HAPs assume as a worst case that all elemental phosphorus would be emitted as PH_3. In reality, the majority of phosphorus would be emitted as oxidized phosphorus compounds and only a small fraction would be emitted as PH_3.

The scrubber would be considered emission control equipment, and was not included in the assessment of the uncontrolled potential to emit emission rate for the permitting applicability analysis, which demonstrates that a MAQP or Title V Operating Permit would not be required. However, Solvay would operate the scrubber to further reduce air emissions from the elemental phosphorus recovery operations. The elemental phosphorus recovery operations (including the operation of the scrubber) would be conducted in accordance with the 7003 Order, which could give regulators the equivalent of federally enforceable permit conditions requiring operation of the wet scrubber whenever the phosphorus recovery system were operated. The controlled emissions estimates are included on Table 1 of Attachment 2. The controlled emissions assume that the wet scrubber would have a 90% removal efficiency.

After each roasting cycle was completed, the skip would be cleaned out by a vacuum system and the material would be pneumatically transferred to a storage silo. Solids would be transferred by gravity from the silo into “super sacks” for final disposal. No controls were assumed in the potential to emit calculation for either material handling operation. EPA emission factors for uncontrolled material handling operations were used to calculate these emissions. For the pneumatic transfer, the AP-42 calculation procedures for conveyor drops in Chapter 13.2.4 were used. This approach was taken to account for particulates entrained in the air used for pneumatic transport. The velocity of the pneumatic transfer air exiting the storage silo vent pipe was used for the wind velocity in emission calculations. Air velocities within the silo where the actual material drop occurs would be much lower. As noted above, the silo would be equipped with a cyclone and a baghouse or bin vent filter for material recovery and for particulate control. For the gravity transfer of material to the super sacks, emission factors for conveyor transfers of crushed and pulverized stone and minerals from AP-42 Chapter 11.19.2 were used based on the assumption that the residual material would be similar in nature to pulverized stone or pulverized minerals. The uncontrolled conveyor drop emission factor for PM2.5 was listed as “non-detect”. So, to be conservative, $PM_{2.5}$ emissions were assumed to be equal to PM_{10}.

Moving the skips filled with crude phosphorus from the clarifier to the mud still and returning the empty skips to the clarifier would generate a small amount of fugitive dust emissions associated with the movement of heavy equipment on unpaved plant roads. Emission calculation procedures for unpaved roads from AP-42 Chapter 13.2.2 were used to calculate fugitive emissions from unpaved roads.

Conclusion

This memorandum evaluated the potential to emit from a production-scale mud still that would be constructed at the Silver Bow Plant, should EPA select this alterative for the final disposition. The equipment associated with the production-scale mud still does not have the potential to emit more than 25 TPY of any regulated airborne pollutant, and the predicted emissions of hazardous air pollutants were

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estimated to be less than 10 TPY. As such, the On-site Phosphorus Recovery Alternative would not require a MAQP or Title V Operating Permit.

References

FEG 2011. Clarifier Waste Treatability Study Phase 2 Report – Pilot Plant Design and Testing. Prepared for Rhodia Inc. by Franklin Engineering Group Inc. February 2011.

FEG 2012. Clarifier Material Treatability Study, Phase 3 Report, Pilot Plant Operation. Prepared for Rhodia Inc. by Franklin Engineering Group Inc. February 2012.

US EPA AP-42, Fifth Edition from US EPA's Clearinghouse for Inventories and Emission Factors (CHIEF) http://www.epa.gov/ttn/chief/ap42/index.html

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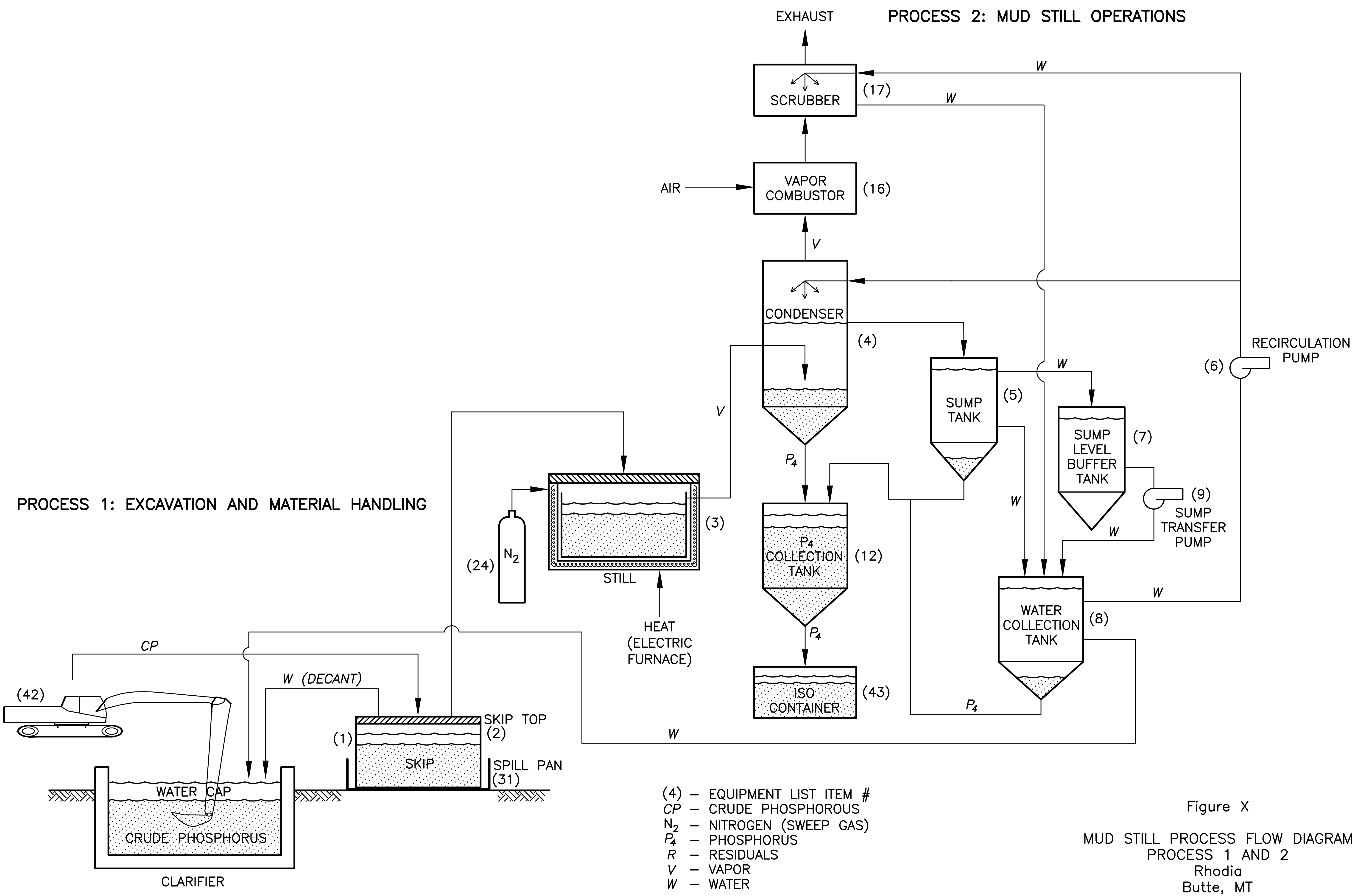
Figures



(4) – EQUIPMENT LIST ITEM #
CP – CRUDE PHOSPHOROUS
N_2 – NITROGEN (SWEEP GAS)
P_4 – PHOSPHORUS
R – RESIDUALS
V – VAPOR
W – WATER

Figure X

MUD STILL PROCESS FLOW DIAGRAM
PROCESS 1 AND 2
Rhodia
Butte, MT

CADD USER: Rick Gustner FILE: M:\ADEPTWORK\RLG\2646000630_MUD STILL PFD.DWG PLOT SCALE: 1:1 PLOT DATE: 11/6/2013 9:25 AM
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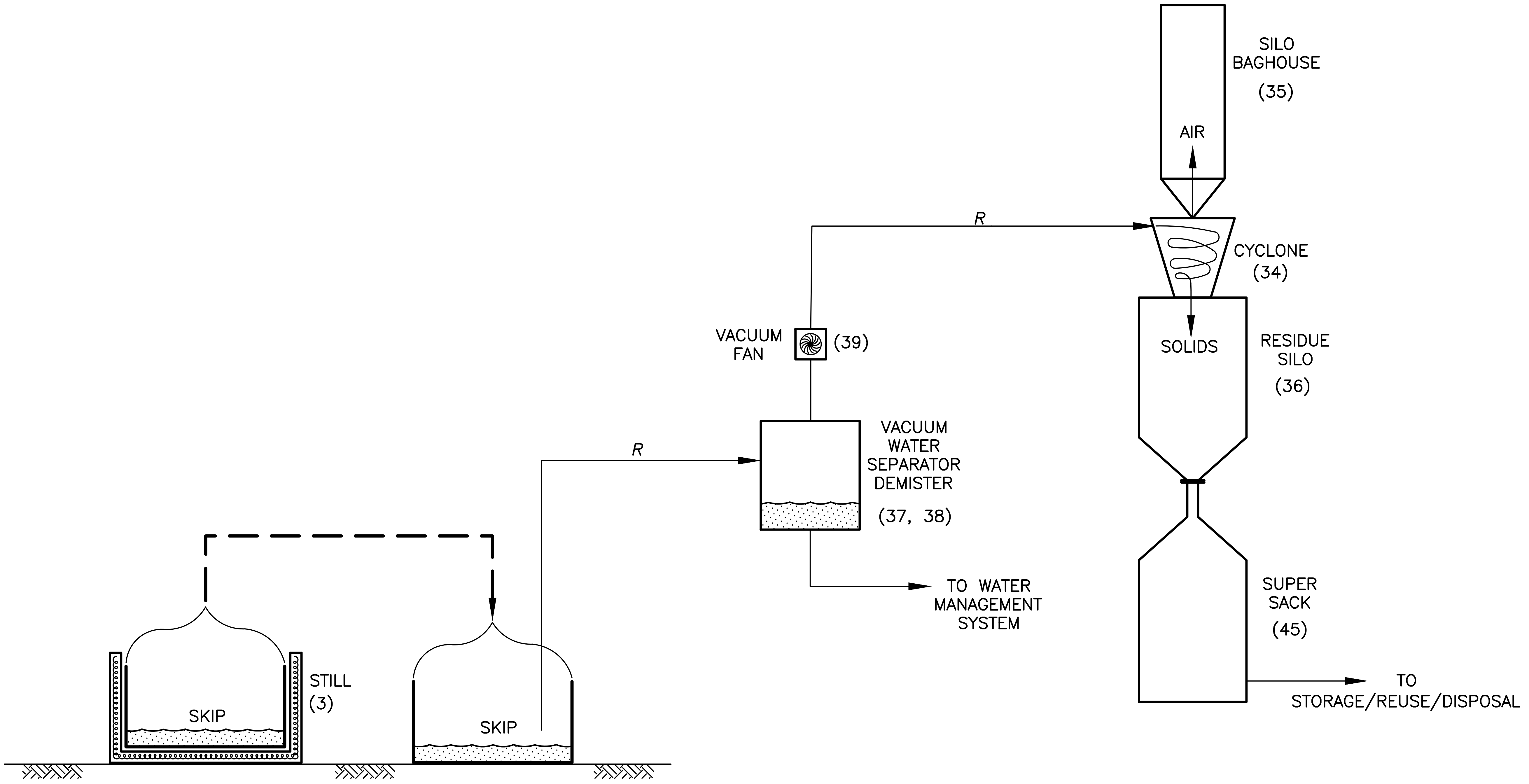
. rlg M:\AdeptWork\RLG\2646000630_Mud Still PFD.dwg Plot at 0 11/05/2013 14:34:27

PROCESS 3: PROCESS RESIDUE MANAGEMENT



(4) – EQUIPMENT LIST ITEM #
CP – CRUDE PHOSPHOROUS
N_2 – NITROGEN (SWEEP GAS)
P_4 – PHOSPHORUS
R – RESIDUALS
V – VAPOR
W – WATER

Figure X

MUD STILL PROCESS FLOW DIAGRAM
PROCESS 3
Rhodia
Butte, MT

CADD USER: Rick Gustner FILE: M:\ADEPTWORK\RLG\2646000630_MUD STILL PFD P3.DWG PLOT SCALE: 1:1 PLOT DATE: 11/7/2013 10:51 AM
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rlg M:\AdeptWork\RLG\2646000630_Mud Still PFD P3.dwg Plot at 0 11/07/2013 10:46:12

Attachment 1

Permit Determination Letter – Pilot-scale Mud Still
Montana Department of Environmental Quality
Air Resources Management Bureau (Dec 2009)

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Montana Department of
ENVIRONMENTAL QUALITY
Brian Schweitzer, Governor
P. O. Box 200901 Helena, MT 59620-0901 (406) 444-2544 Website: www.deq.mt.gov

December 28, 2009

Dan Bersanti
Rhodia, Inc.
119130 German Gulch Road
Butte, MT 59570

Dear Mr. Bersanti:

The Montana Department of Environmental Quality – Air Resources Management Bureau (Department) has completed its Montana Air Quality Permit (MAQP) determination for the Clarifier Waste Treatability Study Phase 2 – Batch Still Technology Testing that Rhodia, Inc. (Rhodia) is proposing at their Silver Bow, Montana facility. Rhodia proposes to recover phosphorus from the clarifier sludge at the former Rhodia phosphorus manufacturing facility. The sludge contains approximately 500,000 gallons of solidified phosphorus-rich waste. The Department was supplied a batch still technology evaluation report prepared by Franklin Engineering Group, Inc. (FEG) which described this phase of the project as a pilot study to evaluate the performance of three different types of vessels (stills) and associated heating systems used to heat batches of the clarifier sludge and vaporize the phosphorus. The phosphorus vapor would be routed to a condenser system which utilizes water to condense the phosphorus for recovery. All three still designs would utilize the same condenser system.

After reviewing the FEG report, the Department noted two potential sources of air pollutant emissions. These sources include escaping phosphorus vapor at the condenser vent (proposed to be used in all three still designs) and combustion emissions from the propane burner utilized in the third still design (with a rated capacity of 0.525 million British Thermal units per hour (MMBtu/hr)). Phosphorus is designated by the Environmental Protection Agency as a hazardous air pollutant (HAP). According to the FEG report, the mass balance indicates that approximately 0.09 pounds of phosphorus vapor per batch run would be vented to the atmosphere through the condenser vent based on the vapor pressure of phosphorus at the venting temperature at vapor-liquid equilibrium. This calculation does not account for any additional phosphorus entrainment in the gas stream vented to the atmosphere that may be encountered due to condenser inefficiency. Rhodia was unable to provide an accurate condenser efficiency value; however, they did predict that the vast majority of the phosphorus vapor would be recovered within the condenser. The Department believes that because the condenser would be designed to recover the maximum amount of phosphorus as possible that a high degree of efficiency can be expected.

Pursuant to the Administrative Rules of Montana (ARM) 17.8.743, any facility or emitting unit that has the potential to emit more than 25 tons per year (TPY) of any airborne pollutant is required to have an MAQP. Additionally, ARM 17.8.1201(23) states that any source with the potential to emit more than 10 TPY of an individual HAP is considered a major source of air pollutants and therefore required to have a Title V Operating Permit. While the Department acknowledges that the pilot study will consist of only 10 to 15 batch tests, the total potential emissions are calculated based on continuous operation during a year (8,760 hours per year). Upon review of the information provided by Rhodia and the FEG report, the Department has determined that the equipment associated with this pilot study does not exhibit the potential to emit more than 25 TPY of any regulated airborne pollutant and therefore does not require an MAQP. Predicted emissions of phosphorus are expected to be less than 10 TPY and therefore do not require a Title V Operating Permit. These conclusions pertain only to the proposed pilot study and do not represent a permit determination for a production-scale system. The following information summarizes the Department's determination.

Potential Emissions from Condenser Vent:
Mass Balance indicates 0.09 pounds of phosphorus vented per batch run (lb/batch) (Rhodia information)
Length of batch run = 5 hours (Rhodia information)
Phosphorus emissions = (0.09 lb/batch) / (5 hours/batch) = 0.018 lb/hr (based on mass balance)
Phosphorus condensed under ideal conditions = 93 lb/batch (Rhodia information)
Condenser efficiency = 90% (assumption)
Phosphorus vented based on condenser efficiency = (1-90%) * (93 lb/batch) / (5 hours/batch) = 1.86 lb/hr
Total phosphorus emissions = (0.018 lb/hr + 1.86 lb/hr) * (8760 hours/year) / (2000 lb/ton) = 8.2 TPY

Potential Emissions from Propane Combustion:
Propane burner capacity = 0.525 MMBtu/hr (Rhodia information)
Propane heat content = 91.5 MMBtu/10^3 gallons propane (AP-42, Section 1.5, Table 1.5-1, 7/08)
Propane burner capacity = (0.525 MMBtu/hr) / (91.5 MMBtu/10^3 gallons) = 5.74E-3 10^3 gal/hr

Particulate Matter with an Aerodynamic Diameter of 10 microns or less (PM_{10}) Emissions:
Assume all particulate matter is PM_{10} (AP-42, Sec. 1.5, Table 1.5-1, 7/08)
Emission Factor = 0.7 lb/10^3 gal (AP-42, Sec. 1.5, Table 1.5-1, 7/08)
Calculation: (8760 hrs/yr) * (5.74E-3 10^3 gal/hr) * (0.7 lb/10^3 gal) * (ton/2000 lb) = 0.02 TPY

Oxides of Nitrogen (NO_x) Emissions:
Emission Factor = 13 lb/10^3 gal (AP-42, Sec. 1.5, Table 1.5-1, 7/08)
Calculation: (8760 hrs/yr) * (5.74E-3 10^3 gal/hr) * (13 lb/10^3 gal) * (ton/2000 lb) = 0.36 TPY

Carbon Monoxide (CO) Emissions:
Emission Factor = 7.5 lb/10^3 gal (AP-42, Sec. 1.5, Table 1.5-1, 7/08)
Calculation: (8760 hrs/yr) * (5.74E-3 10^3 gal/hr) * (7.5 lb/10^3 gal) * (ton/2000 lb) = 0.19 TPY

Volatile Organic Compounds (VOC) Emissions:
Emission Factor = 0.8 lb/10^3 gal (VOC = TOC – CH_4, AP-42, Sec. 1.5, Table 1.5-1, 7/08)
Calculation: (8760 hrs/yr) * (5.74E-3 10^3 gal/hr) * (0.8 lb/10^3 gal) * (ton/2000 lb) = 0.02 TPY

Oxides of Sulfur (SO_x) Emissions:
Emission Factor = 0.10S lb/10^3 gal (S = sulfur content in gr/100 ft^2, AP-42, Sec. 1.5, Table 1.5-1, 7/08)
S = 50 gr/100 ft^2 (ARM 17.8.322(5), highest content allowable by ARM)
Emission Factor = 0.10 * 50 = 0.50 lb/10^3 gal
Calculation: (8760 hrs/yr) * (5.74E-3 10^3 gal/hr) * (0.5 lb/10^3 gal) * (ton/2000 lb) = 0.01 TPY

If you have any questions regarding this determination or any other permitting questions concerning your facility, please contact me at (406) 444-2467.

Sincerely,

Ed Warner

Ed Warner
Environmental Engineer
Montana Department of Environmental Quality – Air Resources Management Bureau
ewarner@mt.gov

Attachment 2

Emission Calculations
On-site Phosphorus Recovery Alternative

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Attachment 2 Table 1

Solvay (Rhodia- Silver Bow, MT)

Phosphorus Recovery Project Emissions Summary

11/19/2013

Uncontrolled Emissions

	PM	PM10	PM2.5	HAPs (PH3)	Lead (Pb)
Mud Still	9.9	9.9	9.9	4.8	0.50
Residue Handling	0.09	0.03	0.005	n/a	n/a
Fugitive Dust	0.15	0.04	0.004		n/a
Total	10.2	10.0	9.9	4.8	0.5

Controlled Emissions

	PM	PM10	PM2.5	HAPs (PH3)	Lead (Pb)
Mud Still with wet scrubber	0.99	0.99	0.99	0.48	0.05
Residue Handling	0.09	0.03	0.005	n/a	n/a
Fugitive Dust	0.15	0.04	0.004	n/a	n/a
Total	1.23	1.06	1.00	0.48	0.1
Wet Scrubber Control Efficiency	90%	90%	90%	90%	90%

Attachment 2 Table 2

Solvay (Rhodia- Silver Bow, MT)

Mud Still Operations Emissions Estimate

11/19/2013

Particulate and Phosphorus Compound Emissions

Loaded Skip per Batch (wet)	6,675.7	lbs		Total P4 at			
Wt % P4	25%	Per Mass Balance		170 Batches			
Wt % Residue	30%	Per Mass Balance		1,418,584			
Recovery Efficiency	98%	Per Pilot Testing					
P4 Recovered per Batch	1,635.5	lbs					
P4 to Ox Chamber per Batch	33.4	lbs					
Batch Cycle Time	33.6	Hrs					
Batches per Week	5						
Weeks per Year	52						
Annual P4 to Ox Chamber	4.34	t/yr	assumes all P4 is emitted as P_4		123.92	lb/mol	P_4
Annual P4 Emitted as PH_3	4.76	t/yr	assumes all P4 is emitted as PH_3		283.89	lb/mol	P_4O_{10}
Annual P4 Emitted at P_4H_{10}	9.94	t/yr	assumes all P_4 is emitted as P_4O_{10}				

Residue Per Batch	2,003	lbs
Annual Residue	260.4	t/yr

Lead Emissions

Loaded Skip per Batch (wet)	6,675.7	lbs		
Wt % P4	25%	Per Mass Balance		
Wt % Residue	30%	Per Mass Balance		
Crude P4 per Batch	3,671.6	lbs		
Lead[1]	1050	mg/kg crude phosphorus	0.11%	wt%
Lead Emitted per Batch	3.86	lbs		
Batches per Year	260			
Lead Emitted per Year	1002.4	lbs		
Lead Emitted per Year	0.50	tons		

1. A sample of crude phosphorus analyzed by EPA reported a lead concentration of 1050 mg/kg.

Attachment 2 Table 3
Solvay (Rhodia- Silver Bow, MT)
Residual Material Handling Emissions
11/19/2013

Use AP-42 Factors for Conveyor Drops Chapter 13.2.4 for pnumatic transftter and
Crushed Stone Processing Chapter 11.19 for filling super sacks

Pneumatic transfer from skip to silo; assume wind velocity equals speed of air in exhaust pipe
Exhaust Flow Rate Calcuations

4	**in**	**diameter exhaust pipe**
0.26	ft^2	opening
585	ft^3/min	Air flow rate for pneumatic transfer

$$\frac{585\ \text{ft}^3}{\text{min}} \;\Bigg|\; \frac{60\ \text{min}}{\text{hr}} \;\Bigg|\; \frac{1}{0.26\ \text{ft}^2} \;\Bigg|\; \frac{1\ \text{mi}}{5280\ \text{ft}} \quad = \quad \frac{25.4\ \text{mi}}{\text{hr}}$$

Residue	260.4	tons/yr		
$k_{PM2.5}$	0.053			
k_{PM10}	0.35			
k_{PM}	1			
U	25.4	mph		
M	0.2	% Moisture		
$E_{PM2.5}$=	0.035	lb $PM_{2.5}$/ton	0.0046	ton/yr $PM_{2.5}$
E_{PM10}=	0.233	lb PM_{10}/ton	0.0303	ton/yr PM_{10}
E_{PM}=	0.665	lb PM/ton	0.0865	ton/yr PM

Gravity transfer from silo to supersack

Residue Processed	260.4	tons/yr	260.4	tons/yr	260.4	tons/yr
Emission Factor Uncontrolled Conveyor Transfer Point	0.0030	PM lb/ton processed	0.00110	PM_{10} lb/ton processed	Non-Detect	$PM_{2.5}$ lb/ton processec
AP-42 Table 11.19.2-2	0.78	lb/yr	0.29	lb/yr	0.29	lb/yr
	0.0004	T/yr	0.0001	T/yr	0.0001	T/yr
					(Asume $PM_{2.5}$ = PM_{10})	

Totals Transfer to Silo and Super Sack

Particle Size	T/Yr
$PM_{2.5}$	0.005
PM_{10}	0.030
PM	0.087

Attachment 2 Table 4

Solvay (Rhodia- Silver Bow, MT)

Fugitive Emissions Calculations from Sludge and Mud Still Residuals Transport

11/19/2013

Calculations

Average Vehicle wgt. (W)	26.1
Miles traveled (VMT)	42.5
Silt content, % (s)	5.1

Empirical Constants[1]	TSP	PM_{10}	$PM_{2.5}$
k (lb/VMT)	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

Uncontrolled Fugitive Dust Emissions

Emission Factor, E (lb $PM_{2.5}$/vehicle-mile traveled)[1]	0.18
Emission Factor, E (lb PM_{10}/vehicle-mile traveled)[2]	1.84
Emission Factor, E (lb TSP/vehicle-mile traveled)[2]	7.13

Emissions (lb $PM_{2.5}$/yr)	8
Emissions (lb PM_{10}/yr)	78
Emissions (lb TSP/yr)	303
Emissions (ton $PM_{2.5}$/yr)	0.00
Emissions (ton PM_{10}/yr)	0.04
Emissions (ton TSP/yr)	**0.15**

Assumed % Silt Content[3]	5.1

Vehicle Weight

Spec Sheet Catapiller 966H Wheeled Loader	52,254 lbs
	26.1 tons

Annual Vehicle Miles Traveled

Calrifier Sludge Processing

Distance Clarifier to Still	300 ft
Trips per Batch	2
Batches per week	5
Annual # of batches	260
Allowance for travel in/out processing area	20%
Annual VMT for Sludge Processing	187,200 ft
	35.5 mi

"Super Sack" Transport

Distance Silo to Clarifier	300 ft
Trips per Batch	2
Super sack loads per week	1
Annual # of loads	52
Allowance for travel in/out processing area	20%
Annual VMT for Sludge Processing	37,440 ft
	7.1 mi

Total annual VMT	42.5 mi

[1] Empirical Constants from AP-42 5th Ed. (11/06), 13.2.2 Unpaved Roads, Table 13.2.2-2 for Equation 1a

[2] Formula for emission factor from AP-42 5th Ed. (11/06), 13.2.2 Unpaved Roads, Equation 1a

$E = k\,(s/12)^a\,(W/3)^b$

Where:

k, a, and b are empirical constants
E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)

[3] Western surface coal mining, plant road AP-42 Table 13.2.2-1

Attachment 3

Air Quality Permit Applicability Summary

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MT Air Quality Permit Requirements by Emission Rate and Source Category

Regulation	Applies To:	Applicable	Reason
17.8.743(a)	Construction of new sources with a potential to emit of more than 5 tons per year of lead.	No	The mud still would not emit more than 5 tons of lead per year. Maximum potential emissions of lead were estimated at 0.5 tons per year.
17.8.743(b)	Asphalt concrete plant, mineral crusher or mineral screen with a potential to emit of more than 15 tons per year of any air pollutant, other than lead.	No	The mud still would not be an asphalt concrete plant, mineral crusher or mineral screen.
17.8.743(c)	An incinerators as defined under Montana statute 75-2-103(11).	No	The oxidizer for the mud still condenser exhaust would meet the definition of a flare under MCA 75—2-103(13)(b)(i) because it would be used to combust a toxic or hazardous gas. Therefore, it is not an incinerator and a permit would not be required.
17.8.743(d)	Modification of existing sources	No	The mud still would be a new source.
17.8.743(e)	Construction of sources with a potential to emit of more than 25 tons per year of any air pollutant, other than lead.	No	The mud still would be a source of particulate emissions, but potential emissions of particulates (PM, PM10 and PM2.5) were estimated to be $\leq$ 10.2 tons per year.
17.8.904	Major new stationary sources of air pollution	No	The mud still would not be a major new source of particulate emissions (>100 ton/yr any FCAA air pollutant or > 70 ton/yr PM_{10} in a non-attainment area) because potential emissions of particulates (PM, PM10 and PM2.5) were estimated to be $\leq$ 10.2 tons per year.
17.8.1204(1)(a)	An operating permit is required for major sources. A major source is one that potential emissions of 100 tons or more per year of any air pollutant.	No	The mud still would be a source of particulate emissions, but potential emissions of particulates (PM, PM_{10} and $PM_{2.5}$ were estimated to be $\leq$ 10.2 tons per year.
17.8.1204(1)(a)	An operating permit is required for a major source of hazardous air pollutants (HAPs) because it has potential emissions of more than 10 tons per year of a single HAP or the total of all HAPs emitted exceeds 25 tons per year.	No	The mud still would be a source of HAPs (e.g., P_4, PH_3). The potential emissions of P4 and/or PH_3 as a single HAP or as total HAPs would be less than 4.8 tons per year. Potential emissions of PH_3 are based on the very conservative assumption that all elemental phosphorus would be emitted as PH_3.
17.8.1204(1)(b)	Any source subject to new source performance standards under section 111 of the FCAA	No	The mud still would not be subject to any standards under section 111 of the FCAA. Section 111 standards related to phosphorus production only apply to phosphate rock processing, fertilizer and phosphoric acid production. In addition, the mud still would be exempt from permitting under 17.8.1204(c) because it would not be a major source.
17.8.1204(1)(c)	Any source subject to standards for control of HAPS under section 112 of the FCAA	No	The mud still would not be subject to any standards under section 112 of the FCAA. Section 112 standards for area sources related to phosphorus production have been issued to date. In addition, the mud still would be exempt from permitting under 17.8.1204(c) because it would not be a major source.
17.8.1204(1)(d)	Any affected source subject to the acid rain control requirements under Title IV of the FCAA	No	The mud still would not emit SO_2 or NO_x and would not be a coal fired electric utility or any other large emission source of acid rain precursors meeting the definition of an affected source under Title IV of the FCAA.
17.8.1204(e)	Any source required to get a permit under section 129(e) of the FCAA	No	The mud still would not be a solid waste combustor.
17.8.1204(f)	Any source in a category designated by the US EPA administrator required to obtain a permit under 40 CFR 60 70.3	No	Categories requiring permits are listed above under 17.8.1204(1)(a)-(e). None of these categories apply to the proposed mud still.
17.8.1204(g)	Any source required to obtain a permit under Title V of the FCAA	No	Categories requiring permits are listed above under 17.8.1204(1)(a)-(e). None of these categories apply to the proposed mud still.

