

350620

DuPont Engineering
 Barley Mill Plaza - Bldg. 27
 Lancaster Pike & Rte. 141
 Wilmington, DE 19805



DuPont Engineering

bcc: E.J. Lutz, DuPont
 J.A. Wilkens, DuPont
 M.A. Turco, URSD
 P.B. Butler, URSD
~~N.L. Gish, URSD~~
 J.E. Wolfe, URSD
 W.R. Kahl, URSD
 J. Wokasien, URS-Buffalo
 File:Newport/D1NE7105/South Landfill

Mr. Randy Sturgeon, 3HS23
 Remedial Project Manager
 U.S. EPA, Region III
 1650 Arch Street
 Philadelphia, PA 19103-2029

January 22, 2001

**FEASIBILITY STUDY AND PROPOSAL
 SOUTH LANDFILL PERMEABLE REACTIVE BARRIER REMEDY
 Newport Superfund Site, Newport, Delaware**

Dear Randy,

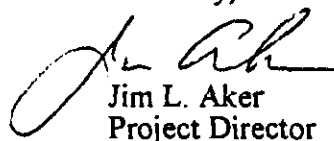
DuPont has developed a more protective and cost-effective remedy for the South Landfill at the Newport Superfund Site. We propose a permeable reactive barrier (PRB)-based treatment remedy for the South Landfill. Overall, the new remedy would consist of a permeable reactive and slurry wall surrounding the landfill to the extent practical, riverbank stabilization with a HDPE geomembrane, single-barrier HDPE cap tied into South James Street, and monitoring. We believe that this remedy meets the NCP selection criteria and is a superior alternative to both the ROD and ESD remedies.

We have demonstrated the ability to treat all of the metals migrating from the landfill. This remedy is essentially the same as that proposed on July 7, 2000, with the addition of magnesite (a hydrated magnesium carbonate mineral) to treat manganese. At present, our in-situ field tests have demonstrated in excess of 250 years' treatment life. We will submit the results of ongoing testing (extending the predicted wall life further) in early February.

DuPont has every intention to complete the South Landfill remedy in September 2001. Due to the short timeline, we are preparing (at risk) a pre-final design plan in parallel with the attached assessments. We expect to submit a pre-final design plan on, or before, February 2, 2001, and begin pre-bid discussions with potential contractors soon. While we this work is done at risk, we are committed to completing this work on schedule, if at all possible.

We look forward to an early review of this proposal and upcoming design plan. Please call me if you, or your staff, have any questions regarding this proposal.

Sincerely,