Appendix U

Commercial TSD Facility Survey and Responses

Work Plan

BARR

Barr Engineering Company
4700 West 77th Street • Minneapolis, MN 55435-4803
Phone: 952-832-2600 • Fax: 952-832-2601

Minneapolis, MN • Hibbing, MN • Duluth, MN • Ann Arbor, MI • Jefferson City, MO

October 18, 2000

Ms. Tina Diebold
U.S. EPA, Region 8, Montana Office
301 S. Park St., DWR 10096-0026
Helena, MT 59626-0096

Re: TSD Facility Survey Work Plan
Rhodia Silver Bow Plant
Docket No. RCRA-8-2000-07

Dear Ms. Diebold:

Rhodia plans to conduct a survey of commercial hazardous waste treatment, storage, and disposal (TSD) facilities concerning their ability to receive, treat and dispose of two materials from the Rhodia Silver Bow Plant. This survey is in addition to Rhodia's efforts to identify treatment options for phosphorus recovery for the materials in the clarifier.

This work plan describes the process to be used to conduct the TSD facility survey. This information will be incorporated into the Waste Plan that will be prepared pursuant to the Amended Administrative Order under RCRA § 7003 ("7003 Order") that was issued to Rhodia Inc. by EPA, Region 8, on June 29, 2000. The 7003 Order requires Rhodia to evaluate alternatives for the lawful removal and disposal of the crude phosphorus and used carbon brick and furnace liner materials. Accordingly, the survey is intended to identify commercial TSD facilities with the ability to treat and dispose of these materials.

Scope of Work

The overall scope of the survey involves:

1. Identification of commercial TSD facilities;
2. Screening to eliminate facilities that do not have appropriate treatment technologies to manage the phosphorus-containing materials;

3. Screening of facilities based on their response to FMC Corporation's TSD Facility Survey conducted in 1999.
4. Contacting each facility (i.e., questionnaire) that was retained in the screening process to inquire about their ability to receive, treat and dispose of the phosphorus-containing materials.
5. Follow-up contacts with all facilities that indicate they have the ability to receive, treat and dispose of the phosphorus-containing materials. Retain facilities that can demonstrate their ability to handle phosphorus-containing materials.
6. Obtain cost and scheduling requirements for the facilities that have demonstrated their ability to handle these materials.

The results of each step will be summarized and maintained in a spreadsheet for inclusion in the Waste Plan.

Step 1

Commercial TSD Facilities

The Resource Conservation and Recovery Information System (RCRIS) database was accessed from the EPA WebPage {http://www.epa.gov/epaoswer/hazwaste/data/tsd.htm}. This database was last updated on April 4, 2000 and identifies 3,083 hazardous waste TSD facilities throughout the United States. The RCRIS database provides the EPA identification number, company name, address, and contact for each TSD facility. "The Hazardous Waste Consultant" publishes a survey of commercial TSD facilities. The last survey results were published in 1998 (Volume 16, Issue 2, March/April 1998). The commercial TSD facility list was referenced to the RCRIS database to develop Table 1. Table 1 identifies 151 commercial TSD facilities by EPA Identification number, company name, and the onsite treatment and disposal methods identified in the "Hazardous Waste Consultant" Annual TSD Survey.

FMC Surveys

FMC Corporation explored nation-wide for treatment and disposal capacity for materials containing elemental phosphorus. FMC documented a lack of available treatment capacity for their waste streams in 1995 and again in 1999. Treatment, storage, and disposal (TSD) facilities surveyed by FMC cited a number of factors in declining to manage these waste streams, including the presence of elemental phosphorus, the potential for generation of phosphine gas, levels of naturally occurring radioactive materials (NORM), and the volume of wastes to be managed.

In 1995, FMC surveyed 168 treatment, storage, and disposal facilities (TSDs) throughout the nation, in an effort to locate commercial treatment or disposal capacity. Not one of the surveyed facilities was able or willing to provide treatment or disposal capacity for the FMC Pocatello waste streams. Likewise, EPA was not aware of any available capacity for these waste streams. As such, EPA granted a national capacity variance for the FMC Pocatello waste streams, extending the LDR effective date for these waste streams to May 26, 2000. [See 63 FR 28556, May 26, 1998]

In support of its request for this case-by-case extension of the LDR effective date, FMC performed another survey in February--May 1999 that supplemented the initial 1995 survey of available commercial treatment capacity. This supplemental survey was designed to focus on those facilities likely to have developed additional or new capacity since the 1995 survey. The results of this survey were obtained from the Federal Register Docket Number F-2000-FMCP-FFFFF; S0011.C & S0012.B. All but three facilities surveyed by FMC are listed in the "Hazardous Waste Consultant" Annual TSD Survey. These three facilities were added at the end of Table 1 along with the respective survey results (i.e., basis for rejecting FMC's wastestream).

FMC Corporation is currently designing a wastewater treatment process to treat their waste streams to render them non-ignitable and non-reactive, and to remove other identified hazardous characteristics. The process reacts the elemental phosphorus to generate phosphine. The phosphine is then thermally oxidized to phosphorus pentoxide (i.e., P_2O_5) which is recovered as a product. Since FMC is planning to construct a hazardous waste treatment facility for processing phosphorus-containing materials, FMC Corporation was added at the end of Table 1, even though we have no information to suggest the FMC facility intends to receive materials on a commercial basis.

The one hundred fifty five (155) commercial TSD facilities identified during Step 1 are listed in Table 1.

Step 2

This step involves screening to retain facilities with potentially appropriate treatment technologies for the proper management of the phosphorus-containing materials. EPA has indicated they believe these materials should be managed as D001 and D003 hazardous wastes.

According to the land disposal restriction identified in 40 CFR 268.40, D001 non-wastewater wastestreams must be treated according the to the following technology codes: DEACT and meet universal treatment standards (40 CFR 268.48); or RORGS; or CMBST. Non-wastewater wastestreams with the D003 code must be treated according the to the following technology codes: DEACT and meet universal treatment standards (40 CFR 268.48). Table 2 explains the technology codes and describes the treatment technologies that EPA has recommended under 40 CFR 268, Appendix VI.

In addition, under 40 CFR 268.40, D001 and D003 hazardous waste may be treated and disposed of in a surface impoundment that meets minimum technology requirements (MTR). This treatment option was retained, but no commercial facilities were identified that provide these services. Also, EPA has recognized that deactivation for phosphorus-containing materials includes mixing with water [see Exhibit to Final Report to BDAT Related Comments Documents - D001 Characteristic Ignitable Wastes. pp. 170-173, Volume 1-B (May, 1990)]. Because this is the current management strategy at the site, no further inquiry was made of offsite facilities.

These recommended treatment technologies were further evaluated for applicability to the phosphorus-containing materials from the Rhodia facility. The results of this evaluation are summarized in Table 3.

The applicable technologies were used to evaluate whether a TSD facility's treatment technology was appropriate for the phosphorus-containing materials. Facilities with appropriate treatment technologies (i.e., incineration, BIF, or similar) were retained for further evaluation. The results of Step 2 are summarized on Table 1.

Step 3

The results of FMC's most recent survey of TSD facilities are summarized on Table 1. All of the facilities surveyed by FMC were unable or unwilling to treat the FMC Pocatello waste streams for one or more of the following reasons:

- Elevated levels of naturally occurring radioactive materials (NORM);
- Presence of elemental phosphorus;
- Volume of wastes to be managed; and
- Potential for generation of phosphine gas.

Because the material volume for Rhodia is less than that for FMC, facilities were retained for further evaluation if the only reason they rejected the FMC waste streams was due to the excessive volume. All other facilities were eliminated from further consideration since the Rhodia and FMC materials have similarities in phosphorus content and possibly NORM.

Step 4

Facilities that were retained through the screening process will be contacted to inquire about their ability to receive, treat, and dispose of the phosphorus-containing materials. Forty (40) facilities with potentially appropriate technologies are included on the questionnaire list (Table 4).

A cover letter, material descriptions, and a brief questionnaire will be mailed to each facility with a request to complete and return the questionnaire within one week. Facility name, mailing address, and EPA identification number were obtained from the RCRIS database. The cover letter, material descriptions and questionnaire are contained in Attachment 1.

The responses to the questionnaire will be summarized on Table 4.

Step 5

Follow-up discussions will be held with each facility that indicates they are able to treat and dispose of the materials. The purpose of the follow-up discussions is to evaluate whether the facility is knowledgeable about managing phosphorus-containing materials and whether the facility has experience. A script for these conversations may be prepared to assure consistent relay of information to the TSD facilities. Follow-up discussion will be documented in phone memos and will be summarized on Table 4.

Step 6

If the TSD Facility can demonstrate they are capable of treating and disposing of the materials, a price quote and scheduling information will be requested from the facility and summarized for the Waste Plan.

Conclusion

Rhodia plans to mail the surveys to the identified TSD facilities on October 23, 2000. If you have any comments or suggestions, please contact me by October 20, 2000.

Sincerely,

Dan Bersanti
Plant Manager – Silver Bow
Rhodia, Inc.

Tables

Table 1

Identification and Screening of Commercial TSD Facilites
Phosphorus-containing Materials

Commercial TSD	EPA ID #	Company	Retained Technologies: CMBST: Incineration	Retained Technologies: CMBST: Detonation/Open Burning	Retained Technologies: CMBST: Cement Kiln	Retained Technologies: CMBST: Aggregrate Kiln	Retained Technologies: WTTRX	Inappropriate Technologies: CHOXD/CHRED	Inappropriate Technologies: STABL	Inappropriate Technologies: Distillation	Inappropriate Technologies: HTMR	Inappropriate Technologies: Biological/Chemical/Thermal	Inappropriate Technologies: GAC Regeneration	Inappropriate Technologies: Landfill	Inappropriate Technologies: Other (See Annual TSD Survey)	FMC Survey Results: Elevated NORM Levels	FMC Survey Results: Elemental P	FMC Survey Results: Large Volumes	FMC Survey Results: Potential Ignitability	FMC Survey Results: Hazardous Waste	FMC Survey Results: Pyrophoric Materail	FMC Survey Results: Composition (Metals)	Retained Commercial TSD Facilities (Yes or No)
1	ALD031499833	Allied Signal Inc Fairfield Tar								X													N
2	ALD000622464	Chemical Waste Management												X		X							N
3	ALD981019045	Systech Environmental Corporation/Medusa Cement Company			X																		Y
4	AKD983068685	Alaska Pollution Control										X											N
5	AZD009015389	Romic Environmental Technologies Inc								X													N
6	AZD982441263	Westates Carbon Arizona Inc Pk											X										N
7	AZD980735500	World Resources Co													X								N
8	ARD981512270	Ash Grove Cement Co-Foreman			X																		Y
9	ARD069748192	ENSCO Inc	X													X							N
10	ARD006354161	Reynolds Metals Co Gum Springs Plant	X																				Y
11	CAT080022148	Denova Environmental Inc		X																			Y
12	CAT000646117	Chemical Waste Mgmt Inc												X		X	X						N
13	CAT080033681	Chem Tech Systems Inc						X															N
14	CAD028409019	Crosby & Overton Plt No 1							X														N
15	CAT080013352	Demenno/Kerdoon								X													N
16	CAD000633164	Safety Kleen Westmorland Inc												X									N
17	CAD980675276	Safety Kleen Inc												X		X	X	X	X				N
18	CAD050806850	Safety Kleen Inc						X															N
19	CAD008488025	Phibro Tech Inc							X														N
20	CAD009452657	Romic Environmentaltechnologies Corp								X													N
21	CAD094030993	U.S. Filter Recovery Services						X									X						N
22	COD980591184	Oil & Solvent Process Company (Osco)								X													N
23	COD991300484	Safety-Kleen (Deer Trail) Inc						X															N
24	CTD000604488	Clean Harbors Of Connecticut Inc						X															N
25	GAD096629282	Onyx Environmental Services (Former Cwm)							X														N
26	GAD000616367	MKC Enterprises Inc							X														N
27	IDD073114654	Envirosafe Svcs Of Idaho Site B												X									N
28	ILD000716894	American Waste Processing Ltd													X								N
29	ILD098642424	Trade Waste Incinerator Inc	X													X							N
30	ILD000608471	Clean Harbors Of Chicago						X															N

Table 1

Identification and Screening of Commercial TSD Facilites
Phosphorus-containing Materials

Commercial TSD	EPA ID #	Company	Retained Technologies					Inappropriate Technologies								FMC Survey Results							Retained Commercial TSD Facilities (Yes or No)
			CMBST																				
			Incineration	Detonation/Open Burning	Cement Kiln	Aggregate Kiln	WTTRX	CHOXD/CHRED	STABL	Distillation	HTMR	Biological/Chemical/Thermal	GAC Regeneration	Landfill	Other (See Annual TSD Survey)	Elevated NORM Levels	Elemental P	Large Volumes	Potential Ignitability	Hazardous Waste	Pyrophoric Materall	Composition (Metals)	
31	ILD000666206	Envirite Of Illinois Inc							X														N
32	ILD085349264	Heritage Environmental Services							X														N
33	ILD040891368	Horeshead Resource Development Company, Inc.									X												N
34	ILD984766279	Hydromet Environmental Usa Inc								X													N
35	ILD000805812	Peoria Disposal Co												X									N
36	ILD062480850	Phibro Tech Inc							X														N
37	IND078911146	Chemical Waste Mgmt Of Indiana Llc												X									N
38	IND005081542	Essroc Cement Corp			X																		Y
39	IND093219012	Heritage Environmental Svcs Llc						X															N
40	IND006419212	Lone Star Greencastle Wdf			X																		Y
41	IND001859032	Rhodia Inc	X																				Y
42	IAD005289806	John Deere Waterloo Works						X															N
43	KSD981506025	Safety Kleen Sys Inc Argonite	X																				Y
44	KSD031203318	Ash Grove Cement Plant			X																		Y
45	KSD980739999	Heartland Cement Co			X																		Y
46	KSD980633259	Systech Environmental Corp			X																		Y
47	KYD000770313	Environmental Conservation Systems				X																	Y
48	KYD088438817	LWD Inc Calvert City	X																				Y
49	LAD000777201	Chemical Waste Management Inc						X								X							N
50	LAD981055791	Safety Kleen Colfax Inc		X																			Y
51	LAD008161234	Rhodia Inc	X																				Y
52	LAD010395127	Safety Kleen Baton Rouge Inc	X																				Y
53	LAD000778514	Safety Kleen Plaquemine Inc													X								N
54	MED019051069	Environmental Compliance Corp							X														N
55	MDD980555189	Clean Harbors Of Baltimore Inc						X															N
56	MAD053452637	Clean Harbors Of Braintree Inc								X													N
57	MAD062179890	Environmental Compliance Corp									X												N
58	MID096963194	Chem Met Services Inc								X													N
59	MID054683479	City Environmental And Disposal Sys						X															N
60	MID092947928	Drug And Laboratory Disposal Inc						X															N

Table 1

Identification and Screening of Commercial TSD Facilites
Phosphorus-containing Materials

			Retained Technologies					Inappropriate Technologies								FMC Survey Results							
			CMBST																				
Commercial TSD	EPA ID #	Company	Incineration	Detonation/Open Burning	Cement Kiln	Aggregrate Kiln	WTTRX	CHOXD/CHRED	STABL	Distillation	HTMR	Biological/Chemical/Thermal	GAC Regeneration	Landfill	Other (See Annual TSD Survey)	Elevated NORM Levels	Elemental P	Large Volumes	Potential Ignitability	Hazardous Waste	Pyrophoric Materall	Composition (Metals)	Retained Commercial TSD Facilities (Yes or No)
61	MID074259565	Dynecol Inc						X															N
62	MID000724831	Michigan Disposal Waste Treatment Plant						X								X	X						N
63	MID098011992	Cyanokem Inc						X									X						N
64	MID981200835	Systech Environmental Corp			X																		Y
65	MID048090633	Wayne Disposal Inc Site #2												X									N
66	MN0000903468	Recyclights Inc													X								N
67	MND981098478	U S Filter Recovery Svcs Inc						X															N
68	MSD077655876	Holnam, Inc. Artesia Plant			X																		Y
69	MOD980962849	West Star Environmental Inc							X														N
70	MOR000001230	Frontier Technoilogies, Inc.									X												N
71	MOD981505555	Heritage Environmental Svcs Llc						X															N
72	MOD029729688	Holnam Inc Safety Kleen Corp			X																		Y
73	MOD985798164	I C I Explosives Environmental Co	X																				Y
74	MOD069277549	Laidlaw Environmental Services													X								N
75	MOD981127319	Lone Star Ind Inc			X																		Y
76	MOD054018288	Continental Cement Co Llc			X																		Y
77	NED981723513	Clean Harbors Env Services Inc	X													X							N
78	NVD980895338	21St Century Emi Dba Transporter													X				X				N
79	NVT330010000	US Ecology Inc												X									N
80	NJD002200046	Cycle Chem Inc							X														N
81	NJD002385730	Dupont E I De Nemours & Co - Deepwater							X														N
82	NJD002141950	C P Chemicals Inc							X														N
83	NJD053288239	Safety Kleen Bridgeport Inc	X															X				X	Y
84	NJD991291105	S & W Waste Inc							X														N
85	NYD049836679	C W M Chemical Services LLC												X			X						N
86	NYD000632372	Safety-Kleen Bdt Inc Clarence	X																				Y
87	NYD048148175	Mercury Refining Co Formerly Mws Ny Inc													X								N
88	NYD080469935	Norlite Corp				X																	Y
89	NCD121700777	Heritage Environmental Services Inc						X															N
90	NCD000773655	Giant Resource Recovery Inc				X																	Y

Table 1

Identification and Screening of Commercial TSD Facilites
Phosphorus-containing Materials

			Retained Technologies					Inappropriate Technologies								FMC Survey Results							
			CMBST																				
Commercial TSD	EPA ID #	Company	Incineration	Detonation/Open Burning	Cement Kiln	Aggregrate Kiln	WTTRX	CHOXD/CHRED	STABL	Distillation	HTMR	Biological/Chemical/Thermal	GAC Regeneration	Landfill	Other (See Annual TSD Survey)	Elevated NORM Levels	Elemental P	Large Volumes	Potential Ignitability	Hazardous Waste	Pyrophoric Materail	Composition (Metals)	Retained Commercial TSD Facilities (Yes or No)
91	OHD020273819	Waste Management Of Ohio													X								N
92	OHD000816629	Spring Grove Resource Recovery						X															N
93	OHD000724153	Clean Harbors Environmental Services, Inc.						X															N
94	OHD093945293	Chemical Waste Mgmt Resource Recovery In								X													N
95	OHD980568992	Envirite Of Ohio Inc							X														N
96	OHD083377010	Environmental Enterprises Inc						X										X				X	N
97	OHD045243706	Envirosafe Services Otter Creek Rd												X									N
98	OHD081290611	Laidlaw Environmental Services, Inc.						X															N
99	OHD055522429	Republic Environmental Systems							X														N
100	OHD004178612	Pure Tech Systems Inc								X													N
101	OHD048415665	Ross Incineration Services Inc	X													X		X					N
102	OHD980587364	Safety Kleen Systems Inc								X													N
103	OHD005048947	Systech Environmental Corporation			X																		Y
104	OHD980613541	Waste Technologies Industries	X													X							N
105	OKD065438376	Lone Mountain Facility						X									X						N
106	OKD000402396	Perma-Fix Treatment Svcs Inc							X														N
107	ORD089452353	Chemical Waste Management of the NW												X		X	X						N
108	PAD002390961	Bethlehem Apparatus Co Inc								X													N
109	PAD010154045	Envirite Of Pa Inc							X														N
110	PAD980707087	Envirotrol Inc Beaver Falls											X										N
111	PAD002395887	Horsehead Resource Dev Co Inc									X												N
112	PAD002389559	Keystone Cement Co			X																		Y
113	PAD004835146	Mill Svc Inc Yukon Plt						X															N
114	PAD085690592	Republic Environmental Sys						X															N
115	PAD083965897	Southdown Inc			X																		Y
116	RID040098352	Northland Environmental Inc						X														X	N
117	RID980906986	21St Century Environmental Mgmt Inc						X															N
118	SCD003351699	Giant Cement Company			X																		Y
119	SCD070375985	Safety Kleen Pinewood Inc												X			X	X					N
120	SCD981467616	Safety Kleen Roebuck Inc	X																				Y

Table 1

Identification and Screening of Commercial TSD Facilites
Phosphorus-containing Materials

Commercial TSD	EPA ID #	Company	Retained Technologies: CMBST: Incineration	Detonation/Open Burning	Cement Kiln	Aggregate Kiln	WTTRX	Inappropriate Technologies: CHOXD/CHRED	STABL	Distillation	HTMR	Biological/Chemical/Thermal	GAC Regeneration	Landfill	Other (See Annual TSD Survey)	FMC Survey Results: Elevated NORM Levels	Elemental P	Large Volumes	Potential Ignitability	Hazardous Waste	Pyrophoric Materail	Composition (Metals)	Retained Commercial TSD Facilities (Yes or No)
121	SCD070371885	Phibro-Tech Inc							X														N
122	SCD003368891	Holnam Inc Safety Kleen Systems Inc			X																		Y
123	TND982109142	Diversified Scientific Services Inc (Dss	X																				Y
124	TND982144099	Horsehead Resource Dev Co Inc									X												N
125	TND000772277	Safety Kleen (Wt) Inc						X															N
126	TXD000838896	Chemical Waste Mgmt	X													X							N
127	TXD000761254	Chemical Waste Mgmt Of Corpus Christi													X								N
128	TXD074196338	Philip Reclamation Services							X														N
129	TXD097673149	Empak Inc Deer Park									X												N
130	TXD008117186	Encycle Texas Inc						X															N
131	TXD000719518	Disposal Systems Inc								X													N
132	TXD982560294	Nssi/Recovery Services Inc								X													N
133	TXD008097487	Arch Chemicals Inc													X								N
134	TXD047823265	Phibro-Tech Inc							X														N
135	TXD008099079	Rhodia Inc	X																				Y
136	TXD055141378	Safety Kleen Deer Park Inc	X													X	X						N
137	TXD069452340	Texas Ecologists Inc												X									N
138	TXD007349327	TXI Midlothian Cement Plant			X																		Y
139	TXD055135388	Treatment One Div Of Set Environmental						X															N
140	TXD988088464	Waste Control Specialists Llc						X															N
141	UTD982598898	Envirocare Of Utah Inc												X									N
142	UTD981552177	Safety-Kleen (Aragonite)	X															X					Y
143	UTD991301748	Safety-Kleen (Lone & Grassy)												X		X	X	X					N
144	VAD988175055	Clean Harbors Env Svcs Inc							X														N
145	VAD098443443	Giant Resource Recovery Inc				X																	Y
146	VAD077942266	Giant Resource Recovery				X																	Y
147	WAD000812909	Burlington Environmental Inc George						X															N
148	WAD991281767	Burlington Environmental Inc Kent						X															N
149	WAD020257945	Burlington Environmental Inc Tacoma								X													N
150	WID003967148	Controlled Waste Division							X														N

Table 1

Identification and Screening of Commercial TSD Facilites
Phosphorus-containing Materials

			Retained Technologies					Inappropriate Technologies								FMC Survey Results							
			CMBST																				
Commercial TSD	EPA ID #	Company	Incineration	Detonation/Open Burning	Cement Kiln	Aggregate Kiln	WTTRX	CHOXD/CHRED	STABL	Distillation	HTMR	Biological/Chemical/Thermal	GAC Regeneration	Landfill	Other (See Annual TSD Survey)	Elevated NORM Levels	Elemental P	Large Volumes	Potential Ignitability	Hazardous Waste	Pyrophoric Materall	Composition (Metals)	Retained Commercial TSD Facilities (Yes or No)
151	WID990829475	WRR Environmental Services Co Inc	X																				Y
152		EnviroSource															X		X				N
153	CAD076180843	McWhorter Technologies														X	X			X		X	N
154	GAD033582461	Alternate Energy Resources																		X			N
155	IDD070929518	FMC Corp Phosphorus Chemicals Group					X																Y
			21	2	18	5	1	33	22	15	6	1	2	16	10	15	13	7	3	2	0	4	155
Number of facilites retained for Rhodia Survey																							40

Table 2

Recommended Treatment Technologies D001/D003 Hazardous Wastes

Waste Code	Subcategory	Technology Code [40 CFR 268.40]	Description of Technology-Based Standard [40 CFR 268.42]	Recommended Technology [40 CFR 268, Appendix VI]
D001	Ignitable Reactives based on 40 CFR 261.21(a)(2).	DEACT	Deactivation to remove the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity.	WTTRX CHOXD CHRED STABL INCIN
		RORGS	Recovery of organics utilizing one or more of the following technologies: (1) Distillation; (2) thin film evaporation; (3) steam stripping; (4) carbon precipitation/crystalization (including freeze); or (8) chemical phase separation techniques (i.e., addition of acids, bases, demulsifiers, or similar chemicals);-- Note: this does not preclude the use of other physical phase separation techniques such as a decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above listed recovery technologies.	These treatment technologies are not appropriate for inorganic material streams.
		CMBST	High temperature organic destruction technologies, such as combustion in incinerators, boilers, or industrial furnaces operated in accordance with the applicable requirements of 40 CFR part 264, subpart O, or 40 CFR part 265, subpart O, or 40 CFR part 266, subpart H, and in other units operated in accordance with applicable technical operating requirements; and certain non-combustive technologies, such as the Catalytic Extraction Process.	INCIN BIF Boiler or Industrial Furnace
D003	Other Reactives based on 40 CFR 261.23(a)(3).	DEACT	Deactivation to remove the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity.	INCIN CHOXD CHRED
D003	Water Reactives based on 40 CFR 261.23(a)(2),(3), and (4)	DEACT	Deactivation to remove the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity.	INCIN WTTRX CHOXD CHRED

Table 3

Evaluation of Recommended Treatment Technologies
Phosphorus-containing Materials

Recommended Technology [40CFR 268, Appendix VI]	Technology Description [40 CFR 268.42]	Applicability to Phosphorus-containing Materials
WTTRX	Controlled reaction with water for highly reactive inorganic or organic chemicals with precautionary controls for protection of workers from potential violent reactions as well as precautionary controls for potential emissions of toxic/ignitable levels of gases released during the reaction.	Yes – Phosphorus-containing materials will react to form highly toxic phoshine gas under aqueous and alkaline conditions. Upon generation, the phosphine can be thermally oxidized to form P2O5 that can be recovered as a product. This technology system will be constructed at the FMC facility to treat its wastewater streams.
CHOXD	Chemical or electrolytic oxidation utilizing the following oxidation reagents (or waste reagents) or combinations of reagents: (1) Hypochlorite (e.g., bleach); (2) chlorine; (3) chlorine dioxide; (4) ozone or UV (ultraviolet light) assisted ozone; (5) peroxides; (6) persulfates; (7) perchlorates; (8) permangantes; and/or (9) other oxidizing of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., Total Organic Carbon can often be used as an indicator parameter for the oxidation of many organic constituents that cannot be directly analyzed in wastewater residues). Chemical oxidation specifically includes what is commonly referred to as alkaline chlorination.	No –Treatment via chemical oxidation is not a proven technology for treatment of phosphorus containing materials.
CHRED	Chemical reduction utilizing the following reducing reagents (or waste reagents) or combinations of reagents: (1) Sulfur dioxide; (2) sodium, potassium, or alkali salts or sulfites, bisulfites, metabisulfites, and polyethylene glycols (e.g., NaPEG and KPEG); (3) sodium hydrosulfide; (4) ferrous salts; and/or (5) other reducing reagents of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., Total Organic Halogens can often be used as an indicator parameter for the reduction of many halogenated organic constituents that cannot be directly analyzed in wastewater residues). Chemical reduction is commonly used for the reduction of hexavalent chromium to the trivalent state.	No –Treatment via chemical reduction is not a proven technology for treatment of phosphorus containing materials.
STABL	Stabilization with the following reagents (or waste reagents) or combinations of reagents: (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust)--this does not preclude the addition of reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength, or to overall reduce the leachability of the metal or inorganic.	No – Treatment via stabilization is not a proven technology for treatment of Phosphorus-containing materials. Stabilization is not demonstrated to alter the D001 or D003 characteristics.
INCIN	Incineration in units operated in accordance with the technical operating requirements of 40 CFR part 264 subpart 0 and part 265 subpart 0.	Yes
BIF (i.e., Cement or Aggregate Kilns)	Combustion in boilers, or industrial furnaces operated in accordance with the applicable requirements of 40 CFR part 264, subpart O, or 40 CFR part 265, subpart O, or 40 CFR part 266, subpart H, and in other units operated in accordance with applicable technical operating requirements.	Yes
Other Technologies		
Surface Impountment (MTR)	Phosphorus-containing materials are mixed with and covered by water.	Yes - EPA considers this technology as BDAT for phosphorus-containing materials.

[illegible] 4

Retained Commercial TSD Facilities

RCRIS Database						
EPA ID #	Company	Address1	Address2	City	State	PostalCode
ALD000622464	Chemical Waste Management	Hwy 17 N/Mi Marker 163	P O Box 55	Emelle	AL	35459
ALD981019045	Systech Environmental Corporation (Closed Facility)	P.O. Box 1097, Arcola Rd		Demopolis	AL	36732
ARD981512270	Ash Grove Cement Co-Foreman	4457 Hwy 108		Foreman	AR	71836
ARD069748192	ENSCO Inc	309 American Circle	309 American Circle	El Dorado	AR	71730-6555
ARD006354161	Reynolds Metals Co Gum Springs Plant	500 E Reynolds Rd		Arkadelphia	AR	71923-0520
CAT080022148	Denova Environmental Inc	2610 N Alder	2824 N Locust Ave	Rialto	CA	92377
ILD098642424	Trade Waste Incinerator Inc	7 Mobile Ave Site B		Sauget	IL	62201
IND005081542	Essroc Cement Corp	Sr 25 S 3084 W Cr 225 S		Logansport	IN	46947
IND006419212	Lone Star Greencastle Wdf	3301 S Cr 150 W	PO Box 486	Greencastle	IN	46135
IND001859032	Rhodia Inc	2000 Michigan St		Hammond	IN	46320
KSD981506025	Safety Kleen Sys Inc Argonite	Hwy 169 N Industrial Park	PO Box 1328	Coffeyville	KS	67337
KSD031203318	Ash Grove Cement Plant	1801 N Santa Fe	PO Box 519	Chanute	KS	66720
KSD980739999	Heartland Cement Co	1765 Limestone Ln	PO Box 428	Independence	KS	67301
KSD980633259	Systech Environmental Corp	Cement Plant Rd	PO Box 111	Fredonia	KS	66736
KYD000770313	Environmental Conservation Systems	Highway 1020	PO Box 7	Brooks	KY	40109
KYD088438817	LWD Inc Calvert City	Ky Hwy 1523, 2475 Indust. Pkwy	PO Box 327	Calvert City	KY	42029
LAD000777201	Chemical Waste Management Inc	7170 John Brannon Rd		Sulphur	LA	70665
LAD981055791	Safety Kleen Colfax Inc	3763 Hwy 471		Colfax	LA	71417-5614
LAD008161234	Rhodia Inc	1275 Airline Hwy	PO Box 828	Baton Rouge	LA	70805
LAD010395127	Safety Kleen Baton Rouge Inc	13351 Scenic Hwy Id127	PO Box 74137	Baton Rouge	LA	70807-1021
MID981200835	Systech Environmental Corp (Closed Facility)	1480 Ford Ave	245 N Valley Rd	Alpena	MI	49707
MSD077655876	Holnam, Inc. Artesia Plant	8677 Hwy 45 South Alternate		Artesia	MS	39736
MOD029729688	Holnam Inc Safety Kleen Corp	N Hwy 79	PO Box 67	Clarksville	MO	63336
MOD985798164	I C I Explosives Environmental Co	3078A County Rd 180	PO Box 1386	Joplin	MO	64801
MOD981127319	Lone Star Ind Inc	2524 S Sprigg St	PO Box 968	Cape Girardeau	MO	63701
MOD054018288	Continental Cement Co Llc	10107 Hwy 79	PO Box 71	Hannibal	MO	63401-0071
NED981723513	Clean Harbors Env Services Inc	Highway 71, 5 Mi S Of Town		Kimball	NE	69145
NJD053288239	Safety Kleen (Bridgeport) Inc	Us Rte 322 & I 295	PO Box 337	Bridgeport	NJ	08014
NYD000632372	Safety-Kleen Bdt Inc Clarence	4255 Research Pkwy		Clarence	NY	14031
NYD080469935	Norlite Corp	628 S Saratoga St	PO Box 694	Cohoes	NY	12047
NCD000773655	Giant Resource Recovery Inc	12423 Old Aquadale Rd	PO Box 987	Norwood	NC	28128-9550
OHD005048947	Systech Environmental Corporation	11397 County Road 176	PO Box 266	Paulding	OH	45879
OHD980613541	Waste Technologies Industries	1250 St George Street	PO Box 919	East Liverpool	OH	43920
PAD002389559	Keystone Cement Co	Route 329	PO Drawer A	Bath	PA	18014
PAD083965897	Southdown Inc	2001 Portland Park		Wampum	PA	16157
SCD003351699	Giant Cement Company	654 Judge St	PO Box 354	Harleyville	SC	29448
SCD981467616	Safety Kleen Roebuck Inc	301 Railroad Street		Roebuck	SC	29376
SCD003368891	Holnam Inc Safety Kleen Systems Inc	2175 Gardner Blvd		Holly Hill	SC	29059
TND982109142	Diversified Scientific Services Inc (Dss	657 Gallaher Rd		Kingston	TN	37763
TXD000838896	Chemical Waste Mgmt	Hwy 73 W 3M	PO Box 2563	Port Arthur	TX	77640
TXD008099079	Rhodia Inc	8615 Manchester Boulevard	PO Box 5275	Houston	TX	77012

Table 4

Retained Commercial TSD Facilities

RCRIS Database						
EPA ID #	**Company**	**Address1**	**Address2**	**City**	**State**	**PostalCode**
TXD007349327	TXI Midlothian Cement Plant	245 Ward Rd		Midlothia	TX	76065
UTD981552177	Safety-Kleen (Aragonite)	11373 N 29527 W Aragonite	7050 Union Park Cntr.Suite 680	Argonite	UT	84047
VAD098443443	Giant Resource Recovery Inc	Rt 1 St Rd 652	PO Box 68	Arvonia	VA	23004
VAD077942266	Giant Resource Recovery	Solite Rd		Cascade	VA	24069-9701
WID990829475	WRR Environmental Services Co Inc	5200 St Rd 93		Eau Claire	WI	54701
IDD070929518	FMC Corp Phosphorus Chemicals Group	HWY 30	Box 4111	Pocatello	ID	83202
	47 Facilities Included in TSD Survey					

Attachment 1

TSD Facility Survey
Cover Letter, Materials Description, and Questionnaire

BARR

Barr Engineering Company
4700 West 77th Street • Minneapolis, MN 55435-4803
Phone: 952-832-2600 • Fax: 952-832-2601

Minneapolis, MN • Hibbing, MN • Duluth, MN • Ann Arbor, MI • Jefferson City, MO

October 26, 2000

«Name»
«Company»
«Address1»
«Address2»
«City», «State» «PostalCode»

Re: Phosphorus-containing Materials
Rhodia Silver Bow Plant
Butte, Montana

«Name»:

Rhodia, Inc. is evaluating alternatives for the lawful removal and disposal of two materials that are located at a closed elemental phosphorus facility near Butte, Montana. Rhodia, Inc. is inquiring about your ability to receive, treat and dispose of these phosphorus-containing materials. The materials are (1) crude phosphorus and (2) used carbon brick and furnace liner. Crude phosphorus contains elemental phosphorus; elevated levels of naturally occurring radioactive material (NORM); and has the potential to generate phosphine gas. The used carbon brick and furnace liner contains forms of phosphorus, may have elevated levels of NORM, and has the potential to generate oxides of phosphorus. In addition, EPA has expressed concern that elemental phosphorus could have saturated the carbon brick and furnace liner while they were in service, although Rhodia has seen no evidence to substantiate this concern.

The U.S. EPA believes that the crude phosphorus should be characterized as D001 and D003 hazardous waste, and that the used carbon brick and furnace liner should be characterized as D001 hazardous waste. For purposes of this request, please assume that the materials will be shipped to you as such. Under the land disposal restriction (LDR) requirements, D001 hazardous wastes will have to be treated so that they are nonignitable and D003 hazardous wastes will have to be treated so that they are nonreactive (do not generate toxic gases) before land disposal. The materials are not known to contain underlying hazardous constituents that exceed their Universal Treatment Standards. However, EPA believes the materials should be assumed to contain metals that do not meet their universal treatment standards.

Special handling requirements for these materials are identified in the detailed material descriptions that are attached to this letter. A brief questionnaire regarding these materials is also attached. Please review the material descriptions, respond to the specific questions and return the completed questionnaire by Friday, November 3, 2000 in the stamped, self-addressed envelope.

Please direct any questions concerning these materials to me at (952)832-2600 or email (tmattison@barr.com). Thank you for your time and consideration.

Sincerely,

Thomas D. Mattison
Senior Chemical Engineer

Material Description
Crude Phosphorus

Generator Name and Location

Rhodia, Inc.
Silver Bow Plant
119130 German Gulch Road
Silver Bow, Montana 59750

General Description

Crude Phosphorus (*i.e.*, Phosphorus-containing material)

Process Description

This material is crude phosphorus from a closed elemental phosphorus production facility. The crude phosphorus that remains in a 100-foot diameter clarifier would be removed from the clarifier, packaged in appropriate containers and shipped for treatment and disposal.

Generation Amount

500,000 gallons; one-time only.

Material Characteristics

Color:	Brown to Tan
pH:	6 - 7 (aqueous extract)
Physical State:	Solid under water

Material Composition

	Range	**Typical**
Elemental Phosphorus	5 to 50	20 wt%
Other solids (*i.e.*, phosphate ore, coke, silica, etc.	20 to 80	50 wt%
Water	15 to 75	30 wt%
TOTAL		100 wt%

Material Safety Data Sheet (MSDS) and Analytical Data

The following data is attached to this Material Description

1) **MSDS for Phosphorus**
2) **TCLP Metal Data** (attached)

		Reg. Limit	**Sample 01**	**Sample 02**
Arsenic	[mg/l]	5.0	<0.5	<0.5
Barium	[mg/l]	100.0	<10.0	<10.0
Cadmium	[mg/l]	1.0	<0.1	<0.1
Chromium	[mg/l]	5.0	<0.5	<0.5
Lead	[mg/l]	5.0	<0.5	<0.5
Mercury	[mg/l]	0.2	<0.02	<0.02
Selenium	[mg/l]	1.0	<0.1	<0.1
Silver	[mg/l]	5.0	<0.5	<0.5

RCRA Classification

EPA has indicated they believe the following codes are applicable:
D001
D003

DOT Requirements

Proper Shipping Name:	Phosphorus, yellow, under water
Hazard Class:	4.2
UN/NA Number:	UN 1381
Packing Group:	I
Label:	SPONTANEOUSLY COMBUSTIBLE; POISON
Reportable Quantity:	1 lb

Packaging Requirements:
Closed head drums:
55 gallon drum; 1A1/X1.8/300
30 gallon drum; 1A1/X1.3/250
or
Open head drums:
30 gallon drum; 1A2/X160/S

Material Description
Crude Phosphorus

Additional Information

Special handling is required for this material due to the presence of elemental phosphorus. Upon exposure to air, concentrated phosphorus may spontaneously ignite and form oxides of phosphorus (mainly P_2O_5; a dense white acrid fume). To prevent spontaneous oxidation, crude phosphorus must be handled under water or in another manner that prevents oxygen from contacting the elemental phosphorus. Rhodia intends to package the crude phosphorus under water for shipping, consistent with 49 CFR 173.188(a)(2).

The material is naturally occurring radioactive material (NORM) due to it deriving from phosphate ore. A radiation survey at the Silver Bow Plant found gamma radiation ranging from 17 to 170 microRoentgens per hour. The survey included measurements near the 100' diameter clarifier (*i.e.,* where the crude phosphorus is stored).

Elemental phosphorus has the potential to generate phosphine gas when in contact with water. The crude phosphorus will be shipped under water. Higher temperature and higher pH typically increase the generation of phosphine. Phosphine is highly toxic and may be fatal if inhaled at high concentrations. Effects may include dizziness, headache, nausea, vomiting, abdominal and chest pain, difficulty with breathing, diarrhea and collapse. Phosphine inhalation at excess concentrations causes irritation of the respiratory tract and lungs and pulmonary edema may occur 1 to 2 days after exposure. Repeated exposure may result in anemia, bronchitis, gastrointestinal disturbances, and visual, speech and motor disturbances. Central nervous system depression, heart, liver and kidney damage, and cerebral edema may occur from overexposure.

In order to handle this material, particular attention to temperature and pH is needed. Generally phosphorus containing materials should be maintained at temperatures above 60 degrees C during handling to ensure that the phosphorus is in the liquid state. During transport, solids in phosphorus-containing material will settle to the bottom of the container and the residual phosphorus will solidify. In order to unload a typical container, it will be necessary reheat the contents to above the melting point of phosphorus and provide agitation to suspend the liquid phosphorus and contained solids. Otherwise, phosphorus-containing solids will remain in the bottom of the shipping container.

During any operations involving the storage and handling of phosphorus-containing materials, pH must be carefully controlled to avoid high alkaline conditions, and adequate ventilation should be provided to prevent excessive generation and buildup of phosphine gas.

Based on process knowledge, the material **does not** contain any of the following substances:

- DOT Radioactive, Explosives, or materials forbidden from transport.
- TSCA regulated materials, Chlorinated biphenyls (PCB) or Brominated biphyenyls (PBB), Chlorinated dibenzodioxins or furans.
- Products used as pesticides, herbicides, or by-products of pesticide manufacture.
- Human carcinogens above exclusion levels as defined by OSHA (Ref. 29CFR1910.1001)
- Sulfides, Cyanides, Shock sensitive materials.
- Biological hazards (such as Pathogenic materials, infectious agents, etiologic agents, USEPA Medical Waste).
- Water or amine-reactive components (such as unreacted isocyanate monomers and resins, Acid chlorides, Anhydrides, Epoxides).

RHONE-POULENC BASIC CHEMICALS CO.
1 Corporate Drive Box 881 Shelton, CT. 06484 (203)925-3300
24-HOUR EMERGENCY TELEPHONE CHEMTREC 1-800-424-9300

PRODUCT NAME:

Page: 1 of 10

PHOSPHORUS

Effective Date: JUNE 9, 1992
Supercedes: APRIL 17, 1990

I. IDENTIFICATION

CHEMICAL NAME OF PRIMARY COMPONENT(S): Phosphorus
FORMULA: P_4 FORMULA WEIGHT: 123.9
SYNONYMS: White Phosphorus; WP; Yellow Phosphorus; Phosphorus, elemental, white;
CAS# & NAME: 7723-14-0 Phosphorus

II. INGREDIENTS/SUMMARY OF HAZARDS

INGREDIENT(S)	CAS NUMBER	OSHA HAZARDOUS (H)/ NON-HAZARDOUS (NH)	PERCENT
Phosphorus	7732-14-0	H	100

WARNING STATEMENTS:

DANGER! EXTREMELY FLAMMABLE - CATCHES FIRE IF EXPOSED TO AIR · CAUSES SEVERE BURNS TO SKIN AND EYES · MAY BE FATAL IF SWALLOWED · SMOKE AND FUMES FROM BURNING PHOSPHORUS ARE EXTREMELY IRRITATING TO EYES, NOSE, THROAT AND LUNGS · POSSIBLE HAZARD TO WOMEN OF CHILD-BEARING POTENTIAL, BASED ON ANIMAL DATA ·

Contents packed under water and will ignite if water is removed • Container headspace may contain toxic and flammable phosphine gas • Store in a cool place • Do not get in eyes, on skin or on clothing • Avoid breathing vapors or dust • Wear appropriate protective clothing, NIOSH/MSHA approved respirator, goggles, face shield, and heavy rubber gloves when handling • Use only with adequate ventilation • Never use welding or cutting torch on or near any container (even empty) - explosions can result.

(See Section VI for complete Health Hazard Data)

NATIONAL FIRE PROTECTION ASSOCIATION RATING
HAZARDOUS MATERIALS IDENTIFICATION SYSTEM

(4=Extreme/Severe, 3=High/Serious,
2=Moderate, 1=Slight, 0=Minimum)

	NFPA	HMIS
HEALTH	3	3
FIRE	3	3
REACTIVITY	1	1

SARA TITLE III HAZARD CLASSIFICATION

IMMEDIATE (ACUTE) HEALTH	YES
DELAYED (CHRONIC) HEALTH	YES
FIRE	YES
SUDDEN RELEASE OF PRESSURE	NO
REACTIVE	YES

III. PHYSICAL DATA

SPECIFIC GRAVITY:	1.82 @ 20 °C
BULK DENSITY:	70 LBS/FT^3
BOILING POINT, 760 mm Hg, °C (°F):	280.5°C (536°F)
MELTING POINT, °C (°F):	44.1°C (111°F)
VAPOR PRESSURE, @ 20°C	0.026 mm Hg
pH :	6 (aqueous extract)
SOLUBILITY IN WATER (%/wt @ 20°C):	0.0003%
APPEARANCE AND ODOR:	White to yellow, soft, waxy solid; garlic odor

(For additional technical information call 1-800-642-4200)

IV. FIRE AND EXPLOSION HAZARD DATA

FLAMMABLE SOLID as defined in the OSHA Hazard Communication Standard, 29 CFR 1910.1200(c).

FLASH POINT [°C (°F)]:	Ignites spontaneously on contact with air.
FLAMMABLE LIMITS IN AIR:	Not applicable
AUTOIGNITION TEMPERATURE [°C (°F)]:	30°C (86°F)

EXTINGUISHING MEDIA: Deluge with water spray, being careful not to scatter material until fire is extinguished and phosphorus has solidified. Cover with wet sand or dirt.

SPECIAL FIRE FIGHTING PROCEDURES:

Provide for the protection of employees and residents:

a) Evacuate residents who are downwind of fire.
b) Prevent unauthorized entry to fire area.
c) Persons who may have been exposed to contaminated smoke should be examined by a physician and treated appropriately.
d) Dike area to prevent runoff and contamination of water sources.
e) Cool exposed containers with water spray.

Notify local authorities that firemen should:

a) Wear flame-retardant full protective clothing and use self-contained breathing apparatus.
b) Be immediately relieved from duty, if exposed to contaminated smoke and checked for symptoms of overexposure. These should not be mistaken for heat exhaustion or smoke inhalation. See section VI, Health Hazard Data for symptoms of overexposure, first aid procedures, and notes to physician.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

Phosphorus burns rapidly, releasing dense, white fumes (smoke) that are highly irritating. Hazardous combustion products include phosphoric acid and phosphorus pentoxide and may also contain highly toxic phosphorus vapor or phosphine gas. The combustion of phosphorus in a closed space will lead to rapid oxygen depletion.

This product will reignite itself after fire is extinguished unless covered with water, sand or earth.

Avoid contact with potassium chlorate, potassium permanganate, peroxides and other oxidizing agents. Explosions may result on contact or friction.

Elemental phosphorus reacts slowly with water to produce phosphine, especially at high (alkaline) pH. Hot water or steam may accelerate the reaction.

V. REACTIVITY DATA

STABILITY: Stable in the absence of air. Ignites spontaneously upon exposure to air.

CONDITIONS TO AVOID:
FLAMMABLE SOLID: Keep away from heat , sparks, open flame, and other ignition sources.
Light causes discoloration.
Protect from air.

MATERIALS TO AVOID:

AIR:	Ignites spontaneously.
OXIDIZERS:	Explosive.
STRONG BASES:	Releases highly toxic phosphine gas which may spontaneously ignite.
NOTE:	Elemental phosphorus reacts slowly with water to form phosphine, especially at high (alkaline) pH. Hot water or steam may accelerate the reaction.

HAZARDOUS DECOMPOSITION PRODUCTS:
Thermal decomposition produces toxic or irritating materials such as phosphoric acid and phosphorus pentoxide. Phosphine gas is released when reacted with bases, hot water or steam.

HAZARDOUS POLYMERIZATION:
Above 200°C (392°F), phosphorus polymerizes exothermically to red phosphorus. It may then heat uncontrollably, developing vapor pressures above the tank-bursting pressure.

VI. HEALTH HAZARD DATA/FIRST AID PROCEDURES

EXPOSURE LIMITS:

Chemical Name(s)	ACGIH (TWA)	OSHA (TWA)
Phosphorus (yellow)	0.1 mg/m^3, (0.02 ppm)	0.1 mg/m^3

HEALTH EFFECTS SUMMARY:

The following information presents both human experience and the result of scientific experiments used by qualified experts to assess the effects of phosphorus on the health of industrially exposed individuals and to support the Precautionary Statements and Occupational Control Procedures recommended in this document. To avoid misunderstanding, the data provided in this section should be interpreted by individuals trained in the evaluation of this type of information.

ROUTES OF ENTRY:

DERMAL CONTACT AND INHALATION are expected to be the primary routes of occupational exposure to phosphorus. Phosphorus can be absorbed through the skin, respiratory tract and gastrointestinal tract. Phosphorus ignites and burns spontaneously when exposed to air and the gas, vapor or fume produced is irritating to the eyes, nose, throat and lungs. The solid in contact with the skin or eyes produces severe burns.

INGESTION: The acute lethal oral dose of phosphorus for an adult is reported to be about 1 mg/kg, with adverse effects reported at 0.1 mg/kg. Acute oral phosphorus intoxication is usually described as having three stages. In the initial phase, gastrointestinal effects, characterized by nausea, vomiting, belching, and severe abdominal pain predominate. Death from cardiovascular collapse can occur in about 12 hours. In stage two, symptoms may regress with an apparent recovery lasting approximately two days.

VI. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

The third stage is characterized by return of gastrointestinal distress with signs of hepatic, cardiovascular and renal involvement, including jaundice, oliguria (diminished urine production), pitting edema, increased pulse rate, low blood pressure and coma.

CHRONIC SYSTEMIC SYMPTOMS: Early signs of chronic systemic intoxication by phosphorus are reported to include anemia, loss of appetite, gastrointestinal distress, chronic cough, a garlic-like odor of the breath, and pallor (paleness). A response to severe chronic poisoning which was seen in the past is "phossy jaw". The first indications of "phossy jaw" are toothache and excessive salivation, followed by loosening of the teeth, severe pain, and swelling of the jaw. Ulcerations can develop which may invade the bone. (4)

ANIMAL TOXICOLOGY DATA

Oral LD50 (rats):	3.03 mg/kg body weight	(1)
Dermal LD50 (rabbits):	No information available	
Inhalation LC50 (rats):	No information available	
Skin Effects (rabbits):	Corrosive, causes severe burns	(2)
Eye Effects (rabbits):	Corrosive	(3)

SHORT-TERM EXPOSURE:
Bone changes were reported in female rats (23 days old) given phosphorus at a dietary level of 1.30 mg/kg/day for 8 or 16 days. In the animals treated for 16 days, the bone changes were reversed following withdrawal of the test diet.

SUB-CHRONIC EXPOSURE:
Depressed growth was reported in a 22 week feeding study in young female rats fed diets containing phosphorus at median daily dosage levels of 0.0032, 0.018, and 0.072 mg/kg/day. A recovery in growth occurred at the mid-dose level following withdrawal of phosphorus from the diet; no recovery in growth was reported at the high-dose level. Old male rats fed diets containing 0.0027 mg/kg/day displayed no overt effects. Pathology and bone studies were not performed.

In a sub-chronic toxicity study, female dogs were injected subcutaneously with 0.1, 0.2, or 0.4 mg phosphorus/kg/day. Mortality resulted within 6 days with animals given 0.4 mg/kg. The one animal given 0.2 mg/kg developed severe kidney hemorrhage and died by day 12. Fatty livers, hydropic degeneration in the kidneys, body weight loss, and changes in blood chemistry parameters were reported in dogs surviving treatment with 0.1 mg/kg/day for 116 days.

Retardation of longitudinal bone growth and body weight gain were reported in rabbits given 0.6 mg phosphorus/day orally via capsule for periods of 13 to 117 days. Similar effects were noted in rats treated for 22 to 57 days with cod liver oil containing 0.1% phosphorus mixed in the diet. Disturbance of dentin calcification in the teeth of rats was also reported.

CHRONIC EXPOSURE:
Phosphorus was administered to rats by subcutaneous injection of oil solutions at dosages ranging from 0.05 to 3.2 mg/kg/day twice weekly for periods up to 610 days. Guinea pigs were injected subcutaneously with similar solutions at dosages of 0.05 to 0.4 mg/kg/day twice weekly for up to 720 days. In the rats, mortality was reported to increase with increasing dosage. Bone pathology (reported to be more marked in rats than in guinea pigs) was observed in an apparent dose-related fashion. Less conspicuous bone changes were noted in rats fed for 174 to 512 days. Mortality was reported to increase in these rats with increase in the total amount of phosphorus administered. The decreased growth rate observed in rats fed phosphorus in the diet was attributed to decreased food consumption. (4)

VI. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

CARCINOGENICITY:

This product does not contain any ingredient designated by IARC, NTP, ACGIH OR OSHA as a probable human carcinogen.

TERATOGENICITY:

Phosphorus in corn oil was administered by gavage to female rats at dosages of 0, 0.1, 0.3 or 0.75 mg/kg/day on days 6 through 19 of gestation. A second, satellite study was conducted in which rats received either 0.6 mg phosphorus /kg/day in corn oil or corn oil (control) on a comparable regimen. Due to significant maternal mortality (84%), at 0.75 mg/kg, no fetal evaluations were performed at this dosage. Decreased mean body weights were noted in surviving dams at 0.75 mg/kg. No teratogenic or fetotoxic effects were observed at dosages of 0.6 mg/kg or lower. Mortality and decreased mean body weight were noted in dams at 0.6 mg/kg.

REPRODUCTIVE TOXICITY:

In a one generation reproduction study, male and female rats were dosed orally with phosphorus (0.005, 0.015, 0.075 mg/kg/day) throughout premating, mating, pregnancy and lactation periods (males were dosed only through mating). An increased incidence of mortality at the end of pregnancy (days 21 and 22) and a decrease in the number of live pups were observed among high-dose females. The no-observable-effect-level (NOEL) for males and females was considered to be 0.075 and 0.015 mg/kg/day, respectively. No effects on reproductive function or fertility were found in males or females. In a second study, increased late-pregnancy mortality was observed in females treated with 0.075 mg/kg/day either throughout pre-mating and the first two trimesters of pregnancy (to day 15).

METABOLISM:

Following administration of single oral doses (0.3 mg/kg) of phosphorus to rats, elimination of phosphorus or its metabolites was reported to occur primarily in urine and feces. Approximately 46.7% and 33% of the absorbed radioactivity was excreted in the urine and feces,respectively, of rats dosed within five days. Increases in total body burden were noted in rats dosed once. (4)

EFFECTS OF SINGLE OVEREXPOSURE:

Swallowing:	MAY BE FATAL IF SWALLOWED. Symptoms of acute poisoning develop in three stages. First, ingestion produces a sensation of warmth or burning pain in the throat and abdomen with intense thirst followed by nausea, vomiting, diarrhea and severe abdominal pain. The breath has a garlic odor. Shock may be severe enough to cause death in 24-48 hours. The second stage is a period of several days which may be symptom free. Third, symptoms of systemic toxicity from absorbed poison develop including nausea, protracted vomiting, diarrhea, massive hematemesis (vomiting blood), liver tenderness and enlargement, jaundice, pruritus (severe itching), hemorrhages into the skin, mucous membranes and viscera, renal damage, cardiovascular collapse and central nervous system involvement resulting in convulsions, confusion and coma. Death usually occurs in 4 to 8 days.
Skin Absorption:	Phosphorus is readily absorbed through the skin when present in an oil solution or when burning on the skin. If burning phosphorus is not rapidly cleansed from the skin, severe effects including hypocalcemia, shock and fatal cardiac arrest can occur. Severe liver and kidney damage may occur.
Inhalation:	CORROSIVE. Breathing of concentrated gas, vapor, or fume may cause severe damage to the respiratory tract and lungs. Systemic effects as described under swallowing may also occur.

VI. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

Skin Contact: CORROSIVE. Ignites on contact with air which causes severe second and third degree burns which are necrotic, yellowing, and fluorescent under UV light. (2) Phosphorus may be absorbed by damaged skin and cause systemic toxicity.

Eye Contact: CORROSIVE. Causes irreversible eye damage, seen as corneal opacity.

EFFECTS OF REPEATED OVEREXPOSURE:
Chronic overexposure to elemental phosphorus by inhalation or ingestion has been reported to produce a form of generalized weakness, accompanied by anemia, loss of appetite, gastrointestinal complaints, chronic cough and paleness. Chronic poisoning may also cause changes in bones, especially the jawbones, known as "phossy jaw".

OTHER EFFECTS OF OVEREXPOSURE: See Notes to Physician.

EXISTING MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE:
Skin irritation may be aggravated in persons with existing skin lesions. Smoke from burning phosphorus may aggravate acute or chronic asthma and other chronic pulmonary disease.

EMERGENCY AND FIRST AID PROCEDURES:

****** POISON **** GET IMMEDIATE MEDICAL HELP ******

If contact with this material occurs or is suspected, DO NOT WAIT FOR SYMPTOMS TO DEVELOP!! Immediately initiate the recommended procedures below and simultaneously contact a Poison Control Center, a physician or the nearest hospital.

PRECAUTION:
Persons attending the patient should avoid direct contact with heavily contaminated clothing and vomitus. Wear impervious gloves while decontaminating skin and hair.

Remove the patient from the source of exposure and confirm that the individual is breathing. If not breathing, use artificial respiration or cardiopulmonary resuscitation (CPR). GET IMMEDIATE MEDICAL ATTENTION.

Swallowing: If patient is conscious and alert, give large quantities of water or milk to drink and induce vomiting immediately. Give one tablespoon of Syrup of Ipecac. If vomiting has not occurred in 20 minutes, the same dose of Syrup of Ipecac may be repeated one additional time. Alternatively, induce vomiting by touching the back of the throat with a finger. NEVER give anything by mouth to an unconscious or convulsing person or make an unconscious person vomit. GET IMMEDIATE MEDICAL ATTENTION.

Skin: Immediately wash skin with a large volume of water (preferably cold) while removing contaminated clothing and shoes. Solutions of 5% sodium bicarbonate can then be used if readily available. Keep burned area submerged in water or 5% sodium bicarbonate solution or wrapped in dressings, towels, bandages, etc. soaked in water or bicarbonate solution until medical attention is available. Water gel wraps or water gel blankets can also be used. GET MEDICAL ATTENTION.
Shoes and clothing contaminated by phosphorus should be placed under water in closed containers and discarded in a safe manner with due consideration of possible ignition and contamination.

VI. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

Inhalation: Remove patient to fresh air. If not breathing administer cardiopulmonary resuscitation or artificial respiration. If breathing is difficult administer oxygen. GET MEDICAL ATTENTION.

WARNING! If phosphorus has been ingested, administration of mouth-to-mouth resuscitation may expose the first aid provider to the chemical. In these situations, use of a pocket mask or Ambu bag is recommended.

Eyes: Hold eyelids open and flush with a steady, gentle stream of water for at least 15 minutes. GET MEDICAL ATTENTION, PREFERABLY AN OPHTHALMOLOGIST.

NOTES TO PHYSICIANS:

WARNING! Patient and attendants must be protected from contact with residual phosphorus, vomitus, and gastric washing.

All treatments should be based on observed signs and symptoms of distress in the patient. Consideration should be given to the possibility that overexposure to materials other than this product may have occurred.

TREATMENT FOR INGESTION:

1. Immediate gastric lavage with potassium permanganate solution (1:5000). Lavage volume is 4 liters for an adult. Use half normal saline if permanganate solution is not immediately available. Also, follow permanganate lavage with half normal saline. Lavage with 0.2% cupric sulfate solution is recommended in some poison texts but carries a risk of copper poisoning.
2. Instill activated charcoal through lavage tube.
3. An initial dose of 200 - 250 ml of mineral oil as a cathartic and to prevent absorption, followed by 30 - 40 ml every 3 hours for the first 48 hours. Avoid digestible fats and oils.
4. Treatment of severe shock.
5. Control of convulsions by rapid-acting barbiturates or diazepam.
6. Vitamin K_1, IV to combat hypoprothrombinemia. Fresh blood transfusions may be necessary.
7. Hospitalization for observation to ascertain possible liver and kidney damage.
8. EKG monitoring to detect hypocalcemia (prolonged QT interval) and to evaluate possible myocardial damage.

TREATMENT FOR EYE EXPOSURES:

1. Continue irrigation of eyes.
2. If available, instill several drops of 3% cupric sulfate solution which will turn phosphorus particles dark and reduce the potential for continued burning.
3. Mechanically remove embedded particles.

TREATMENT FOR INHALATION:

1. Prolonged inhalation of high vapor levels of phosphorus can lead to delayed onset pulmonary edema.
2. Treat pulmonary edema the same as for other corrosive gas overexposure.
3. Consider the need for same measures as noted in 4.- 8. under TREATMENT FOR INGESTION.

VI. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

TREATMENT OF DERMAL PHOSPHORUS BURNS:

1. Flood with large quantities of water or 5% sodium bicarbonate solution if not already done.
2. Keep burn areas covered with saline soaked dressings.
3. Remove all particles of phosphorus using forceps or sharp dissection if necessary. Ultraviolet light should be used to help identify phosphorus particles which fluoresce under UV. A Woods lamp is satisfactory.
4. Some poison texts recommend use of 1% cupric sulfate solutions or 2 - 3% silver nitrate solutions to coat phosphorus particles which reduces burning and allows easier identification for removal. Use of cupric sulfate solutions has the risk of copper poisoning and intravascular hemolysis especially if burns are extensive. Silver nitrate solutions presumably present less risk of poisoning. Some authorities feel removal under UV light is preferable to copper or silver solutions. If the latter are used they should be thoroughly rinsed away with saline and used cautiously in patients with large burn areas.
5. Consider need for the same measures as noted in 4. - 8. under TREATMENT FOR INGESTION, especially for more extensive burns.
6. Observe and treat for possible systemic effects.

References: 2,7,8,9,10

VII. PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:

Persons involved in clean-up must wear appropriate protective equipment (see section VIII). Ventilate spill area.
Do not touch spilled material; stop leak if you can do so without risk. Water spray may reduce vapor, but it may not prevent ignition in closed spaces.

For small spills: Contain all spilled material by diking with earth or sand and apply a low pressure, cold water spray to extinguish fire and freeze contents. Cover with water, sand or earth. Shovel into a metal container and keep material under water. Residual spillage that cannot be removed by shovelling should be cleaned from hard surfaces as appropriate.
Do not flush material to public sewer systems or any waterways. Ensure adequate decontamination of tools and equipment following clean up.

Large spills should be handled according to a predetermined plan. For assistance in developing a plan, contact the Technical Service Department, 1-800-642-4200.

WASTE DISPOSAL METHOD:

Dispose of in accordance with Local, State and Federal regulations.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:

Do not breathe vapor or fume. Do not swallow. Do not get in eyes or on skin and clothing.
FLAMMABLE SOLID: Will spontaneously ignite on contact with air. Never use welding or cutting torch on or near any container (even empty). Explosion can result.

Product should be stored in a cool, dry, well-ventilated area in tightly closed containers away from all sources of ignition. Protect from light and air. Do not store near food or feedstuffs. Keep away from oxidizing materials. Contents are packed under water and will ignite if water is removed.

VII. PRECAUTIONS FOR SAFE HANDLING AND USE

Phosphine may be present in the headspace of the containers. Extreme care must be exercised during loading and unloading. Follow Rhone-Poulenc Basic Chemicals Company procedures and only use trained personnel.

Do not eat, drink or smoke in the area where material is handled, processed or stored. Wash thoroughly after handling. Shower at the end of each workday. Wear clean work clothes every day.

VIII. SPECIAL PROTECTION INFORMATION

PROTECTIVE EQUIPMENT SHOULD BE USED DURING THE FOLLOWING PROCEDURES:
- Manufacture or formulation of this product
- Repair and maintenance of contaminated equipment
- Clean up of leaks and spills
- Any activity with potential for hazardous overexposure.

RESPIRATORY PROTECTION:
Use NIOSH/MSHA approved full-facepiece positive pressure supplied-air equipment. Use positive-pressure self-contained breathing apparatus for emergency conditions. If airborne concentrations of phosphorus vapors and phosphine gas are known to be well below the permissible limits, an air-purifying respirator equipped with a fume or high-efficiency filter may be used to protect against exposure to phosphorus pentoxide and phosphoric acid.

VENTILATION: Use local exhaust ventilation to control exposure levels below airborne exposure limits.

PROTECTIVE CLOTHING: Full-body flame-retardant protective clothing, heavy rubber gloves and boots.

EYE PROTECTION: When small quantities are handled, wear face shield with splash-proof goggles. When bulk quantities are handled, a fire-resistant face shield integrated with a whole head hood is recommended.

OTHER PROTECTIVE EQUIPMENT:
Maintain a sink, safety shower, eyewash fountain and submersion tub in the work area. Have oxygen readily available.

IX. REGULATORY STATUS

TSCA Inventory: This product is listed on the TSCA inventory.

Transportation Status:	DOT
Proper shipping name:	Phosphorus, yellow, under water
Hazard Class:	4.2
Packing Group:	I
ID Number:	UN 1381
Label:	SPONTANEOUSLY COMBUSTIBLE; POISON

Reportable Quantity under 49 CFR 172.101 Appendix 1 : 1 lb

IX. REGULATORY STATUS, (Continued)

SARA Title III
Section 302 Extremely Hazardous Substance List: YES
Section 313 Toxic Chemicals: YES

Reportable Quantity (RQ) under US EPA CERCLA: RQ = 1 lb
TPQ = 100 lbs

State/International Right-to-Know Regulations:

California:	Not listed
Connecticut:	Survey
Florida:	Toxic
Illinois:	Toxic, Chemical
Louisiana:	RTK, Spill RQ=1 lb
Massachusetts:	RTK, EHS (E), Spill RQ = 1 lb
New Jersey:	ID# 1534, RTK, Spec. Haz. (F3), TAX
New York:	Spill RQ=1 lb (air), 1 lb (l/w)
Pennsylvania:	RTK, ENV
Rhode Island:	HAZ, Note TF
Canada:	List, 1%, No. 1295

X. REFERENCES

(1) RTECS, 62963, 12/87
(2) Gosselin, Clinical Toxicology of Commercial Products, 5th ed.
(3) NIOSH Pocket Guide to Chemical Hazards, Sept. 1985.
(4) Monsanto MSDS for Phosphorus.
(5) Sax, Dangerous Properties of Industrial Materials, 6th ed.
(6) Sittig, Handbook of Toxic and Hazardous Chemicals and Carcinogens, 2nd ed.
(7) Proctor, Chemical Hazards in the Workplace, 2nd ed.
(8) Arena, Poisoning, 5th ed.
(9) Ellenhorn, Barceloux, Medical Toxicology - Diagnosis and Treatment of Human Poisoning, 1988.
(10) Grant, Toxicology of the Eye, 2nd ed.

ENERGY LABORATORIES

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LABORATORY REPORT

ADDRESS:
Lisa L. Palmer
Rhone-Poulenc
P.O. Box 314C
Butte, MT 59702

LAB NO.: 97-18565
DATE: 03/03/97 kr

WASTE ANALYSIS

crude phosphorous

Sludge #01
Submitted 02/27/97
Extracted 02/27/97

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l in Extract	Spike Percent Recovery	Date Analyzec
Arsenic	7440-38-2	5.0	0.5	<0.5	100	02/28/97
Barium	7440-39-3	100.0	10.0	<10	91	02/28/97
Cadmium	7440-43-9	1.0	0.1	<0.1	103	02/28/97
Chromium	7440-47-3	5.0	0.5	<0.5	92	02/28/97
Lead	7439-92-1	5.0	0.5	<0.5	96	02/28/97
Mercury	7439-97-6	0.2	0.02	<0.02	106	03/03/97
Selenium	7782-49 2	1.0	0.1	<0.1	91	03/03/97
Silver	7440-22-4	5.0	0.5	<0.5	95	02/28/97

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1120 SOUTH 27TH STREET • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

A :SS:

Lisa L. Palmer
Rhone-Poulenc
P.O. Box 3146
Butte, MT 59702

LAB NO.: 97-18566
DATE: 03/03/97 kr

Crude phosphorous

WASTE ANALYSIS

Sludge #02
Submitted 02/27/97
Extracted 02/27/97

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l in Extract	Spike Percent Recovery	Date Analyzed
Arsenic	7440-38-2	5.0	0.5	<0.5	102	02/28/97
Barium	7440-39-3	100.0	10.0	<10	90	02/28/97
Cadmium	7440-43-9	1.0	0.1	<0.1	101	02/28/97
Chromium	7440-47-3	5.0	0.5	<0.5	91	02/28/97
Lead	7439-92-1	5.0	0.5	<0.5	93	02/28/97
Mercury	7439-97-6	0.2	0.02	<0.02	107	03/03/97
Selenium	7782-49 2	1.0	0.1	<0.1	91	03/03/97
Silver	7440-22-4	5.0	0.5	<0.5	92	02/28/97

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

LAB NO.: Blank
DATE: 03/03/97 kr

ADDRESS:

Lisa L Palmer
Rhone-Poulenc
P.O. Box 3146
Butte, MT 59702

WASTE ANALYSIS

Method Blank
Extracted 02/27/97

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l in Extract	Spike Percent Recovery	Date Analyzed
Arsenic	7440-38-2	5.0	0.5	<0.5	103	02/28/97
Barium	7440-39-3	100.0	10.0	<10	93	02/28/97
Cadmium	7440-43-9	1.0	0.1	<0.1	104	02/28/97
Chromium	7440-47-3	5.0	0.5	<0.5	96	02/28/97
Lead	7439-92-1	5.0	0.5	<0.5	98	02/28/97
Mercury	7439-97-6	0.2	0.02	<0.02	82	03/03/97
Selenium	7782-49 2	1.0	0.1	<0.1	105	03/03/97
Silver	7440-22-4	5.0	0.5	<0.5	101	02/28/97

Material Description
Used Carbon Brick and Furnace Liner

Generator Name and Location

Rhodia, Inc.
Silver Bow Plant
119130 German Gulch Road
Silver Bow, Montana 59750

General Description

Used carbon brick and furnace liner

Process Description

The used brick and furnace liner is an inert; carbon refractory lining that was removed from electric arc furnaces that were used to convert phosphate ore into elemental phosphorus. The brick and furnace liner material ranges in size from cinder block size to as large as a refrigerator. A small fraction of the used brick and furnace liner surfaces contain a thin veneer of amorphous phosphorus (a flammable solid).

Generation Amount

Case 1: Approximately 2,000 Tons; one-time only.

Case 2: Approximately 100 Tons; one-time only. Rhodia may able to reduce the volume by segregating and packaging only the carbon bricks that have the veneer of amorphous phosphorus.

Material Characteristics

Color:	Black
pH:	Solid
Physical State:	Solid

Material Composition

	Range	Typical
Phosphorus amorphous	Trace	Trace
Used Carbon Brick and Furnace Liner	99 to 100	>99 wt%
TOTAL		100 wt%

Material Safety Data Sheet (MSDS) and Analytical Data

The following data is attached to this Material Description

1) **MSDS for Phosphorus amorphous**
2) **MSDS for Carbon Block and Brick**
3) **TCLP Metal Data** (Sample is labeled Spent Furnace Brick in the attached report.)

		Reg. Limit	Results
Arsenic	[mg/l]	5.0	<0.015
Barium	[mg/l]	100.0	0.205
Cadmium	[mg/l]	1.0	0.022
Chromium	[mg/l]	5.0	0.156
Lead	[mg/l]	5.0	<0.040
Mercury	[mg/l]	0.2	<0.0003
Selenium	[mg/l]	1.0	<0.02
Silver	[mg/l]	5.0	<0.006

4) **Method 8270B Semi-Volatile and 8260A Volatile Data** (Sample is labeled "SCB: Spent Carbon Brick in the attached report.) All results were below detection limits.

RCRA Classification

EPA has indicated they believe the following code is applicable:
D001

Material Description
Used Carbon Brick and Furnace Liner

DOT Requirements		
Proper Shipping Name:	Phosphorus, amorphous	Packaging Requirements:
Hazard Class:	4.1	Tri-wall cubic yard box; 11G/1Y
UN/NA Number:	UN 1338	**or**
Packing Group:	III	55-gallon drum; 1A2/Y1.8/200
Label:	FLAMMABLE SOLID	
Reportable Quantity:	1 lb	

Additional Information

Special handling is required for this material due to the presence of elemental phosphorus in a thin veneer of amorphous phosphorus on some areas of some of the carbon brick and furnace liner. The veneer of amorphous phosphorus does not spontaneously react with air, but may ignite if sufficient friction is applied to its surface. Upon ignition, phosphorus will form oxides of phosphorus (mainly P_2O_5; a dense white acrid fume). The material safety data sheet indicates that the carbon brick and furnace liner is noncombustible; only the veneer of phosphorus would burn. EPA has expressed concern that elemental phosphorus could have saturated the carbon brick and furnace liner while they were in service, although Rhodia has seen no evidence to substantiate this concern.

The used carbon brick and furnace liner has been in the presence of material derived from phosphate ore. Phosphate ore is a naturally occurring radioactive material (NORM). A radiation survey at the Silver Bow Plant found gamma radiation ranging from 17 to 170 microRoentgens per hour.

Phosphorus has the potential to generate phosphine gas in the presence of water. Higher temperature and higher pH typically increase the general of phosphine when phosphorus is in contact with water. The used carbon brick and furnace liner will be packaged consistent with 40 CFR 173.213 and may be packaged under water.

Phosphine is highly toxic and may be fatal if inhaled at high concentrations. Effects may include dizziness, headache, nausea, vomiting, abdominal and chest pain, difficulty with breathing, diarrhea and collapse. Phosphine inhalation at excess concentrations causes irritation of the respiratory tract and lungs and pulmonary edema may occur 1 to 2 days after exposure. Repeated exposure may result in anemia, bronchitis, gastrointestinal disturbances, and visual, speech and motor disturbances. Central nervous system depression, heart, liver and kidney damage, and cerebral edema may occur from overexposure.

Based on process knowledge, the material **does not** contain any of the following substances:

- DOT Radioactive, Explosives, or materials forbidden from transport.
- TSCA regulated materials, Chlorinated biphenyls (PCB) or Brominated biphyenyls (PBB), Chlorinated dibenzodioxins or furans.
- Products used as pesticides, herbicides, or by-products of pesticide manufacture.
- Human carcinogens above exclusion levels as defined by OSHA (Ref. 29CFR1910.1001)
- Sulfides, Cyanides, Shock sensitive materials.
- Biological hazards (such as Pathogenic materials, infectious agents, Etiologic agents, USEPA Medical Waste).
- Water or amine-reactive components (such as unreacted isocyanate monomers and resins, Acid chlorides, Anhydrides, Epoxides).

Please reduce your browser font size for better viewing and printing.

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

MSDS *Material Safety Data Sheet*

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 202-483-7616

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

MALLINCKRODT J.T.Baker

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

PHOSPHORUS AMORPHOUS

MSDS Number: P4017 — *Effective Date: 11/17/99*

1. Product Identification

Synonyms: Red Phosphorus; Phosphorus Amorphous Red
CAS No.: 7723-14-0
Molecular Weight: 30.97
Chemical Formula: P
Product Codes:
J.T. Baker: 9358
Mallinckrodt: 6620

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Phosphorus	7723-14-0	90 - 100%	Yes

3. Hazards Identification

Emergency Overview

WARNING! FLAMMABLE SOLID. MAY IGNITE FROM FRICTION OR ROUGH HANDLING. CAUSES EYE IRRITATION. MAY BE HARMFUL IF SWALLOWED OR INHALED.

J.T. Baker SAF-T-DATA$^{(tm)}$ Ratings (Provided here for your convenience)

Health Rating: 0 - None
Flammability Rating: 2 - Moderate
Reactivity Rating: 2 - Moderate
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES; LAB COAT; VENT HOOD; PROPER GLOVES; CLASS D EXTINGUISHER
Storage Color Code: Red Stripe (Store Separately)

Potential Health Effects

Inhalation:
Not considered highly toxic but acute exposure may cause coughing, bronchitis, possible liver or kidney impairment if contaminated with yellow phosphorus.

Ingestion:
Red phosphorus is not readily absorbed and, in pure form, is considered non-poisonous. However, possible contamination with the yellow form must be considered, and symptoms such as nausea, vomiting, abdominal pain or garlic odor on breath will indicate poisoning by the latter. The estimated lethal adult human dose for white phosphorus is 50 - 100 mg.

Skin Contact:
Red phosphorous is not harmful to skin. If contaminated with white phosphorus, however, contact may cause deep, slow healing burns.

Eye Contact:
Red phosphorus causes eye irritation. If contaminated with yellow phosphorus, eye contact can cause severe irritation and burns.

Chronic Exposure:
Chronic ingestion or inhalation may induce systemic phosphorous poisoning. Liver damage, kidney damage, jaw/tooth abnormalities, blood disorders and cardiovascular effects can result.

Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems, jaw/tooth abnormalities, or impaired liver, kidney or respiratory function may be more susceptible to the effects of the substance.

---

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion:
If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately. Get medical attention.

Skin Contact:
Wash exposed area with soap and water. Get medical advice if irritation develops.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

---

5. Fire Fighting Measures

Fire:
Autoignition temperature: 260C (500F)
Flammable solid. May ignite from friction or rough handling.
Explosion:
May form explosive mixtures with oxidizing materials. Sensitive to static discharge.
Fire Extinguishing Media:
Water flooding followed by covering with wet sand, clay, ground limestone until clean-up.
Special Information:
Burning phosphorus produces irritating but not highly toxic oxides. Flame-retardant full protective clothing and full breathing apparatus should be worn with phosphorus fires. The red form can convert to the more readily-flammable yellow form at high temperatures.

---

6. Accidental Release Measures

Moisten the spilled phosphorus as a precaution and keep it under wet sand or the like until it can be collected and placed in a closed container for recovery or disposal. Remove all sources of ignition. Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Clean up spills in a manner that does not disperse dust into the air. Use non-sparking tools and equipment. Reduce airborne dust and prevent scattering by moistening with water. Pick up spill for recovery or disposal and place in a closed container. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

---

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from incompatible substances. Protect from light. Avoid dust formation and control ignition sources. Employ grounding, venting and explosion relief provisions in accord with accepted engineering practices in any process capable of generating dust and/or static electricity. Empty only into inert or non-flammable atmosphere. Emptying contents into a non-inert atmosphere where flammable vapors may be present could cause a flash fire or explosion due to electrostatic discharge. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
None established.
Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
For conditions of use where exposure to the dust or mist is apparent, a half-face dust/mist respirator may be worn. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear protective gloves and clean body-covering clothing.
Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.
Other Control Measures:
Presence of yellow phosphorous as an impurity will change necessary protective equipment.

9. Physical and Chemical Properties

Appearance:
Red to violet powder.
Odor:
Odorless.
Solubility:
Insoluble in water.
Specific Gravity:
2.34 @ 20C/4C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
0
Boiling Point:
No information found.
Melting Point:
No information found.
Vapor Density (Air=1):
No information found.

Vapor Pressure (mm Hg):
No information found.
Evaporation Rate (BuAc=1):
No information found.

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
White phosphorous, oxides of phosphorous, phosphine, and phosphoric acid (if water is present) may be released if this material is heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Halogens, halides, sulfur, oxidizing materials and alkalis (forms phosphine).
Conditions to Avoid:
Heat, flame, ignition sources, shock, friction, incompatibles.

11. Toxicological Information

No LD50/LC50 information found relating to normal routes of occupational exposure.

```
--------\Cancer Lists\------------------------------------------------------
                                         ---NTP Carcinogen---
Ingredient                               Known    Anticipated    IARC Category
------------------------------------     -----    -----------    -------------
Phosphorus (7723-14-0)                    No          No             None
```

12. Ecological Information

Environmental Fate:
No information found.
Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: RQ, PHOSPHORUS, AMORPHOUS
Hazard Class: 4.1
UN/NA: UN1338
Packing Group: III
Information reported for product/size: 500G

International (Water, I.M.O.)

Proper Shipping Name: PHOSPHORUS, AMORPHOUS
Hazard Class: 4.1
UN/NA: UN1338
Packing Group: III
Information reported for product/size: 500G

International (Air, I.C.A.O.)

Proper Shipping Name: PHOSPHORUS, AMORPHOUS
Hazard Class: 4.1
UN/NA: UN1338
Packing Group: III
Information reported for product/size: 500G

15. Regulatory Information

```
--------\Chemical Inventory Status - Part 1\---------------------------------
Ingredient                                         TSCA  EC   Japan  Australia
-----------------------------------------------    ----  ---  -----  ---------
Phosphorus (7723-14-0)                              Yes  Yes   No       Yes

--------\Chemical Inventory Status - Part 2\---------------------------------
                                                         --Canada--
Ingredient                                         Korea  DSL   NDSL  Phil.
-----------------------------------------------    -----  ---   ----  -----
Phosphorus (7723-14-0)                              Yes   Yes   No     Yes

--------\Federal, State & International Regulations - Part 1\----------------
                                             -SARA 302-    ------SARA 313------
Ingredient                                   RQ    TPQ     List  Chemical Catg.
-----------------------------------------    ---   -----   ----  --------------
Phosphorus (7723-14-0)                       1     100     Yes        No
```

```
--------\Federal, State & International Regulations - Part 2\---------------
                                                         -RCRA-    -TSCA-
Ingredient                                     CERCLA    261.33     8(d)
---------------------------------------------  ------    ------    ------
Phosphorus (7723-14-0)                         1         No        Yes

Chemical Weapons Convention:  No     TSCA 12(b):  No     CDTA:  No
SARA 311/312:  Acute: Yes      Chronic: Yes  Fire: Yes Pressure: No
Reactivity: No          (Pure / Solid)
```

Australian Hazchem Code: 2WE
Poison Schedule: S7
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **1** Flammability: **1** Reactivity: **1**
Label Hazard Warning:
WARNING! FLAMMABLE SOLID. MAY IGNITE FROM FRICTION OR ROUGH HANDLING. CAUSES EYE IRRITATION. MAY BE HARMFUL IF SWALLOWED OR INHALED.
Label Precautions:
Keep away from heat, sparks and flame.
Avoid breathing dust.
Avoid contact with eyes.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.
Label First Aid:
If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. In all cases, get medical attention.
Product Use:
Laboratory Reagent.
Revision Information:
No changes.
Disclaimer:
****

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****

Prepared by: Strategic Services Division
Phone Number: (314) 539-1600 (U.S.A.)

UCAR CARBON COMPANY INC
MATERIAL SAFETY DATA SHEET

UCAR CARBON REQUESTS THE USERS OF THIS PRODUCT TO STUDY THIS MATERIAL SAFETY DATA SHEET (MSDS) AND BECOME AWARE OF PRODUCT HAZARDS AND SAFETY INFORMATION. TO PROMOTE SAFE USE OF THIS PRODUCT, USERS SHOULD NOTIFY THEIR EMPLOYEES, AGENTS AND CONTRACTORS OF THE INFORMATION ON THIS MSDS AND ANY PRODUCT HAZARDS AND SAFETY INFORMATION.

UCAR CARBON COMPANY INC 39 OLD RIDGEBURY ROAD, DANBURY, CT 06817-0001	EMERGENCY TELEPHONE NUMBER 1-800-822-4357 (24 HOURS)
TRADE NAME UCAR(R) CARBON BLOCK AND BRICK, GRADE D, AND GRADE CJD	MSDS NUMBER 4014
CHEMICAL NAME CARBON BLOCK AND BRICK	SYNONYMS CARBON
ACGIH TLV - 1992-1993 OSHA PEL - 1989	DATE OF ISSUE / REVISION 1/93 2/94

1. HAZARDOUS INGREDIENTS

MATERIAL	PERCENT	ACGIH (TLV)	OSHA (PEL)
1. COAL (NO CAS NUMBER)	65-85	2 MG/M3 RESPIRABLE	2.4 MG/M3 RESPIRABLE
2. GRAPHITE (CAS #7782-42-5)	3-20	2.0 MG/M3 RESPIRABLE	5.0 MG/M3 RESPIRABLE
3. CARBON (CAS #7440-44-0)	11.6	10 MG/M3	15 MG/M3
4. CRYSTALLINE SILICA (CAS #14808-60-7)	< 3.0	0.1 MG/M3 RESPIRABLE	0.1 MG/M3 RESPIRABLE

2. PHYSICAL DATA

APPEARANCE BLACK SHAPES	ODOR NONE	MELT POINT > 5000 DEGREES F	SPECIFIC GRAVITY NOT APPLICABLE
VAPOR DENSITY (AIR=1) NOT APPLICABLE	% VOLATILE BY VOLUME NOT VOLATILE	BULK DENSITY 1.6 - 1.8 G/CC	BOILING POINT NOT APPLICABLE
VAPOR PRESSURE NOT APPLICABLE	% SOLUBILITY (H2O) NEGLIGIBLE	EVAPORATION RATE (BUOAC=1) NOT APPLICABLE	OTHER NOT APPLICABLE

3. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT & METHOD
NOT APPLICABLE

FLAMMABLE LIMITS
LEL : NOT APPLICABLE UEL : NOT APPLICABLE

EXTINGUISHING MEDIA
BULK MATERIAL IS NONCOMBUSTIBLE. DUSTS ARE COMBUSTIBLE - USE WATER, CARBON DIOXIDE, DRY CHEMICAL OR FOAM.

SPECIAL FIRE FIGHTING PROCEDURES
MATERIAL IN OR NEAR FIRES SHOULD BE COOLED WITH A WATER SPRAY OR FOG. A SELF-CONTAINED BREATHING APPARATUS, OPERATING IN THE POSITIVE PRESSURE MODE, AND FULL FIRE-FIGHTING PROTECTIVE CLOTHING SHOULD BE WORN FOR COMBATING FIRES.

UNUSUAL FIRE AND EXPLOSION HAZARDS
THERMAL DECOMPOSITION OR COMBUSTION MAY PRODUCE DENSE SMOKE, OXIDES OF CARBON AND SILICON, AS WELL AS LOW MOLECULAR WEIGHT ORGANIC COMPOUNDS WHOSE COMPOSITIONS HAVE NOT BEEN CHARACTERIZED. FINELY DIVIDED CARBON DUSTS FORM POTENTIALLY EXPLOSIVE MIXTURES IN AIR AT CONCENTRATIONS [illegible]

[illegible]

4. HEALTH HAZARD DATA

LD50 ORAL (INGESTION) : NOT ESTABLISHED FOR PRODUCT

LD50 DERMAL (SKIN CONTACT) : NOT ESTABLISHED FOR PRODUCT

LD50 (INHALATION) : NOT ESTABLISHED FOR PRODUCT

PRIMARY ROUTE OF EXPLOSURE
INHALATION OF DUSTS GENERATED DURING PROCESSING AND HANDLING AND DERMAL AND OCULAR CONTACT.

THRESHOLD LIMIT VALUES (TLV)
NOT ESTABLISHED FOR PRODUCT - SEE SECTIONS 1 AND 11

EFFECTS OF OVEREXPOSURE

ACUTE :

HIGH CONCENTRATIONS OF CARBON AND/OR CRYSTALLINE SILICA DUSTS MAY BE IRRITATING TO THE EYES, SKIN, MUCOUS MEMBRANES AND RESPIRATORY TRACT.

CHRONIC :

INHALATION OF HIGH CONCENTRATIONS OF CARBON DUSTS OVER PROLONGED PERIODS OF TIME MAY CAUSE CARBON PNEUMOCONIOSIS. SYMPTOMS CAN INCLUDE COUGH, SHORTNESS OF BREATH AND A DECREASE IN PULMONARY FUNCTION.

INHALATION OF HIGH CONCENTRATIONS OF CRYSTALLINE SILICA DUSTS OVER PROLONGED PERIODS OF TIME MAY CAUSE SILICOSIS, A PROGRESSIVELY DEBILITATING LUNG DISEASE. THE SYMPTOMS ARE SIMILAR TO THOSE CITED ABOVE FOR CARBON PNEUMOCONIOSIS. INHALATION OF HIGH CONCENTRATIONS OF CRYSTALLINE SILICA OVER PROLONGED PERIODS OF TIME HAS ALSO BEEN LINKED TO AN INCREASED INCIDENCE OF LUNG CANCER.

PREEXISTING PULMONARY DISORDERS SUCH AS EMPHYSEMA MAY POSSIBLY BE AGGRAVATED BY PROLONGED EXPOSURES TO HIGH CONCENTRATIONS OF CARBON AND/OR CRYSTALLINE SILICA DUSTS.

SEE SECTION 11.

5. EMERGENCY AND FIRST AID PROCEDURES

FOR OVEREXPOSURE TO PARTICULATE MATTER, MOVE THE EXPOSED PERSON TO FRESH AIR. IF BREATHING IS DIFFICULT, OXYGEN MAY BE ADMINISTERED. IF BREATHING HAS STOPPED, ARTIFICIAL RESPIRATION SHOULD BE STARTED IMMEDIATELY. SEEK MEDICAL ATTENTION.

IF THE MATERIAL ENTERS THE EYES, FLUSH WITH WATER FOR AT LEAST 15 MINUTES. SEEK MEDICAL ATTENTION IF IRRITATION DEVELOPS OR PERSISTS.

IF THE MATERIAL GETS ON THE SKIN, WASH THOROUGHLY WITH MILD SOAP AND WATER. SEEK MEDICAL ATTENTION IF IRRITATION DEVELOPS OR PERSISTS. DERMATITIS SHOULD BE TREATED SYMPTOMATICALLY BY A PHYSICIAN.

INGESTION IS NOT EXPECTED TO BE AN IMPORTANT ROUTE OF ENTRY INTO THE BODY. IF, HOWEVER, THE MATERIAL IS INGESTED, GIVE TWO GLASSES OF WATER AND INDUCE VOMITING. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. SEEK MEDICAL ATTENTION.

6. PHYSICAL HAZARDS

CARBON DUSTS ARE ELECTRICALLY CONDUCTIVE. ACCUMULATIONS OF DUST MAY CAUSE SHORTING OF ELECTRICAL CIRCUITS. CARE SHOULD BE TAKEN TO SEAL ELECTRICAL CIRCUITS AND SWITCHES THAT MAY BE AFFECTED. DUSTS SHOULD NOT BE EMITTED INTO THE ATMOSHERE WHERE THEY MAY SETTLE ON AND CAUSE SHORTING OF OUTSIDE ELECTRICAL EQUIPMENT.

7. SPECIAL PROTECTION INFORMATION

VENTILATION

IF DUSTS ARE GENERATED DURING PROCESSING OR USE, LOCAL EXHAUST VENTILATION SHOULD BE PROVIDED TO MAINTAIN EXPOSURES BELOW THE LIMITS CITED IN SECTION 1. DESIGN DETAILS FOR LOCAL EXHAUST VENTILATION SYSTEMS MAY BE FOUND IN THE LATEST EDITION OF "INDUSTRIAL VENTILATION: A MANUAL OF RECOMMENDED PRACTICES" PUBLISHED BY THE ACGIH COMMITTEE ON INDUSTRIAL VENTILATION, P. O. BOX 16153, LANSING, MI 48910. THE NEED FOR LOCAL EXHAUST VENTILATION SHOULD BE EVALUATED BY A PROFESSIONAL INDUSTRIAL HYGIENIST. LOCAL EXHAUST VENTILATION SYSTEMS SHOULD BE DESIGNED BY A PROFESSIONAL ENGINEER.

RESPIRATORY

IF EXPOSURES EXCEED THE LIMITS CITED IN SECTION 1 BY LESS THAN A FACTOR OF 10, USE AS A MINIMUM A NIOSH APPROVED 1/2 FACEPIECE RESPIRATOR EQUIPPED WITH CARTRIDGES APPROVED FOR PARTICULATE MATTER WITH AN EXPOSURE LIMIT OF NOT LESS THAN 0.05 MG/M3. IF EXPOSURES EXCEED 10 TIMES THE LIMITS CITED IN SECTION 1, CONSULT A PROFESSIONAL INDUSTRIAL HYGIENIST OR YOUR RESPIRATORY PROTECTIVE EQUIPMENT SUPPLIER FOR SELECTION OF THE PROPER EQUIPMENT. THE EVALUATION OF THE NEED FOR RESPIRATORY PROTECTION SHOULD BE DETERMINED BY A PROFESSIONAL INDUSTRIAL HYGIENIST.

EYE PROTECTION

PROTECTIVE GLASSES WITH SIDESHIELDS SHOULD BE WORN TO PREVENT EYE CONTACT WITH PARTICULATE MATTER.

PROTECTIVE GLOVES:

PROTECTIVE GLOVES ARE RECOMMENDED TO PREVENT CUTS, ABRASIONS AND IRRITATION DURING HANDLING AND PROCESSING.

OTHER:

WHERE NORMAL WORK CLOTHES MAY BECOME SOILED WITH DUSTS, COVERALLS ARE RECOMMENDED. WASH SOILED CLOTHING BEFORE REUSE.

ALL CHEMICALS SHOULD BE HANDLED SO AS TO PREVENT EYE CONTACT AND EXCESSIVE OR REPEATED SKIN CONTACT. APPROPRIATE EYE AND SKIN PROTECTION SHOULD BE EMPLOYED. INHALATION OF DUSTS AND VAPORS SHOULD BE AVOIDED.

8. CHEMICAL REACTIVITY

CONDITION CAUSING INSTABILITY

NONE THAT ARE KNOWN. MATERIAL IS STABLE. HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

INCOMPATABILITY (MATERIALS TO AVOID)

AVOID CONTACT WITH STRONG OXIDIZING AND REDUCING AGENTS.

HAZARDOUS DECOMPOSITION PRODUCTS

SEE SECTION 3 FOR POSSIBLE COMBUSTION AND/OR THERMAL DECOMPOSITION PRODUCTS. THESE WOULD BE EXPECTED ONLY DURING EMERGENCY CONDITIONS.

SPECIAL SENSITIVITY

NONE THAT ARE KNOWN.

9. STORAGE INFORMATION

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING

STORE AWAY FROM HEAT, SPARKS, OPEN FLAMES AND OTHER SOURCES OF IGNITION. DO NOT STORE WITH OR NEAR INCOMPATIBLE CHEMICALS CITED IN SECTION 8. DO NOT LET MATERIAL ACCUMULATE IN THE WORKPLACE. PROMPTLY CLEAN UP ANY SPILLS THAT MAY OCCUR. ANY DUSTS GENERATED DURING HANDLING OR PROCESSING SHOULD BE CLEANED UP BY WET MOPPING OR VACUUMING WITH A HEPA FILTER. DRY SWEEPING CAN RESUSPEND PARTICULATE MATTER INTO THE ATMOSPHERE.

10. SPILL, LEAK, AND DISPOSAL INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS SPILLED OR RELEASED

SPILLED OR RELEASED MATERIAL SHOULD BE PICKED UP WITH A SUITABLE IMPLEMENT. IF NOT REUSABLE, THE MATERIAL SHOULD BE PLACED IN DOT APPROVED CONTAINERS FOR DISPOSAL. PERSONNEL INVOLVED IN THE CLEANUP SHOULD WEAR APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT. SEE SECTION 7. UNAUTHORIZED PERSONNEL SHOULD BE KEPT CLEAR OF THE AREA OF SPILLS OR RELEASES. DO NOT ALLOW MATERIAL TO ENTER STORM OR SANITARY SEWERS, GROUNDWATER OR SOIL. RELEASES MAY BE REPORTABLE TO LOCAL, STATE OR FEDERAL AUTHORITIES.

EPA RCRA ID NUMBER

NOT APPLICABLE.

WASTE DISPOSAL METHOD

MATERIAL SHOULD BE DISPOSED OF IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL REGULATIONS. DISPOSAL IN AN EPA APPROVED LANDFILL IS RECOMMENDED.

7. SPECIAL PROTECTION INFORMATION

VENTILATION
IF DUSTS ARE GENERATED DURING PROCESSING OR USE, LOCAL EXHAUST VENTILATION SHOULD BE PROVIDED TO MAINTAIN EXPOSURES BELOW THE LIMITS CITED IN SECTION 1. DESIGN DETAILS FOR LOCAL EXHAUST VENTILATION SYSTEMS MAY BE FOUND IN THE LATEST EDITION OF "INDUSTRIAL VENTILATION: A MANUAL OF RECOMMENDED PRACTICES" PUBLISHED BY THE ACGIH COMMITTEE ON INDUSTRIAL VENTILATION, P. O. BOX 16153, LANSING, MI 48910. THE NEED FOR LOCAL EXHAUST VENTILATION SHOULD BE EVALUATED BY A PROFESSIONAL INDUSTRIAL HYGIENIST. LOCAL EXHAUST VENTILATION SYSTEMS SHOULD BE DESIGNED BY A PROFESSIONAL ENGINEER.

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OTHER:
WHERE NORMAL WORK CLOTHES MAY BECOME SOILED WITH DUSTS, COVERALLS ARE RECOMMENDED. WASH SOILED CLOTHING BEFORE REUSE.

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8. CHEMICAL REACTIVITY

CONDITION CAUSING INSTABILITY
NONE THAT ARE KNOWN. MATERIAL IS STABLE. HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

INCOMPATABILITY (MATERIALS TO AVOID)
AVOID CONTACT WITH STRONG OXIDIZING AND REDUCING AGENTS.

HAZARDOUS DECOMPOSITION PRODUCTS
SEE SECTION 3 FOR POSSIBLE COMBUSTION AND/OR THERMAL DECOMPOSITION PRODUCTS. THESE WOULD BE EXPECTED ONLY DURING EMERGENCY CONDITIONS.

SPECIAL SENSITIVITY
NONE THAT ARE KNOWN.

9. STORAGE INFORMATION

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
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EPA RCRA ID NUMBER
NOT APPLICABLE.

WASTE DISPOSAL METHOD
MATERIAL SHOULD BE DISPOSED OF IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL REGULATIONS. DISPOSAL IN AN EPA APPROVED LANDFILL IS RECOMMENDED.

11. ADDITIONAL COMMENTS INFORMATION

1. NOTICE FROM UCAR CARBON COMPANY INC. THE DATA IN THIS MATERIAL SAFETY DATA SHEET RELATES ONLY TO THE SPECIFIC MATERIAL DESIGNATED HEREIN AND DOES NOT RELATE TO USE IN COMBINATION WITH ANY OTHER MATERIAL OR IN ANY PROCESS. THE OPTIONS EXPRESSED HEREIN ARE THOSE OF QUALIFIED EXPERTS WITHIN UCAR CARBON COMPANY INC. WE BELIEVE THAT THE INFORMATION CONTAINED HEREIN IS CURRENT AS TO THE DATE OF ISSUE OF THIS MATERIAL SAFETY DATA SHEET. SINCE THE USE OF THIS INFORMATION AND THESE OPTIONS AND THE CONDITIONS OF USE OF THE PRODUCT ARE NOT WITHIN THE CONTROL OF UCAR CARBON COMPANY INC., IT IS THE USER'S OBLIGATION TO DETERMINE THE CONDITIONS OF SAFE USE OF THIS PRODUCT.

2. THE CRYSTALLINE SILICA (14808-60-7) COMPONENT OF THIS FORMULATION IS LISTED AS AN ANIMAL CARCINOGEN AND A PROBABLE HUMAN CARCINOGEN BY THE INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC). IT HAS NOT BEEN LISTED AS A CARCINOGEN OR POTENTIAL CARCINOGEN BY THE NATIONAL TOXICOLOGY PROGRAM (NTP) OR THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA).

3. WARNING: THE CRYSTALLINE SILICA COMPONENT OF THIS FORMULATON HAS BEEN IDENTIFIED AS A "CHEMICAL KNOWN TO CAUSE CANCER" BY THE STATE OF CALIFORNIA.

Century Testing
Laboratories, Inc.

Mail: Post Office Box 1174
Bend, Oregon 97709
503-382-6432

LABORATORY ANALYSIS

TOXICITY CHARACTERISTICS LEACHING PROCEDURE (TCLP)

RHONE-POULENC
BASIC CHEMICAL
119130 GERMAN GULCH RD
BUTTE, MT 59750

EXTRACTION METHOD: TCLP,40CFR,Pt.268,App 1
LAB SAMPLE NO.: 8880-1
SAMPLE DESCRIP.: SPENT FURNACE CARBON BRICK
MATRIX: OTHER
DATE SUBMITTED: 1/22/92
DATE EXTRACTED: 1/22/92
DATE ANALYZED: 1/23/92
DISCARD DATE: 3/22/92
COLLECTED BY: CAM BALENTINE

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.*	METHOD DETECTION LIMIT	MAXIMUM ALLOWABLE CONC.	UNITS	PERCENT RECOVERY**
EPA 7060	ARSENIC	N.D.	0.015	5.0	mg/l	96.0%
EPA 6010	BARIUM	0.205	0.015	100	mg/l	120.0%
EPA 7130	CADMIUM	0.022	0.004	1.0	mg/l	96.0%
EPA 7190	CHROMIUM	0.156	0.020	5.0	mg/l	104.0%
EPA 7420	LEAD	N.D.	0.040	5.0	mg/l	88.0%
EPA 7470	MERCURY	N.D.	0.0003	0.2	mg/l	88.5%
EPA 7740	SELENIUM	N.D.	0.02	1.0	mg/l	105.0%
EPA 7760	SILVER	N.D.	0.006	5.0	mg/l	97.0%

*N.D. means "not detected."

**Percent Recovery values were within established control limits.

CENTURY TESTING LABORATORIES, INC.

Reviewed and approved by:

Bruce H. Bale
Quality Assurance Manager

01/24/92

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1120 SOUTH 27TH STREET • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489 • E-MAIL eli@energylab.com

lient: MSE-HKM, Inc.
Date Sampled: 22-MAR-99 15:35
Date Received: 24-MAR-99
Analysis Date: 29-MAR-1999 22:44
Project Info: RHODIA, INC.
Sample Info: SCB-1

Lab No.: 003-99-50887
Report Date: 03/31/99 15:51
Extraction Method: EPA 5030
Sample Matrix: SOIL; Moisture=7%

EPA METHOD 8260A: VOLATILE ORGANICS ANALYSIS REPORT

CONCENTRATION UNITS = ug/g (ppm)

COMPOUNDS	CAS NO.	RESULT	QUALIFIER
Acetone	67-64-1	<10	U
Acrolein	107-02-8	<4.0	U
Acrylonitrile	107-13-1	<4.0	U
Benzene	71-43-2	<0.20	U
Bromobenzene	108-86-1	<0.20	U
Bromochloromethane	74-97-5	<0.20	U
Bromodichloromethane	75-27-4	<0.20	U
Bromoform	75-25-2	<0.20	U
Bromomethane	74-83-9	<0.20	U
n-Butylbenzene	104-51-8	<0.20	U
sec-Butylbenzene	135-98-8	<0.20	U
tert-Butylbenzene	98-06-6	<0.20	U
Carbon disulfide	75-15-0	<0.20	U
Carbon tetrachloride	56-23-5	<0.20	U
Chlorobenzene	108-90-7	<0.20	U
Chloroethane	75-00-3	<0.20	U
2-Chloroethylvinyl ether	110-75-8	<0.20	U
Chloroform	67-66-3	<0.20	U
Chloromethane	74-87-3	<0.20	U
2-Chlorotoluene	95-49-8	<0.20	U
4-Chlorotoluene	106-43-4	<0.20	U
Chlorodibromomethane	124-48-1	<0.20	U
1,2-Dibromo-3-chloropropane	96-12-8	<0.20	U
1,2-Dibromoethane	106-93-4	<0.20	U
Dibromomethane	74-95-3	<0.20	U
1,2-Dichlorobenzene	95-50-1	<0.20	U
1,3-Dichlorobenzene	541-73-1	<0.20	U
1,4-Dichlorobenzene	106-46-7	<0.20	U
Dichlorodifluoromethane	75-71-8	<0.20	U
1,1-Dichloroethane	75-34-3	<0.20	U
1,2-Dichloroethane	107-06-2	<0.20	U
1,1-Dichloroethene	75-35-4	<0.20	U
cis-1,2-Dichloroethene	156-59-2	<0.20	U
trans-1,2-Dichloroethene	156-60-5	<0.20	U
1,2-Dichloropropane	78-87-5	<0.20	U
1,3-Dichloropropane	142-28-9	<0.20	U
2,2-Dichloropropane	594-20-7	<0.20	U
1,1-Dichloropropene	563-58-6	<0.20	U
cis-1,3-Dichloropropene	10061-01-5	<0.20	U
trans-1,3-Dichloropropene	10061-02-6	<0.20	U
Ethylbenzene	100-41-4	<0.20	U
Hexachlorobutadiene	87-68-3	<0.20	U
2-Hexanone	591-78-6	<4.0	U
Iodomethane	74-88-4	<0.20	U
Methyl-t-butyl ether	1634-04-4	<0.20	U
Methyl isobutyl ketone	108-10-1	<4.0	U

(report continued on page 2)

Lab No.: 003-99-50887
Sample Info: SCB-1

EPA METHOD 8260A: VOLATILE ORGANICS ANALYSIS REPORT

CONCENTRATION UNITS = ug/g (ppm)

COMPOUNDS	CAS NO.	RESULT	QUALIFIER
Methylene chloride	75-09-2	<0.20	U
Methyl ethyl ketone	78-93-3	<4.0	U
Naphthalene	91-20-3	<0.20	U
Isopropylbenzene	98-82-8	<0.20	U
n-Propylbenzene	103-65-1	<0.20	U
p-Isopropyltoluene	99-87-6	<0.20	U
Styrene	100-42-5	<0.20	U
1,1,1,2-Tetrachloroethane	630-20-6	<0.20	U
1,1,2,2-Tetrachloroethane	79-34-5	<0.20	U
Tetrachloroethene	127-18-4	<0.20	U
Toluene	108-88-3	<0.20	U
1,2,3-Trichlorobenzene	87-61-6	<0.20	U
1,2,4-Trichlorobenzene	120-82-1	<0.20	U
1,1,1-Trichloroethane	71-55-6	<0.20	U
1,1,2-Trichloroethane	79-00-5	<0.20	U
Trichloroethene	79-01-6	<0.20	U
Trichlorofluoromethane	75-69-4	<0.20	U
1,2,3-Trichloropropane	96-18-4	<0.20	U
1,3,5-Trimethylbenzene	108-67-8	<0.20	U
1,2,4-Trimethylbenzene	95-63-6	<0.20	U
Vinyl acetate	108-05-4	<0.20	U
Vinyl chloride	75-01-4	<0.20	U
m+p-Xylenes	108383/106423	<0.20	U
o-Xylene	95-47-6	<0.20	U

------------------- SURROGATE RECOVERY REPORT ------------------

Surrogate Compound	Added-ug/g	Measured-ug/g	%Rec	QC Limits
1,2-Dichloroethane d4	2.00	2.15	108	80--120
Toluene d8	2.00	1.91	96	80--120
p-Bromofluorobenzene	2.00	1.64	82	80--120

QUALIFIER CODE EXPLANATIONS AND NOTES:

Note: Results are reported on a wet weight basis. To convert a result to dry weight basis divide by 0.93.

U= Indicates compound was analyzed for but not detected.

REPORT COMMENTS: None

Analyst:______ Reviewing Supervisor:______ /IONTRAP1.i/vb032999.b/09mar29.d

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1120 SOUTH 27TH STREET • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489 • E-MAIL eli@energylab.com

Lab No.: 003-99-50887
Report Date: 04/01/99 10:03
Sample Matrix: SOIL; Moisture=7%
Extraction Method: EPA 3550
Prep Info: 30g to 1ml

Client: MSE-HKM, Inc.
Date Sampled: 22-MAR-99 15:35
Date Received: 24-MAR-99
Extraction Date: 30-MAR-1999
Analysis Date: 31-MAR-1999 15:47
Project Info: RHODIA, INC.
Sample Info: SCB-1

EPA METHOD 8270B: SEMI-VOLATILE ORGANICS ANALYSIS REPORT

CONCENTRATION UNITS = ug/g (ppm)

COMPOUNDS	CAS NO.	RESULT	QUALIFIER
Acenaphthene	83-32-9	<0.33	U
Acenaphthylene	208-96-8	<0.33	U
Anthracene	120-12-7	<0.33	U
Azobenzene	103-33-3	<0.33	U
Benzidine	92-87-5	<0.67	U
Benzo(a)Anthracene	56-55-3	<0.33	U
Benzo(b)fluoranthene	205-99-2	<0.33	U
Benzo(k)fluoranthene	207-08-9	<0.33	U
Benzo(g,h,i)perylene	191-24-2	<0.33	U
Benzo(a)pyrene	50-32-8	<0.33	U
4-Bromophenyl-phenylether	101-55-3	<0.33	U
Butylbenzylphthalate	85-68-7	<0.33	U
4-Chloro-3-Methylphenol	59-50-7	<0.33	U
bis(-2-Chloroethoxy)Methane	111-91-1	<0.33	U
bis(-2-Chloroethyl)Ether	111-44-4	<0.33	U
bis(2-Chloroisopropyl)ether	108-60-1	<0.33	U
2-Chloronaphthalene	91-58-7	<0.33	U
2-Chlorophenol	95-57-8	<0.33	U
4-Chlorophenol	106-48-9	<0.33	U
4-Chlorophenyl-phenylether	7005-72-3	<0.33	U
Chrysene	218-01-9	<0.33	U
Dibenzo(a,h)anthracene	53-70-3	<0.33	U
1,2-Dichlorobenzene	95-50-1	<0.33	U
1,3-Dichlorobenzene	541-73-1	<0.33	U
1,4-Dichlorobenzene	106-46-7	<0.33	U
3,3'-Dichlorobenzidine	91-94-1	<0.67	U
2,4-Dichlorophenol	120-83-2	<0.33	U
Diethylphthalate	84-66-2	<0.33	U
Dimethyl Phthalate	131-11-3	<0.33	U
2,4-Dimethylphenol	105-67-9	<0.33	U
Di-n-Butylphthalate	84-74-2	<0.33	U
4,6-Dinitro-2-methylphenol	534-52-1	<1.7	U
2,4-Dinitrophenol	51-28-5	<1.7	U
2,4-Dinitrotoluene	121-14-2	<0.33	U
2,6-Dinitrotoluene	606-20-2	<0.33	U
Di-n-octyl Phthalate	117-84-0	<0.33	U
bis(2-ethylhexyl)Phthalate	117-81-7	<0.33	U
Fluoranthene	206-44-0	<0.33	U
Fluorene	86-73-7	<0.33	U
Hexachlorobenzene	118-74-1	<0.33	U
Hexachlorobutadiene	87-68-3	<0.33	U
Hexachlorocyclopentadiene	77-47-4	<0.33	U
Hexachloroethane	67-72-1	<0.33	U

(report continued on page 2)

Lab No.: 003-99-50887
Sample Info: SCB-1

EPA METHOD 8270B: SEMI-VOLATILE ORGANICS ANALYSIS REPORT

CONCENTRATION UNITS = ug/g (ppm)

COMPOUNDS	CAS NO.	RESULT	QUALIFIER
Indeno(1,2,3-c,d)pyrene	193-39-5	<0.33	U
Isophorone	78-59-1	<0.33	U
1-Methylnaphthalene	90-12-0	<0.33	U
2-Methylnaphthalene	91-57-6	<0.33	U
2-Methylphenol	95-48-7	<0.33	U
4Methylphenol/3Methylphenol	106445/108394	<0.33	U
Naphthalene	91-20-3	<0.33	U
Nitrobenzene	98-95-3	<0.33	U
2-Nitrophenol	88-75-5	<0.33	U
4-Nitrophenol	100-02-7	<1.7	U
N-Nitrosodimethylamine	62-75-9	<0.33	U
N-nitroso-Di-n-propylamine	621-64-7	<0.33	U
N-nitrosodiphenylamine	86-30-6	<0.33	U
Pentachlorophenol	87-86-5	<1.7	U
Phenanthrene	85-01-8	<0.33	U
Phenol	108-95-2	<0.33	U
Pyrene	129-00-0	<0.33	U
Pyridine	110-86-1	<0.67	U
1,2,4-Trichlorobenzene	120-82-1	<0.33	U
2,4,5-Trichlorophenol	95-95-4	<0.33	U
2,4,6-Trichlorophenol	88-06-2	<0.33	U

------------------ SURROGATE RECOVERY REPORT ------------------

Surrogate Compound	Added-ug/g	Measured-ug/g	%Rec	QC Limits
2-Fluorophenol	6.67	3.77	57	25--121
Phenol-d5	6.67	3.92	59	24--113
Nitrobenzene-d5	3.33	2.07	62	23--120
2-Fluorobiphenyl	3.33	2.16	65	30--115
2,4,6-Tribromophenol	6.67	6.09	91	19--122
Terphenyl-d14	3.33	1.74	52	18--137

QUALIFIER CODE EXPLANATIONS AND NOTES:
Note: Results are reported on a wet weight basis. To convert a result to dry weight basis divide by 0.93.
U= Indicates compound was analyzed for but not detected.

REPORT COMMENTS: None

Analyst:________ Reviewing Supervisor:________ /disk3/sv5972.i/sb033199.b/31mar0901009.d

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: «Company»
Location: «Address1»
«Address2»
«City», «State» «PostalCode»
EPA ID#: «EPA_ID_»
Individual:
Name: ____________________
Title: ____________________ Phone Number: ____________________

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No ________

If Yes:

(A) What levels are acceptable: ______________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No ________

If Yes:

(A) At what capacity or rate: ________________(Units)

(B) What is the treatment method (Describe in detail):

____

____

____

____

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No ________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ________ No ________

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ________ No ________

(B) At what capacity or rate: ________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes ________ No ________

(D) At what capacity or rate: ________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

Completed Questionnaire Forms and Nonresponse Followup

#2

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Chemical Waste Management

Location: Hwy 17 N/Mi Marker 163
P O Box 55
Emelle, AL 35459

EPA ID#: ALD000622464

Individual:

Name: John O Hanley

Title: Environmental Mgr Phone Number: 205/652-8203

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No ✓

If Yes:

(A) What levels are acceptable: ____________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ______ No ✓

If Yes:

(A) At what capacity or rate: ____________(Units)

(B) What is the treatment method (Describe in detail):

#2

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes __________ No __________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes __________ [✓ No]

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes __________ No __________

(B) At what capacity or rate: ____________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes __________ No __________

(D) At what capacity or rate: ____________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

3
#64

BARR

Telephone Memo

Date: 11/7/00
Time: 10:55

JMS of Barr Engineering Company

☒ placed a call to 11/14/00 10:00 ☐ received a call from ☒ received a voice mail from 11/9/00 3:06 ☒ left message/voice mail to

Name	Position	Company	Telephone
Erica Hawk	Operator	Systech Env. Corp	800 538- 6003
		EPA ID # ALD981019045 ← facility closed 1998	- -
		MID981200835 ← facility closed 2000	- -

Re: **Project Name:**
Rhodia - TSD Facility Survey

Project Number:
26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No
Not sure

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:
resend to Erica Hawk - call first

Fax Number: 937 - 643- 1203

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

fuels to waste Company
handle liquid & sludge fuel quality waste - oils, solvents, paints

2. I

10:22 AM
11/14/00

I: ... the resp

Laidlaw
open burning permit

Systech
phosphorus
D003 - no Paulding

3. W LA or AL

Fredonia D003 Cyanide & sulfide only

phosphorus attacks kiln bricks

SYSTECH

- Company Information
- Fuels Group
- Contact
- Systech Digest Newsletter
- What's New
- Home

Systech Locations

Plant	Bulk Truck Liquid or Sludge	Rail Liquid or Sludge	Drum/Container	Tires
Paulding, OH	X	X		
Fredonia, KS	X	X	X	
Alpena, MI	X			
Whitehall, PA				X

Contact Systech at the following locations:

Systech Environmental Corporation
3085 Woodman Drive, Suite 300
Dayton, OH 45420-1159
Phone: 937-643-1240
Fax: 937-643-1203

Systech Environmental Corporation
South Cement Road, P.O. Box 111
Fredonia, KS 66736
Phone: 316-378-4451 or
800-778-7224
Fax: 316-378-4505

Systech Environmental Corporation closed 2000
1480 Ford Avenue, P.O. Box 588
Alpena, MI 49707
Phone: 517-354-3122
Fax: 517-356-4592

Systech Environmental Corporation
11397 County Road 176, P.O. Box 266
Paulding, OH 45879
Phone: 419-399-4835 or 800-266-3089
Fax: 419-399-4876

Systech Environmental Corporation
5160 Main Street
Whitehall, PA 18052
Phone: 610-261-3450
Fax: 610-262-5375

Email: ericah@xenia.sysenv.com

Systech Environmental Corporation
3085 Woodman Drive, Suite 300
Dayton, OH 45420-1159
Phone: 937-643-1240
Fax: 937-643-1203

#8

BARR

Telephone Memo

Date: 11/7/00
Time: 12:00

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Bill Dugan		Cadence Env. Energy, Inc./	870-542-7278
		Ash Grove Cement Co.	- -
		Foreman, Arkansas	- -
		EPA ID # ARD981512270	- -

Re: **Project Name:** Rhodia - TSD Facility Survey
Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Bill Dugan
870-542-7278

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No
no reactive mat'ls in their permit

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company:	ENSCO Inc
Location:	309 American Circle El Dorado, AR 71730-6555
EPA ID#:	ARD069748192

Individual:

Name: TREASA EVANS

Title: Dir. Regulatory Affairs Phone Number: 870-864-3680

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No X

If Yes:

(A) What levels are acceptable: N/A (Units)

Crude Phosphorus (No, since they cannot manage NORM material)

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes X No ______

If Yes:

(A) At what capacity or rate: Variable (Units)

(B) What is the treatment method (Describe in detail):

Incineration (ROTARY Kiln) via 30 gal poly CONTAINERS by direct drop chute.

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ______ No X – incineration residues (Ash) goes to Class C landfill for final treatment of metals prior to landfill.

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes X No ______

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes X No ______

(B) At what capacity or rate: Variable – (Units) depending on size / hardness and packaging constraints

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes X No ______

(D) At what capacity or rate: Variable (Units)

(E) What is the treatment method (Describe in detail):

Rotary kiln incineration – in-line shredders drop chute

9

Telephone Memo

BARR

Date: 11/7/00
Time: 12:10

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☒ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Elaine Butler		Ensco, Inc.	870 863-7173
			- -
			- -
	EPA ID #		- -

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

   not sure

   (If no, we will verify the mailing address and obtian fax number).
   Mailing Address:

   Fax Number: 870-864-3674

   Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

   Completed waste material data sheet needed

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

   If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#10

Telephone Memo

BARR

Date: 11/7/00
Time: 12:25

JMS of Barr Engineering Company

☐ placed a call to ☒ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Lyn Shephard		Reynolds Metals Co Gum Springs Plant	870 -245 2720 - - - - - -

EPA ID # ARD006354161

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

only K088 waste code

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

- 11

BARR

Telephone Memo

Date: 11/10/00
Time: 2:30

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Colleen		Denova Environmental, Inc.	909-350-0580
		EPA ID # CAT080022148	- -
			- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☒ Yes. ☐ No

Cannot take NORM

2. Do you plan to respond to the questionnaire? ☐ Yes ☒ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

Denova Environmental, Inc.
2824 North Locust Ave
Rialto, CA 92377

909-350-0580

#29

RECEIVED
NOV 02 2000
TO BARR
ENGINEERING

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Trade Waste Incinerator Inc

Location: 7 Mobile Ave Site B
Sauget, IL 62201

EPA ID#: ILD098642424

Individual:

Name: Craig Ragland

Title: Thermal Product Manager Phone Number: 618-271-2804

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes X No ________

If Yes:

(A) What levels are acceptable: < 0.5 millirads/hr (Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes X No ________

If Yes:

(A) At what capacity or rate: 1800 lbs/day (Units) (packaged in 15 lb containers)

(B) What is the treatment method (Describe in detail):

Incineration

#29

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ✓ No ✓ Ash stabalized at Landfill,

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes X No ____

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes X No ____

(B) At what capacity or rate: 20 Tons/day (Units) (must be sized <6")

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes X No ____

(D) At what capacity or rate: 20 Tons/day (Units) (must be sized <6")

(E) What is the treatment method (Describe in detail):

Incineration

#38

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company:	Essroc Cement Corp
Location:	Sr 25 S 3084 W Cr 225 S Logansport, IN 46947
EPA ID#:	IND005081542

Individual:

Name: GRANT MEEKS

Title: CUST. SERV. MNGR. Phone Number: 219-753-2675

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes _________ No ✓

If Yes:

(A) What levels are acceptable: _______________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes _________ No ✓

If Yes:

(A) At what capacity or rate: _________________(Units)

(B) What is the treatment method (Describe in detail):

#38

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No ___✓___

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ________ No ___✓___

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ________ No ___✓___

(B) At what capacity or rate: __________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes ________ No ___✓___

(D) At what capacity or rate: __________________(Units)

(E) What is the treatment method (Describe in detail):

40

BARR

Telephone Memo

Date: 12/13/00
Time: 1:25
12/28/00
3:00 follow up

JMS of Barr Engineering Company

☐ placed a call to ☐ received a call from ☒ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Tony Bannon		LoneStar	765 -653 8316
			- -
			- -
			- -

EPA ID# IND 006419212

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and ~~obtian fax number).~~
Mailing ~~Address:~~
Not sure if they can help us with the waste materials

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#40

BARR

Telephone Memo

Date: 11/10/00
Time: 2:40
Follow-up 11/27/00
1:55

JMS of Barr Engineering Company

☐ placed a call to ☒ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Krista Russell		Lone Star Sales Office	317-706-3300
1/28 30 Carlos Buckelew	site manager	Lone Star - Greencastle	- -
			- -

EPA ID# IND006419212

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:
Tony Bennett - production & site manager

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No
D003 accept under limited basis

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

Lone Star Industries

Sales Office
8902 Vincennes Circle
Suite A
PO Box 681250
Indianapolis IN 46268-1250

Lone Star Industries
3301 S Country Rd 150 W
PO Box 482
Greencastle, IN 46135
(765) 653-9766

#41

RECEIVED
NOV 02 2000
TO BARR ENGINEERING

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Rhodia Inc

Location: 2000 Michigan St
Hammond, IN 46320

EPA ID#: IND001859032

Individual:

Name: R. Eicke

Title: Ops. Supt. Phone Number: 219-932-7651, x277

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No X

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No X

If Yes:

(A) At what capacity or rate: ________________(Units)

(B) What is the treatment method (Describe in detail):

#41

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No ___X___

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ________ No ___X___

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ________ No ___X___

(B) At what capacity or rate: ________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes ________ No ___X___

(D) At what capacity or rate: ________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

#43

BARR

Telephone Memo

Date: 11/7/00
Time: 12:40

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Debbie Z Bill Wattripp		Safety Kleen Sys Inc. Argonite	316 251-6380

EPA ID# KSD981506025

Re: **Project Name:** Rhodia - TSD Facility Survey
Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

Incinerator is shut down - permanently

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

Closing facility

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#44

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Ash Grove Cement Plant

Location: 1801 N Santa Fe
PO Box 519
Chanute, KS 66720

EPA ID#: KSD031203318

Individual:

Name: Drew Hoisington

Title: Kiln Services Phone Number: 316 431 4500 x338

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No X

If Yes:

(A) What levels are acceptable: ______________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No X

If Yes:

(A) At what capacity or rate: ______________(Units)

(B) What is the treatment method (Describe in detail):

#8

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No ________ NA

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ________ No X - Inadequate Btu/lb,

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ________ No ________

(B) At what capacity or rate: ________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes ________ No ________

(D) At what capacity or rate: ________________(Units)

(E) What is the treatment method (Describe in detail):

CADENCE ENVIRONMENTAL ENERGY

FAX COVER SHEET

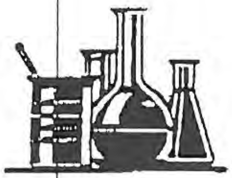
TO: Julie Sullivan 952 832 2601

FROM: Drew Hoisington

DATE: 11-8-00

Number of pages including this cover sheet: three

Please call Drew Hoisington at (316) 431-4122 x338 if there are any problems with this communication.



#44

BARR

Telephone Memo

Date: 11/8/00
Time: 10:55

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Drew Hoisington		Ash Grove Cement Plant Chanute, KS EPA ID # KSD031203318	316 -431- 4500

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

no reactive wastes

2. Do you plan to respond to the questionnaire? ☑ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire? – will fax back

Probably needs 50% carbon base
Only way we can take solids → 6 gal pals
75% < 1 inch size
BTUs? If it does not have any cannot take it

#45

BARR

Telephone Memo

Date: 11/7/00
Time: 3:35
Follow-up 11/27/00
2:00

JMS of Barr Engineering Company

11/27
☒ placed a call to ☐ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Bill Birdie		Heartland Cement Co	316-331-0200

EPA ID # KSD980739999

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

Closure on waste facility currently
→ sent on info to
Steve Majors

#46

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Systech Environmental Corp

Location: Cement Plant Rd
PO Box 111
Fredonia, KS 66736

EPA ID#: KSD980633259

Individual:

Name: Pam Colvin

Title: Customer Service Mgr Phone Number: 800-778-7224 ext. 115

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No X

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No X

If Yes:

(A) At what capacity or rate: ________________(Units)

(B) What is the treatment method (Describe in detail):

#46

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ No _________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ No ____X____

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ No _________

(B) At what capacity or rate: ___________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ No _________

(D) At what capacity or rate: ___________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

#47

L W D, INC.

P.O. BOX 327 • CALVERT CITY, KENTUCKY 42029
PH.: 270-395-8313 FAX: 270-395-8153

LWD INC

ENGINEERING CO

November 1, 2000

Mr. Thomas D. Mattison
Senior Chemical Engineer
Barr Engineering Company
4700 W. 77th. Street
Minneapolis, MN 55435-4803

RE: PHOSPHORUS-CONTAINING MATERIALS
RHODIA SILVER BOW PLANT
BUTTE, MONTANA

Dear Mr. Mattison:

Thank you for considering LWD for your waste treatment needs. At this time we must decline to bid on the above referenced materials because LWD can not accept NORM material. We do not feel we can handle the used carbon brick and furnace liner due to its reactivity and the dimensions of the material.

Thanks again for your interest. If we can be of further assistance please contact us at 270-395-8313.

Sincerely,

Allan R. Orth bkb

Allan R. Orth

ARO:bkb

BARR

Telephone Memo

#49

LAD000777201

Date: 11/1/00

Time: 2:30 pm

TDM of Barr Engineering Company

☐ placed a call to ☒ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Anita		Chemical Waste Management, Sulphur, LA	- -
			- -
			- -
			- -

Re: **Project Name:** Rhodia Silver Bow

Project Number: 26 / 25 - 001 JSL 020

Notes: Chemical Waste Management located in Sulphur, LA cannot accept D001 or D003 wastes at their facility. They can stabilize other hazardous waste prior to landfilling.

50

BARR

Telephone Memo

Date: 11/8/00
Time: 8:10

JMS of Barr Engineering Company

☒ placed a call to
11/10 9:00 ☒ received a call from
☐ received a voice mail from
☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Ken Michaels	Receptionist	Safety Kleen Colfax Inc. Colfax, LA	318 -627- 3443 - - - - - -

EPA ID# LAD981055791

Re: **Project Name:** Rhodia - TSD Facility Survey
Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

   (If no, we will verify the mailing address and obtian fax number).
   Mailing Address:
   Ken Michaels, Operations Manager – back on Friday

   Fax Number:

   Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No
   Cannot accept radioactive materials
   Jim Gallion ? talked w/someone previously

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

   If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#51

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company:	Rhodia Inc
Location:	1275 Airline Hwy PO Box 828 Baton Rouge, LA 70805
EPA ID#:	LAD008161234

Individual:

Name: Anne A. Adrian

Title: Env. Eng / IH Phone Number: 225 359 3410

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No ✓

If Yes:

(A) What levels are acceptable: ____________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ______ No ✓

If Yes:

(A) At what capacity or rate: ____________(Units)

(B) What is the treatment method (Describe in detail):

#51

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes [✓ No]

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes [✓ No]

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes [✓ No]

(B) At what capacity or rate: ____________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes [✓ No]

(D) At what capacity or rate: ____________________(Units)

(E) What is the treatment method (Describe in detail):

Rhodia's Baton Rouge site only handles bulk liquid materials that are NOT Nickel containing

#5

Telephone Memo

Date: 11/8/00
Time: 8:18

BARR

JMS of Barr Engineering Company

☐ placed a call to ☒ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	Position	Company	Telephone
Scott Gendron	Haz waste Incin.	Rhodia, Inc. Baton Rouge, LA	225-356-7111
			- -
			- -
			- -

EPA ID# LAD008161234

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:
Scott Gendron

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

Not at that particular site - (only liquid injection)

Rhodia has purchased → Heat Energy Dallas TX Bryan Kutz (home office sales)
225-654-7100

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

BARR

Telephone Memo

Date: 11/15
Time: 2:47

JMS of Barr Engineering Company

☐ placed a call to ☐ received a call from ☒ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Bryan Kutz		Rhodia	225 654 7000
			- -
			- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

cannot take because of radioactivity

3V

BARR

Telephone Memo

Date: 12/8/00
Time: 9:30

JMS of Barr Engineering Company

☐ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Bill Kestick		Safety Kleen Baton Rouge	225 778 3584
			- -
			- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the ~~mailing~~ address ~~and~~ obtian fax number).
Mailing Address:
Processing Rate & Size limitations? 120 tons/wk - yes
~3 loads
Receive - Roll off boxes or dump trucks
~~Fax Number~~:

~~Can you manage~~ phosphorus-containing mateirals with ~~D001~~ and D003 Codes? ☐ Yes ☐ No
Process: wet brick to remove residual

2. Do you plan to respond ~~to the~~ questionnaire? ☐ Yes ☐ No

If yes, ~~what is~~ the outstanding issue that is delaying ~~the~~ response?

3. When can we expect the completed questionnaire?

safety-kleen®

FAX COVER SHEET

FAX RECEIVED
NOV 15 2000
TO BARR

DATE: 11/15/00

TO: JULIE SULLIVAN FAX NO:

FROM: BILL KESLICK FAX NO: 225 778 3510
PHONE NO: " " 3584

NUMBER OF PAGES INCLUDING COVER SHEET (2)

RE: RHODIA

JULIE, HERE IS PG 2. ALSO, AFTER FURTHER REVIEW WE CAN HANDLE NORM @ 25 micro roentgens ~~and~~ OR LESS. IF IT IS Naturally occurring/exempt the action levels are higher - PLEASE CHANGE FROM 7 ON origanal form (pg 1) per me.

BILL

13351 Scenic Highway, Baton Rouge, LA 70807-1021
Post Office Box 74137, Baton Rouge, LA 70874-4137

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No __X__ TRANSFERRED TO OUR INCINERATOR

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes __X__ No ________ MAY NEED MORE INFO ON HISTORY (SAMPLE) BUT WE CAN OXIDIZE THE RED PHOSPHOROUS FOR TRANSFER

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes __X__ No ________ MAY NEED MORE INFO (SAMPLE)

(B) At what capacity or rate: ________________ (Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)? AS ABOVE

Yes __X__ No ________

(D) At what capacity or rate: __VARIES__ (Units) 120 TONS/WEEK

(E) What is the treatment method (Describe in detail):

SK (BATON ROUGE) HAS AN ENCLOSED BUILDING UNDER NEGATIVE PRESSURE. REACTIONS ARE (VAPORS) VENTED TO A THERMAL OXIDATION UNIT. SINCE THE FURNACE LINER IS REASONABLY LOW IN CONC. WE COULD OXIDIZE WITH WATER, CAPTURE FUMES AND TRANSFER AT GENERATOR'S DESIRED TREATMENT FACILITY.

** TOTAL PAGE.02 **

safety-kleen®

FAX COVER SHEET

DATE: 11/9/00

TO: Julie Sullivan FAX NO:

FROM: Bill Keslick FAX NO:

PHONE NO: 225-778-3584

NUMBER OF PAGES INCLUDING COVER SHEET (   )

RE: Phosphorous / TSD Survey

13351 Scenic Highway, Baton Rouge, LA 70807-1021
Post Office Box 74137, Baton Rouge, LA 70874-4137

#52

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Safety Kleen Baton Rouge Inc

Location: 13351 Scenic Hwy Id127
PO Box 74137
Baton Rouge, LA 70807-1021

EPA ID#: LAD010395127

Individual:

Name: BILL KESLICK

Title: LAB MANAGER Phone Number: 225-778-3584

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes X No ____

If Yes:

(A) What levels are acceptable: 25 < ~~7~~ μR gamma (Units) or if specifically exempt.

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ____ No X (see below)

If Yes:

(A) At what capacity or rate: ________ (Units)

(B) What is the treatment method (Describe in detail):

SK (BATON ROUGE) CAN MANAGE low percentages of elemental phosphorous into incinerable packages. The containers are then tranferred to the Safety Kleen incinerator, Deer Park, TX. where the material is rendered non-ignitable/non-reactive.

- 1 of 2 -

BARR

Telephone Memo

Date: 11/8/00
Time: 8:24

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Bill Keslick		Safety Kleen Baton Rouge, Inc.	225 -778- 1234

EPA ID # LAD010395127

Re:	**Project Name:**	**Project Number:**
	Rhodia - TSD Facility Survey	26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

not sure, fax again

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number: 225-778-3510

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

they have

2. Do you plan to respond to the questionnaire? ☒ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#68

BARR

Telephone Memo

Date: 11/10/00
Time: 3:00

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Kieth Brown	Superintendant	Holnam, Inc. Artesia Plant	662 -272 5121
			- -
			- -
		EPA ID # MSD077655876	- -

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No ?

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

Cannot manage haz solids
only haz liquids & non-haz solids

2. Do you plan to respond to the questionnaire? ☐ Yes ☒ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

~~#38~~
#72

Telephone Memo

BARR

Date: 11/8/00
Time: 10:25

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Don Jones		Holnam Inc./ Safety Kleen Corp	573 -242 ~~3577~~
			- - 3585
			- -
			- -

EPA ID # MOD029729688

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Bob Adams 636-625 8956 sales
may be able to find outlet

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No
no, cannot accept reactive

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

13

Telephone Memo

BARR

Date: 12/8/00
Time: 9:05 AM

12/12/00
8:50 Am

JMS of Barr Engineering Company

☐ placed a call to ☐ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	Position	Company	Telephone
James Kilpatrick	Mgr	ICI Explosives	417 -624 0212 ext. 412
			- -
			- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and ~~supporting materials?~~ ☐ Yes ☐ No

~~(If no, we will verify the mailing address and obtian fax number).~~
~~Mailing Address:~~
What processing rate for brick w/amorphous phosphorus?

~~Fax Number:~~

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?
What temp was kiln operated at during processing?
During kiln shut down was it operated empty, if so, what temp?

Will 850° be sufficent to deactivate?

Ignition Temp = 500°F

BARR

Telephone Memo

Date: 11/8/00
Time: 11:20
Called back 11/9/00
1:40

JMS of Barr Engineering Company

☐ placed a call to ☐ received a call from ☒ received a voice mail from 11:20 11/9/00 ☒ left message/voice mail to

Name	Position	Company	Telephone
Pat Moss		ICI Explosives	417 -624 0212 ext. 409
Rhonda		Env. Co. Joplin MO	- - ext. 400
James Kilpatrick	Manager		- - ext. 403
Willie Roy	Tech Mgr		- - ext. 405

EPA ID # MOD985798164

Re: **Project Name:** Rhodia - TSD Facility Survey
Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☒ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

2. Do you plan to respond to the questionnaire? ☒ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?
possibly can manage the brick

3. When can we expect the completed questionnaire? will fax

Waste Approval process takes several weeks

BARR

Barr Engineering Company
4700 West 77th Street • Minneapolis, MN 55435-4803
Phone: 612-832-2600 • Fax: 612-832-2601

Minneapolis, MN • Hibbing, MN • Duluth, MN • Ann Arbor, MI • Jefferson City, MO

#75

10/30/00
LONE STAR HAS
NO INTEREST IN
THIS MATERIAL.

October 26, 2000

Waste Acceptance Coordinator
Lone Star Ind Inc
2524 S Sprigg St
PO Box 968
Cape Girardeau, MO 63701

Re: Phosphorus-containing Materials
Rhodia Silver Bow Plant
Butte, Montana

Waste Acceptance Coordinator:

Rhodia, Inc. is evaluating alternatives for the lawful removal and disposal of two materials that are located at a closed elemental phosphorus facility near Butte, Montana. Rhodia, Inc. is inquiring about your ability to receive, treat and dispose of these phosphorus-containing materials. The materials are (1) crude phosphorus and (2) used carbon brick and furnace liner. Crude phosphorus contains elemental phosphorus; elevated levels of naturally occurring radioactive material (NORM); and has the potential to generate phosphine gas. The used carbon brick and furnace liner contains forms of phosphorus, may have elevated levels of NORM, and has the potential to generate oxides of phosphorus. In addition, EPA has expressed concern that elemental phosphorus could have saturated the carbon brick and furnace liner while they were in service, although Rhodia has seen no evidence to substantiate this concern.

The U.S. EPA believes that the crude phosphorus should be characterized as D001 and D003 hazardous waste, and that the used carbon brick and furnace liner should be characterized as D001 hazardous waste. For purposes of this request, please assume that the materials will be shipped to you as such. Under the land disposal restriction (LDR) requirements, D001 hazardous wastes will have to be treated so that they are nonignitable and D003 hazardous wastes will have to be treated so that they are nonreactive (do not generate toxic gases) before land disposal. The materials are not known to contain underlying hazardous constituents that exceed their Universal Treatment Standards. However, EPA believes the materials should be assumed to contain metals that do not meet their universal treatment standards.

Special handling requirements for these materials are identified in the detailed material descriptions that are attached to this letter. A brief questionnaire regarding these materials is also attached. Please review the material descriptions, respond to the specific questions and return the completed questionnaire by Friday, November 3, 2000 in the stamped, self-addressed envelope.

Please direct any questions concerning these materials to me at (952)832-2600 or email (tmattison@barr.com). Thank you for your time and consideration.

Sincerely,

Thomas D. Mattison
Senior Chemical Engineer

#76

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Continental Cement Co Llc

Location: 10107 Hwy 79
PO Box 71
Hannibal, MO 63401-0071

EPA ID#: MOD054018288

Individual:

Name: RALPH A. FREAD

Title: SALES REPRESENTATIVE Phone Number: 573-271-6262 EXT. 204

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes [✓ No]

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes [✓ No]

If Yes:

(A) At what capacity or rate: __________________(Units)

(B) What is the treatment method (Describe in detail):

#76

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ No ____X____

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ No ____X____

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ No _________

(B) At what capacity or rate: __________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ No _________

(D) At what capacity or rate: __________________(Units)

(E) What is the treatment method (Describe in detail):

#77

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Clean Harbors Env Services Inc

Location: Highway 71, 5 Mi S Of Town
Kimball, NE 69145

EPA ID#: NED981723513

Individual:

Name: Carol Schaneggs

Title: Lab Manager Phone Number: (308) 235-8205

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes [✓ No]

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes [✓ No]

If Yes:

(A) At what capacity or rate: ________________(Units)

(B) What is the treatment method (Describe in detail):

#77

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ No _________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ [✓ No]

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ No _________

(B) At what capacity or rate: ____________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ No _________

(D) At what capacity or rate: ____________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

#83

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Safety Kleen(Bridgeport)Inc

Location: Us Rte 322 & I 295
PO Box 337
Bridgeport, NJ ~~8014~~ 08014

EPA ID#: NJD053288239

Individual:

Name: ____________________

Title: ____________________ Phone Number: ____________________

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No ✓

If Yes:

(A) What levels are acceptable: ____________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ______ No ✓

If Yes:

(A) At what capacity or rate: ____________(Units)

(B) What is the treatment method (Describe in detail):

#83

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ [✓ No]

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ [✓ No]

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ [✓ No]

(B) At what capacity or rate: ___________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ [✓ No]

(D) At what capacity or rate: ___________________(Units)

(E) What is the treatment method (Describe in detail):

#86

BARR

Telephone Memo

Date: 11/8/00
Time: 12:30
follow-up 11/27/00
2:05

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Sharon Wienckowski		Safety-Kleen Bldt Inc. Clarence	716 -759- 2868
			- -
			- -
		EPA ID # NYD000632372	- -

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number: 716 - 759 - 6034

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☒ Yes. ☐ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#88

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Norlite Corp

Location: 628 S Saratoga St
PO Box 694
Cohoes, NY 12047

EPA ID#: NYD080469935

Individual:

Name: Charles Story

Title: V.P. Business Development Phone Number: 518-235-0401 x 4044

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No X

If Yes:

(A) What levels are acceptable: ____________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ______ No X

If Yes:

(A) At what capacity or rate: ____________(Units)

(B) What is the treatment method (Describe in detail):

#88

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ No _________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ No ____X____

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ No _________

(B) At what capacity or rate: __________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ No _________

(D) At what capacity or rate: __________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

#90

BARR

Telephone Memo

Date: 11/8/00
Time: 12:33

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
	Receptionist	Giant Resource Recovery, Inc.	704-474-3165
			- -
		EPA ID# NCD 000773655	- -
			- -

Re:

Project Name:
Rhodia - TSD Facility Survey

Project Number:
26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

This facility no longer burns haz. waste

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#103

BARR

Telephone Memo

Date: 11/8/00
Time:

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	Position	Company	Telephone
Terri Kanouse		Systech Env. Corp. Paulding OH	419 -399- 4835
		EPA ID #OHD 005048947	- -
			- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☒ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

3 issues
- D003 code
- Phosphorus - problem for cement process
- do not put ~~[illegible]~~ haz mat'l in cold end of kiln

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#104

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Waste Technologies Industries

Location: 1250 St George Street
PO Box 919
East Liverpool, OH 43920

EPA ID#: OHD980613541

Individual:

Name: Stephen Lorah

Title: Materials Processing Mgr Phone Number: (330) 385-7336

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ✓ No ________

If Yes:

(A) What levels are acceptable: < 5 mRem/hour (Units)

Need Isotopic specific Info.

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ✓ No ________

If Yes:

(A) At what capacity or rate: 3000 lbs/hr (Units)

(B) What is the treatment method (Describe in detail):

Incineration in Drums. Drums must be open topped metal drums. Phosphorus must have a minimum of 2 inches of water covering.

#104

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

* Yes ✓ No ________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ✓ No ________

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ✓ No ________

(B) At what capacity or rate: ~3000 lbs/hr (Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes ✓ No ________

(D) At what capacity or rate: ~3000 lbs/hr (Units)

(E) What is the treatment method (Describe in detail):

Incineration in Drums. Due to ~~phospho~~ phosphorus contamination, material must be shipped in Drums.

* If residues exceed LDR for metals, stabilization is performed at another facility.

#112

BARR

Telephone Memo

Date: 11/6/00
Time: 12:47
follow-up 11/27/00
2:06

JMS of Barr Engineering Company

☐ placed a call to ☐ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Mike Luybli		Keystone Cement Co	610-837-1881
		direct	610-837-2229
			- -
			- -

EPA ID # PAD002389559

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

115

BARR

Telephone Memo

Date: 11/10/00
Time: 3:03

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	Position	Company	Telephone
		Southdown Inc.	800 -451- 6771
			- -
			- -
			- -

EPA ID # PAD083965897

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

Do not accept hazardous waste

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#114

Telephone Memo

BARR

Date: 11/8/00
Time: 12:52

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	Position	Company	Telephone
Guy Mobley	Sales	Giant Resource Recovery Inc. / Giant Cement Co.	803 -496- 5033

EPA ID # SCD003351699

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☒ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

no fuel value > 5000 btu
phosphorus inhibits cement

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#122

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Holnam Inc Safety Kleen Systems Inc
Location: 2175 Gardner Blvd
Holly Hill, SC 29059
EPA ID#: SCD003368891
Individual:
Name: S. Lea Simons
Title: Environmental Mngr Phone Number: 803/496-7303 ext. 24

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No __X__

If Yes:

(A) What levels are acceptable: ____________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ______ No __X__

If Yes:

(A) At what capacity or rate: ____________(Units)

(B) What is the treatment method (Describe in detail):

#122

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ No _________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ No ___X___

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ No _________

(B) At what capacity or rate: ___________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ No _________

(D) At what capacity or rate: ___________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

123

BARR

Telephone Memo

Date: 11/8/00
Time: 11:00

JMS of Barr Engineering Company

☐ placed a call to
☒ received a call from 11/9/00 10:50 AM
☒ received a voice mail from 11/10/00 10:00 AM
☒ left message/voice mail to

Name	Position	Company	Telephone
~~Larry Hembree~~	no longer w/company	DSSI	865 -376- 8714
Paul Hickman			- -8740
			- -
		EPA ID # TND982109142	- -

Re: **Project Name:** Rhodia - TSD Facility Survey
Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address: Subsidiary of Permafix
657 Gallaher Rd
Kingston TN 37763

Fax Number: 865-376-0087
fax packet 11/9/00

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☑ No
liquids processor, no heavy amts of solids allowed, especially phosphorus

2. Do you plan to respond to the questionnaire? ☐ Yes ☒ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

BARR

Telephone Memo

Date: 11/8/00
Time: 1:21

Follow-up

11/29/00
2:24

JLS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☒ ~~left message~~/voice mail to

Name	**Position**	**Company**	**Telephone**
Jennifer Edwards		Onyx Env. Services	409-736-4133
		EPA ID # TXD000838896	

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:
jedwards @ onyxes.com

Fax Number: 409 - 736 - 1636

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☒ Yes. ☐ No
Does not appear to be a problem
Need additional info

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

From: "Jennifer Edwards" <jedwards@onyxes.com>
To: Julie Sullivan <jsullivan@barr.com>
Date: Thu, Nov 9, 2000 12:16 PM
Subject: Re: Rhodia - TSD Facility Survey

I received your fax and we aer currently reviewing it.

From: "Jennifer Edwards" <jedwards@onyxes.com>
To: Julie Sullivan <jsullivan@barr.com>
Date: Thu, Nov 9, 2000 7:56 AM
Subject: Re: Rhodia - TSD Facility Survey

I have forward the survey to the appropriate people here at the facility. I should have it completed shortly. I will also include our audit package for your information and overnight it to you.

#135

BARR

Telephone Memo

Date: 11/8/00
Time: 1:33

JMS of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
		Rhodia Inc. Houston TX	713 -928- 3411
			- -
		EPA ID # TXD008099079	- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☐ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:
Dianea Nunez → Rosemary Quintanilla
manifest clerk
talked w/ Ken Evans ?} sales
or Rick Jones?}

Fax Number: 713-928-3431 — 713-996-5407

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No

do not take elemental phosphorus

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

#138

Telephone Memo

BARR

Date: 11/8/00
Time: 1:38
Called back 11/9/00
1:35 PM

JMS of Barr Engineering Company

11/8/00
2:07

☒ placed a call to ☐ received a call from ☒ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Kay Osborn		TXI Midlothian Cement Plant	972-647 6701
Rita Burge		Resource Recovery Dept	972-647-4942

EPA ID # TXD007349327

Re: **Project Name:**
Rhodia - TSD Facility Survey

Project Number:
26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No
Cannot accept D003 waste

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

A2

Telephone Memo

BARR

Date: 11/8/00
Time: 1:46

11/15/00
11:30

JMS of Barr Engineering Company

☐ placed a call to ☒ received a call from ☐ received a voice mail from ☒ left message/voice mail to

Name	Position	Company	Telephone
Steve ~~Simons~~ Symonds		Safety Kleen (Aragonite), Inc.	801-323-8100
		EPA ID# UTD981552177	

Re: **Project Name:** Rhodia - TSD Facility Survey

Project Number: 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

   (If no, we will verify the mailing address and obtian fax number).
   Mailing Address:

   Fax Number: 801 - 323 - 8877

   Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☒ No
   Cannot accept pyrophorics - (white & yellow phosphorus) not permitted
   DOT 4.2 packing ---

2. Do you plan to respond to the questionnaire? ☐ Yes ☒ No

   If yes, what is the outstanding issue that is delaying the response?

3. When can we expect the completed questionnaire?

   Brick - red phosphorus can take in lab pack quantities, under oil

#145

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Giant Resource Recovery Inc

Location: Rt 1 St Rd 652
PO Box 68
Arvonia, VA 23004

EPA ID#: VAD098443443

Individual:

Name: Cynthia Turk

Title: marketing mgr. Phone Number: 804-673-8630

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No ✓

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No ✓

If Yes:

(A) At what capacity or rate: ________________(Units)

(B) What is the treatment method (Describe in detail):

#145

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes _________ No _________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes _________ [✓ No _________]

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes _________ No _________

(B) At what capacity or rate: __________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes _________ No _________

(D) At what capacity or rate: __________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

#146

RECEIVED
[illegible] 2000
[illegible] ENGINEERING CO

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: Giant Resource Recovery
Location: ~~1 Mi S Of Cascade VA on Rt 859~~
~~Rt 1 Box~~ 101 Solite Rd.
Cascade, VA 24069-9701
EPA ID#: VAD077942266
Individual:
Name: Lori Bailey
Title: Manifest Coord. Phone Number: 804-685-3564

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No ✓

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No ✓

If Yes:

(A) At what capacity or rate: __________________(Units)

(B) What is the treatment method (Describe in detail):

#146

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No ________

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ________ No ✓

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ________ No ________

(B) At what capacity or rate: __________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes ________ No ________

(D) At what capacity or rate: __________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

Our process is fueled by waste flammable liquids only

#15

[illegible]

ENGINEERING CO

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: WRR Environmental Services Co Inc

Location: 5200 St Rd 93
Eau Claire, WI 54701

EPA ID#: WID990829475

Individual:

Name: Steve STOKKE

Title: VP Cp. Support Phone Number: 715-834-9624

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No X

If Yes:

(A) What levels are acceptable: ______________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ______ No X

If Yes:

(A) At what capacity or rate: ______________(Units)

(B) What is the treatment method (Describe in detail):

#15

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes __________ No ____X____

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes __________ No ____X____

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes __________ No ____X____

(B) At what capacity or rate: ____________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes __________ No ____X____

(D) At what capacity or rate: ____________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

#155

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: FMC Corp Phosphorus Chemicals Group

Location: HWY 30
Box 4111
Pocatello, ID 83202

EPA ID#: IDD070929518

Individual:

Name: ROB J. HARTMAN

Title: Remediation Project Mngr Phone Number: 208-236-8658

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ________ No X

If Yes:

(A) What levels are acceptable: ________________(Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes ________ No X

If Yes:

(A) At what capacity or rate: ________________(Units)

(B) What is the treatment method (Describe in detail):

#155

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes __________ No ___X___

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes __________ No ___X___

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes __________ No __________

(B) At what capacity or rate: ____________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes __________ No __________

(D) At what capacity or rate: ____________________(Units)

(E) What is the treatment method (Describe in detail):

____

____

____

____

BARR

Telephone Memo

Date: 11/14/00
Time: 1.10

JMS of Barr Engineering Company

☐ placed a call to ☒ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Kieth Gehring	Service Rep	Safety Kleen Seattle WA	253 288-2814

Re: **Project Name:** Rhodia - TSD Facility Survey **Project Number:** 26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

   (If no, we will verify the mailing address and obtian fax number).
   Mailing Address:

   Fax Number:

   Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

2. Do you plan to respond to the questionnaire? ☐ Yes ☐ No

   If yes, what is the outstanding issue that is delaying the response?
   Checking into all their facilities

3. When can we expect the completed questionnaire?
   Aragonite, UT cannot accept large quantity bulk D003 wastes
   Roebuck, SC liquid incinerator

BARR

Telephone Memo

Date: 11/10/00
Time: 3:08

JMS of Barr Engineering Company

☐ placed a call to ☒ received a call from 11/14/00 10:30 ☐ received a voice mail from ☒ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Eric Nielsen		Safety-Kleen Sales (Corporate office)	888-217-7859 803 231-3790

Re:

Project Name:
Rhodia - TSD Facility Survey

Project Number:
26 / 25 - 001 JSL 020

Notes:

1. Have you received the questionnaire and supporting materials? ☐ Yes ☒ No

(If no, we will verify the mailing address and obtian fax number).
Mailing Address:
will contact local sales person to call me & discuss

Fax Number:

Can you manage phosphorus-containing mateirals with D001 and D003 Codes? ☐ Yes. ☐ No

2. Do you plan to respond to the questionnaire?

If yes, what is the outstanding issue that is delaying the response?

Safety - Kleen
1301 Gervais Street
Columbia, SC 29202

Sales
1-888-217-7859

3. When can we expect the completed questionnaire?

Followup Contacts with Candidate Facilities

BARR

Telephone Memo

Date: 12/6/00
Time: 9:00 AM

RTR/TDM of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Steve Lorah	Materials Processing MGR	WTI	330-385-7336
Doug Smith		ENSR	- -
Dan Bersanti		Rhodia	- -
Arnie Feldman		JJDS Environmental	- -

Re: **Project Name:** Rhodia - TSD Facility Survey - Candidate Facility Follow-up Plan

Project Number: 26 / 25 - 001 JSL 020

Notes:
Do you have any preliminary questions?

1. Do you have previous experience processing with phosphorus-containing materials? Provide reference for each stream.

- Waste Technilogies Inc. (WTI) has previously completed 6 projects consisting of 10-20 drums per project.
- They just completed a small (6? drums) white phosphorus drum disposal project for the Aberdeen Proving Ground.
- Other clients included FMC and others who he said were confidential at this time.

2. Do you have a heated facility for the temporary storage of the phosphorus-containing materials prior to treatment ?
(If yes , what is the capacity?)

-Steve said that the normal procedure for managing the phosphorus would be to not store the drums, the drums are processed directly off of the truck. He said that the waste acceptance procedure would take 45 minutes to 1 hour and then they would begin burning the drums.
- He thought that it may be possible to store the drums containing the bricks. They would set up a segregated storage area for the drums containing the bricks.

3. What are your management requirements for elevated NORM materials?
-See the notes on the next set of questions.

4. How will emissions from the phosphorus processing be managed at your facility?
-See the notes on the next set of questions.

5. Do you have written procedures for handling phopshorus-containg materials? (If yes, please provide a copy.)
-See the notes on the next set of questions.

6. What are your procedures for personal air monitoring as it related to phosphine and worker protection?
-See the notes on the next set of questions.

7. What are your fire-fighting capabilites as it relates to a phosphorus fire?
-See the notes on the next set of questions.

8. Can you provide material packageing services in addition to off-site treatment and disposal services?
- Not discussed

9. Who may I contact at the state or federal regulatory agency that is most familiar with your

operations?

- Federal Contacts - Gary Victorine - 312-886-1479
  Tim Fields
- Ohio Contacts - Steve said that the State of Ohio has people on-site daily that approve waste stream profiles and review daily operations for compliance. He will provide their names to us.

10. Do you have a current Facility Audit Package? Can you provided a copy for our review?.

- Yes, he will forward the current package to us.

11. Do you continue to believe that your facility is capable of receiving and safely managing the crude phosphorus? How about the used carbon brick and furnace liner?

Rhodia will continue to evaluate your facility and may request a price quote for these services. Thank you for your cooperation.

QUESTIONS/ISSUES

1. What is your limit on rads? Are you permitted to accept NORM? How do you test; pre-shipment and shipment? What do you do if an incoming load exceeds your permitted level?
- The facility permit restricts the acceptance of NORM waste to below the naturally occurring background levels in the lab on-site (<5 mRem/hour).
- The facility does not require a pre-shipment acceptance sample.
- The shipment acceptance sample will consist of a surface dose (3 cm from the drum) measurement on the exterior of the drum. The drum will not be opened prior to incineration, only the drum ring will be dropped off of the drum.
- The facility only measures gamma radiation with it's radiation meter. Alpha and beta are not measured. A comment was made that alpha and beta most likely would not be detected through the metal drum.
- If the shipment acceptance measurement for radiation exceeds the permitted level the facility will work through the Ohio EPA to see if the material can be accepted at the facility.
- The facility does not require isotopic specific information, they are looking for the activity level of the material.
- The comment was made that P40 would be the main isotope that would be an issue.

2. What is your permit limitation on reactive wastes, if any? Can you accept all D003 categories [reference to 261.23(a)(1)-(8)]?
- The facility has no limitations on reactive D003 wastes. All are acceptable, they have some restrictions on explosives.
- They have burned 450 lbs. of phosphorus in a shot.

3. What is your permit limitation on ignitable wastes, if any? Can you accept ignitable non liquids [reference to 261.21(a)(2)]?
- The facility does not have any permit limit on incineration of ignitable wastes, the feed limit for phosphorus is limited by opacity. Opacity is an issue for phosphorus.
- The facility will not store phosphorus, the drums will be burned with limited handling from the trucks with out being put into storage.
- The facility will accept one truck a day or 80 drums per day. The truck will be held at the facility until all of the drums are burned. It will take 8-10 hours to burn the drums.

4. How does your P&P and Contingency Plan address wastes that if spilled will spontaneously combust? Will you need a permit modification? If so, which Class? How long to obtain the modification?
- The facility requires 3-inches of water be placed on-top of the phosphorus in the drums.
- The facility verifies/inspects the drums for water content by pinging the drums.
- The facility has a material specific spill plan for phosphorus.
- The facility personnel were trained on phosphorus emergency response/spill cleanup procedures by FMC in 1999. No additional training has been conducted in 2000.
- The facility controls phosphorus spills by using sand and/or water. The facility has set-up garden hoses around the facility for control of phosphorus spills and fires. Spilled materials would be disposed of in the incinerator.

5. Does your fire-fighting equipment include equipment used for fighting phosphorous fires ("silver suits")? Have your personnel been trained in such? Part of your RCRA and OSHA programs or will you have to retrain? Are your fire-fighting respirators good for P_2O_5 and PH_3 or will you have to obtain? Will this require a permit modification?
- The facility has purchased flash suits that fit over level-A suits.

6. Are the respirators that your operations personnel use good for PH_3 and P_2O_5? Will you have to obtain

new ones? Will you need a permit modification?
- The facility uses 3M Super Cartridges.
- Emergency response activities would be done in SCBA or supplied air.
- The facility has supplied air throughout the facility.

7. What is your training program in regards to phosphorous wastes and specifically handling procedures, spill response and cleanup? What does your training state specific to P2O5 and PH3 releases? Will you need a permit modification? If so, what Class? How long to obtain?
- The facility has a material specific spill plan for phosphorus.
- The facility personnel were trained on phosphorus emergency response/spill cleanup procedures by FMC in 1999.
- The facility environmental staff could better answer this question.

8. Have your operators been trained in wearing and working in "silver suits"? Will they require retraining and certification? Will this require a permit modification? Class and how long to obtain?
- The facility has purchased flash suits that fit over level-A suits.
- Training question was not specifically answered.

9. Can your scrubbing systems handle P2O5 which is a fine aerosol mist and still stay within the MACT limit for particulate's? P2O5 will hydrolyze to phosphoric acid which is a micron/sub-micron particle?
- The facility has a four stage scrubber system that is the best system at any incinerator in the country.
- The scrubber system consists of a spray dryer, an electrostatic precipitator, a three stage packed bed scrubber and a venturi scrubber.
- The facility has a 0.015 ?not sure of this number? particulate limit (Permit said 0.08 grains per dry standard cubic foot)
- During actual incineration of drums of phosphorus at the facility, the highest particulate level measurement was said to be 12% of the permitted particulate limit.

10. Can you repackage large containers of slurry or will the shipping containers have to be a maximum size?
- Question not asked.

11. The slurry will contain trace organics below the UHC level including SVOC's and PAH's [Ed. Note: comes in with the coke]. Will this impact your risk assessments including your PIC's analysis? Will you have to rerun? Cost; who pays? Timing?
- Trace organic in the PPB or PPM are not a problem.

12. What is the maximum size piece of brick you can receive? What is the maximum size brick you can put in the kiln? Can your sizing equipment (shredders) handle hardened carbon block?
- The facility does not have a shredder.
- The facility could accept the bricks in a 55 gallon drum.

13. Does your shredding equipment include fire suppression and gas collection systems? If not, how will you handle phosphorous fires and P2O5/PH3 releases during shredding?
- The facility does not have a shredder.

BARR

Telephone Memo

Date: 11/20/00
Time: 3 PM

TDM, RTR of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Craig Ragland	Thermal Products Manager	Trade Waste Incinerator, Inc./Onyx	618-271-2804
Doug Bushey	Materials Manager	Trade Waste Incinerator, Inc./Onyx	618-271-2804
			- -
			- -

Re: **Project Name:** Rhodia - TSD Facility Survey - Candidate Facility Follow-up Plan

Project Number: 26 / 25 - 001 JSL 020

Notes:
Do you have any preliminary questions?

1. Do you have previous experience processing with phosphorus-containing materials? Provide reference for each stream.

- TWI worked on a phosphorus project for Rhodia that had to do with phosphorus in a sewer, but TWI was not able to accept the waste due to PCB contamination identified in the material.
- TWI has completed projects for the military involving incineration of hundreds of missile heads each containing 25lbs of phosphorus.

2. Do you have a heated facility for the temporary storage of the phosphorus-containing materials prior to treatment ?
(If yes , what is the capacity?)

- TWI said that they could store 90-days of material, or about 4-trucks worth of storage.
- The facility's feed rate is 1,800 lbs per day (1,800 x 90 = 162,000 lbs)
- The facility is permitted to store 11,000 drums.
- Some of the storage is heated.
- It was suggested that glycols could be added to the drums to serve as anti-freeze during the winter.

Follow-up Phone notes: I asked Doug Bushey to clarify the 1,800 lbs/day feed rate, was this the feed rate for pure phosphorus or crude phosphorus containing 20% phosphorus? He said that TWI had taken into account the 20% phosphorus concentration in the crude phosphorus when they came up with their best guess at the feed rate of 1,800 lbs/day. This feed rate is based on the phosphorus pentoxide scrubbing capability of the incinerator. He further stated that the crude phosphorus waste stream could be further limited by the BTU value of the other materials (debris, plastic, etc.) in the crude phosphorus waste stream. If the debris/plastic content has a high BTU value the feed rate/charge limit could be adjusted.

3. What are your management requirements for elevated NORM materials?
- The facility can not accept radioactive materials.
- Waste analysis plan requires that all materials be screened and if radioactivity is detected at > 0.5 millirad/hour the waste will be rejected.

4. How will emissions from the phosphorus processing be managed at your facility?
- Facility began operations in 1989, DRE is 99.99 %.
- The facility operates a rotary kiln with a dry scrubber system
- Lime is used to scrub the stack gas in the scrubber system.
- Ash goes to a subpart C landfill.
- The landfill stabilizes the ash prior to landfilling.
- Currently the facility uses: Peoria Disposal Co. Peoria, IL, WM in Model City, NY, EQ in Detroit, MI or WM in Lake Charles, LA.

5. Do you have written procedures for handling phopshorus-containg materials? (If yes, please provide a copy.)
- The facility has a reactive procedure for phosphorus. (They will send the procedure with the audit package).
- 15 lb charge limit for phosphorus (plus water).
- Waste acceptance personnel will open each container.

6. What are your procedures for personal air monitoring as it related to phosphine and worker protection?
- PPE is material specific.
- Phosphine air sampling could be done.

7. What are your fire-fighting capabilites as it relates to a phosphorus fire?
- 400,000 gallon tank.

8. Can you provide material packageing services in addition to off-site treatment and disposal services?

- TWI/Onyx does provide on-site packaging services.

9. Who may I contact at the state or federal regulatory agency that is most familiar with your operations?

- We can contack all regulatory agencies.
- IL-EPA contact is Mike Grant.
- Additional contact names are listed in the facility audit package.

10. Do you have a current Facility Audit Package? Can you provide a copy for our review?

- Yes, they will send us an audit package.

11. Do you continue to believe that your facility is capable of receiving and safely managing the crude phosphorus? How about the used carbon brick and furnace liner?

- Will accept phosphorus at a feed rate of 1,800 lbs/hr.
- The brick can be handled as a bulk solid, the facility has no shredder.
- Bulk solids have a six inch size limitation.
- Wash water from bricks is acceptable, the water must be filtered and have a fluorine content of <2% and a total halogen content of <5%.

Rhodia will continue to evaluate your facility and may request a price quote for these services. Thank you for your cooperation.

Follow-up Phone notes are from a telephone interview with Doug Bushey, TWI Inc. conducted by Ron Reding, Barr Engineering Company on December 14, 2000.

TSD Facility Questionnaire
Phosphorus-containing Materials
Rhodia Silver Bow Plant

Location Information (Please make corrections to the facility address, if appropriate)

Company: ENSCO Inc.
Location: 309 American Circle
El Dorado, AR 71730-6555
EPA ID#: ARD069748192
Individual:
Name: Treasa Evans
Title: Dir. Regulatory Affairs Phone Number: 870-864-3680

Naturally Occurring Radioactive Materials (NORM)

Can your facility manage materials that contain NORM?

Yes ______ No X

Phone Notes: The facility does not accept NORM waste at all.

Follow-up Phone Notes: The facility waste analysis plan requires all wastes be surveyed for radioactivity and the facility does not accept waste above background levels which is 50 microcuries. The waste can not be classified as NORM waste.

If Yes:

(A) What levels are acceptable: N/A (Units)

Crude Phosphorus

Does your facility at this location have the ability and capacity to treat the crude phosphorus material to render it nonignitable and nonreactive?

Yes X No ______

If Yes:

(A) At what capacity or rate: Variable (Units)

(B) What is the treatment method (Describe in detail):

Incineration (rotary kiln) via 30 gal poly containers by direct drop chute.

Phone Notes: She did not provide a charge/pack limit rather she stated that there is a 1.7MBTU/charge limit. As for the requirement for poly drums she said that the facility does have depacking capabilities for removing fiber containers from metal drums.

Follow-up Phone Notes: She restated that the 30 gal ploy drum is the charge limit for phosphorus. I asked if we could place 150 lbs of material in a 30 gallon poly drum and that that would be the approved charge size? She said that it would, but stated the DOT packaging requirements for metal drums. I asked what the BTU value of phosphorus would be? She said that phosphorus would have a BTU value of around 10,000 BTU/lb. and that the 1.7 MBTU/charge is the charge limit. I asked what the charge limit is for pure phosphorus and she thought it would be 25lbs/charge. I asked what the charge limit would be for crude phosphorus, based on a concentration of 20% phosphorus? Would it be around 100 lbs.? She said again that they could accept the crude phosphorus in 100 lb. charges. (Note that a 125lb charge would contain 25 lbs. of phosphorus using a 20% concentration).

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No ___X___ -Incinerator residues (ash) goes to Class C landfill for final treatment of metals prior to landfill.

Phone Note: The ENSCO facility treats the ash to the organic standard.

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes ___X___ No ________

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes ___X___ No ________

(B) At what capacity or rate: ______Variable______(Units) – Depending on size/hardness and packaging constraints.

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)?

Yes X No ________

(D) At what capacity or rate: Variable (Units)

(E) What is the treatment method (Describe in detail):

Rotary kiln incinerator – In-line shredders to drop chute.

Phone Notes: The shredder size limitation is 12 inches x 6 inches.

- Furnace liner brick is acceptable at the facility, hardness is not a problem.
- Treasa also suggested that we contact the Waste Management landfill in LA, she said that the facility provides treatment on reactive bulk solids prior to landfill. (Note: Barr Engineering Company has contacted the WM facility in Lake Charles/Sulphur LA and they no longer provide treatment of D001 and D003 reactive wastes).

Phone notes are from telephone interviews with Treasa Evans, ENSCO Inc. conducted by Ron Reding, Barr Engineering Company on October 16, 2000 and December 14, 2000.

safety-kleen®

FAX COVER SHEET

FAX RECEIVED
NOV 15 2000
TO BARR

DATE: 11/15/00

TO: JULIE SULLIVAN FAX NO:

FROM: BILL KESLICK FAX NO: 225 778 3510
PHONE NO: " " 3584

NUMBER OF PAGES INCLUDING COVER SHEET (2)

RE: RHODIA

JULIE, HERE IS PG 2. ALSO, AFTER FURTHER REVIEW WE CAN HANDLE NORM @ 25 microroentgens ~~and~~ or less. IF IT IS Naturally occurring/exempt the action levels are higher - please CHANGE FROM 7 ON origanal form (pg 1) per me.

Bill

13351 Scenic Highway, Baton Rouge, LA 70807-1021
Post Office Box 74137, Baton Rouge, LA 70874-4137

(C) Does your facility at this location have the capacity (e.g., stabilization) to treat the residue to meet the Universal Treatment Standards (UTS) specified in 40 CFR 268.48 for metals?

Yes ________ No __X__ TRANSFERRED TO OUR INCINERATOR

Used Carbon Brick and Furnace Liner

Does your facility at this location have the ability and capacity to treat the used carbon brick and furnace liner to render it nonignitable?

Yes __X__ No ________ MAY NEED MORE INFO ON HISTORY (SAMPLE) BUT WE CAN OXIDIZE THE RED PHOSPHOROUS FOR TRANSFER

If Yes:

(A) Can you manage the Case 1 amount (i.e., approximately 2,000 tons)?

Yes __X__ No ________ MAY NEED MORE INFO (SAMPLE)

(B) At what capacity or rate: ________________(Units)

(C) Can you manage the Case 2 amount (i.e., approximately 100 tons)? AS ABOVE

Yes __X__ No ________

(D) At what capacity or rate: __VARIES__ (Units) 120 TONS/WEEK

(E) What is the treatment method (Describe in detail):

SK (BATON ROUGE) HAS AN ENCLOSED BUILDING UNDER NEGATIVE PRESSURE. REACTIONS ARE (VAPORS) VENTED TO A THERMAL OXIDATION UNIT. SINCE THE FURNACE LINER IS REASONABLY LOW IN CONC. WE COULD OXIDIZE WITH WATER, CAPTURE FUMES AND TRANSFER AT GENERATOR'S DESIRED TREATMENT FACILITY.

BARR

Telephone Memo

Date: 1/11/01
Time: 1:30 PM

TDM/RTR of Barr Engineering Company

☒ placed a call to ☐ received a call from ☐ received a voice mail from ☐ left message/voice mail to

Name	**Position**	**Company**	**Telephone**
Mark Zaugg	Sales	ICI Environmental	- -
Willie Roy	Technical Manager	ICI Environmental	- -
			- -
			- -

Re: **Project Name:**
Rhodia - TSD Facility Survey - Candidate Facility Follow-up Plan

Project Number:
26 / 25 - 001 JSL 020

Notes:
Do you have any preliminary questions?

The discussions are applicable to incineration of brick only.

ICI operates a car bottom furnace, where the materiasl are placed on a mobile car that connects to incinerator's bottom. Then the heat (i.e., gas fired) is applied to incinerate the materials. The car is removed when the internal temperature falls to 300 degrees C and the next car load is placed in the incinerator for processing.

ICI stated that incinerating the brick be a very slow process.

1. Do you have previous experience processing with phosphorus-containing materials? Provide reference for each stream.

ICI has very limited experience processing phosphorus materials. (Military - M825 Rounds). ICI stated that large quantites of phosphorus may be too corrosive for their system. Additional information would be needed to evaluate this concern before acceptance.

Personnel have worked on projects involving incineration of phopshorus. Helped design phosphoric acid plant at Crane Munitions, Fort Wingate.

2. What are your management requirements for elevated NORM materials?

Shipments are screened and materials above background at the facility are questioned.

3. How will emissions from the phosphorus processing be managed at your facility?

Off gas controls included an acid gas scrubber. Solids form this pollution control ewquipment are landfilled.

4. Do you have written procedures for handling phopshorus-containg materials? (If yes, please provide a copy.)

No. The facility develops plans for each materiasl accepted.

5. What are your fire-fighting capabilites as it relates to a phosphorus fire?

Would be developed.

6. Who may I contact at the state or federal regulatory agency that is most familiar with your operations?

Missiouri DNR - Randy Kixmuller - Jefferson City, (573)751-2930

7. Do you have a current Facility Audit Package? Can you provided a copy for our review?.

Yes, Yes.

8. Do you continue to believe that your facility is capable of receiving and safely managing the crude phosphorus? How about the used carbon brick and furnace liner?

Facilty could potentially 3 to 4 truck loads in one of there (magazine) storage cells. However, materials would need to be scheduled and the logistics worked oput in advance.

COMMERCIAL INCINERATOR QUESTIONS/ISSUES

9. What is your limit on rads? Are you permitted to accept NORM? How do you test; pre-shipment and shipment? What do you do if an incoming load exceeds your permitted level?

NA

10. What is your permit limitation on ignitable wastes, if any? Can you accept ignitable non liquids [reference to 261.21(a)(2)]?

Yes

11. How does your P&P and Contingency Plan address wastes that if spilled will spontaneously combust? Will you need a permit modification? If so, which Class? How long to obtain the modification?

NO. The plan would be developed specific to materials accepted for processing.

12. Does your fire-fighting equipment include equipment used for fighting phosphorous fires ("silver suits")? Have your personnel been trained in such? Part of your RCRA and OSHA programs or will you have to retrain? Are your fire-fighting respirators good for P2O5 or will you have to obtain? Will this require a permit modification?

No. The plan would be developed specific to materials accepted for processing.

13. Are the respirators that your operations personnel use good for P2O5? Will you have to obtain new ones? Will you need a permit modification?

Not asked.

14. What is your training program in regards to phosphorous wastes and specifically handling procedures, spill response and cleanup? What does your training state specific to P2O5 releases? Will you need a permit modification? If so, what Class? How long to obtain?

Would be developed.

15. Have your operators been trained in wearing and working in "silver suits"? Will they require retraining and certification? Will this require a permit modification? Class and how long to obtain?

No

16. Can your scrubbing systems handle P2O5 which is a fine aerosol mist and still stay within the MACT limit for particulate's? P2O5 will hydrolyze to phosphoric acid which is a micron/sub-micron particle?

Not asked.

17. What is the maximum size piece of brick you can receive? What is the maximum size brick you can put in the kiln? Can your sizing equipment (shredders) handle hardened carbon block?

9' x 6' x 5'.

18. Does your shredding equipment include fire suppression and gas collection systems? If not, how will you handle phosphorous fires and P2O5 releases during shredding?

No Entire block would be fed to the incinerator.

Rhodia will continue to evaluate your facility and may request a price quote for these services. Thank you for your cooperation.

Permit limitation = 250 pounds of combustible material per hour.

Facility operates 24 hours per day, 5 days/week.

Cant' stop the incineration process once started. Can't open furnace until internal temperature is less than 300 degrees C.

Appendix V

DOT-SP 13552 (May 5, 2009)

May 5, 2009

U.S. Department
of Transportation

**Pipeline and Hazardous
Materials Safety Administration**

East Building, PHH – 30
1200 New Jersey Avenue, Southeast
Washington, D.C. 20590

DOT-SP 13552
(FIFTH REVISION)

(FOR RENEWAL, SEE 49 CFR § 107.109)

1. GRANTEE: (See individual authorization letter)

2. PURPOSE AND LIMITATION:

   a. This special permit authorizes the transportation in commerce of Phosphorus, white dry or Phosphorus, white, under water or Phosphorus white, in solution, or Phosphorus, yellow dry or Phosphorus, yellow, under water or Phosphorus, yellow, in solution in alternate packaging. This special permit provides no relief from the Hazardous Materials Regulations (HMR) other than as specifically stated herein. The most recent revision supersedes all previous revisions.

   b. The safety analyses performed in development of this special permit only considered the hazards and risks associated with transportation in commerce.

   c. Unless otherwise stated herein, this special permit consists of the special permit authorization letter issued to the grantee together with this document.

3. REGULATORY SYSTEM AFFECTED: 49 CFR Parts 106, 107 and 171-180.

4. REGULATIONS FROM WHICH EXEMPTED: 49 CFR § 173.188 in that alternative packaging is authorized as provided herein.

5. BASIS: This special permit is based on the Pipeline and Hazardous Materials Safety Administration's (PHMSA) editorial review under § 107.121 initiated on December 4, 2008.

6. HAZARDOUS MATERIALS (49 CFR § 172.101):

Hazardous Materials Description			
Proper Shipping Name	**Hazard Class/ Division**	**Identi-fication Number**	**Packing Group**
Phosphorus, white dry *or* Phosphorus, white, under water *or* Phosphorus white, in solution, *or* Phosphorus, yellow dry *or* Phosphorus, yellow, under water *or* Phosphorus, yellow, in solution	4.2	UN1381	I

7. SAFETY CONTROL MEASURES:

a. PACKAGING - Prescribed packaging is:

(1) A 55-gallon UN 1A2 steel drum certified to the PG I performance level for solids and the PG II performance level for liquids and dual marked to a minimum of UN1A2 X/400/S and UN1A2 Y/1.2/150; or

(2) A 30-gallon UN 1A2 steel drum certified to the PG I performance level for solids and the PG II performance level for liquids and dual marked to a minimum of UN1A2 X/235/S and UN1A2 Y/1.2/150.

b. OPERATIONAL CONTROLS:

(1) Transportation is authorized by private or contract carrier only.

(2) Transportation is authorized one-time, one-way, only from the generator of the waste material to the hazardous waste treatment facility where it must be unloaded by the consignee for disposal.

(3) Sufficient water must be present in each drum to ensure that the waste phosphorous is covered during transportation, in any orientation of the drum.

(4) Drums must be held and observed for a minimum of 24-hours before transportation. Any leaking or

otherwise unsuitable drums must be replaced prior to transportation.

(5) Packages must be destroyed at the disposal site and may not be reused.

(6) The net mass of the waste material and water, in kilograms, must not exceed the mass that would be permitted by calculating the volume of the packaging in liters multiplied by the specific gravity indicated on the package certification.

8. SPECIAL PROVISIONS:

(1) A current copy of this special permit must be maintained at each facility where the package is offered or reoffered for transportation.

(2) A person who is not a holder of this special permit who receives a package covered by this special permit may reoffer it for transportation provided no modification or change is made to the package and it is reoffered for transportation in conformance with this special permit and the HMR.

9. MODES OF TRANSPORTATION AUTHORIZED: Motor vehicle.

10. MODAL REQUIREMENTS: A current copy of this special permit must be carried aboard each motor vehicle used to transport packages covered by this special permit.

11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this special permit and penalties prescribed by the Federal hazardous materials transportation law, 49 U.S.C. 5101 *et seq*:

o All terms and conditions prescribed in this special permit and the Hazardous Materials Regulations, 49 CFR Parts 171-180.

o Persons operating under the terms of this special permit must comply with the security plan requirement in Subpart I of Part 172 of the HMR, when applicable.

o Registration required by § 107.601 *et seq*., when applicable.

Each "Hazmat employee", as defined in § 171.8, who performs a function subject to this special permit must receive training on the requirements and conditions of this special permit in addition to the training required by §§ 172.700 through 172.704.

No person may use or apply this special permit, including display of its number, when this special permit has expired or is otherwise no longer in effect.

Under Title VII of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)- 'The Hazardous Materials Safety and Security Reauthorization Act of 2005' (Pub. L. 109-59), 119 Stat. 1144 (August 10, 2005), amended the Federal hazardous materials transportation law by changing the term "exemption" to "special permit" and authorizes a special permit to be granted up to two years for new special permits and up to four years for renewals.

12. REPORTING REQUIREMENTS: Shipments or operations conducted under this exemption are subject to the Hazardous Materials Incident Reporting requirements specified in 49 CFR 171.15 - Immediate notice of certain hazardous materials incidents, and 171.16 - Detailed hazardous materials incident reports. In addition, the grantee(s) of this exemption must notify the Associate Administrator for Hazardous Materials Safety, in writing, of any incident involving a package, shipment or operation conducted under terms of this exemption.

Issued in Washington, D.C.:

Diane LaValle

for Theodore L. Willke
Associate Administrator for Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Pipeline and Hazardous Materials Safety Administration, Department of Transportation, Washington, D.C. 20590. Attention: PHH-31.

Copies of this special permit may be obtained by accessing the Hazardous Materials Safety Homepage at http://hazmat.dot.gov/sp_app/special_permits/spec_perm_index.htm Photo reproductions and legible reductions of this special permit are permitted. Any alteration of this special permit is prohibited.

PO: DL/AM

Rhodia

Transportation Safety & Security – NA HSE Services

May 21, 2010

Associate Administrator for Hazardous Materials Safety
Research and Special Programs Administration
U.S. Department of Transportation
400 7th Street, SW
Washington, DC 20590-0001

Attention: Exemptions, DHM-31

RE: **Request for Renewal of Party Status to DOT Special Permit 13552**

Dear Sir/Madam:

This is to request renewal of Rhodia Inc.'s party status to DOT SP-13552 in accordance with 49 CFR §107.109. This exemption authorizes the transportation in commerce of waste phosphorus in alternate packaging.

This request for renewal is for:

Rhodia Inc.	Contact:	Donna Edminster
CN 7500	Phone:	609-860-4085
8 Cedarbrook Drive	Fax:	609-860-2478
Cranbury, NJ 08512	E-mail:	donna.edminster@us.rhodia.com

The 5th revision of this special permit is the current version and is accurate and complete. Since 2006 when Rhodia last renewed this special permit, six (6) shipments of waste phosphorous have been made, involving a total of 112 drums. Rhodia certifies that they are not aware of any incidents involving the inadvertent release of any hazardous material while shipping material authorized under terms of this special permit. Rhodia also certifies that, to the best of our knowledge and belief, we are in compliance with applicable federal security laws and regulations that apply to its transportation operations.

We believe this application is complete to the best of our ability and conforms to the requirements of 49 CFR §107.109. Please contact me should you require additional information.

Sincerely,

Donna Edminster

Donna Edminster
Manager, Transportation Safety & Security
Rhodia Inc.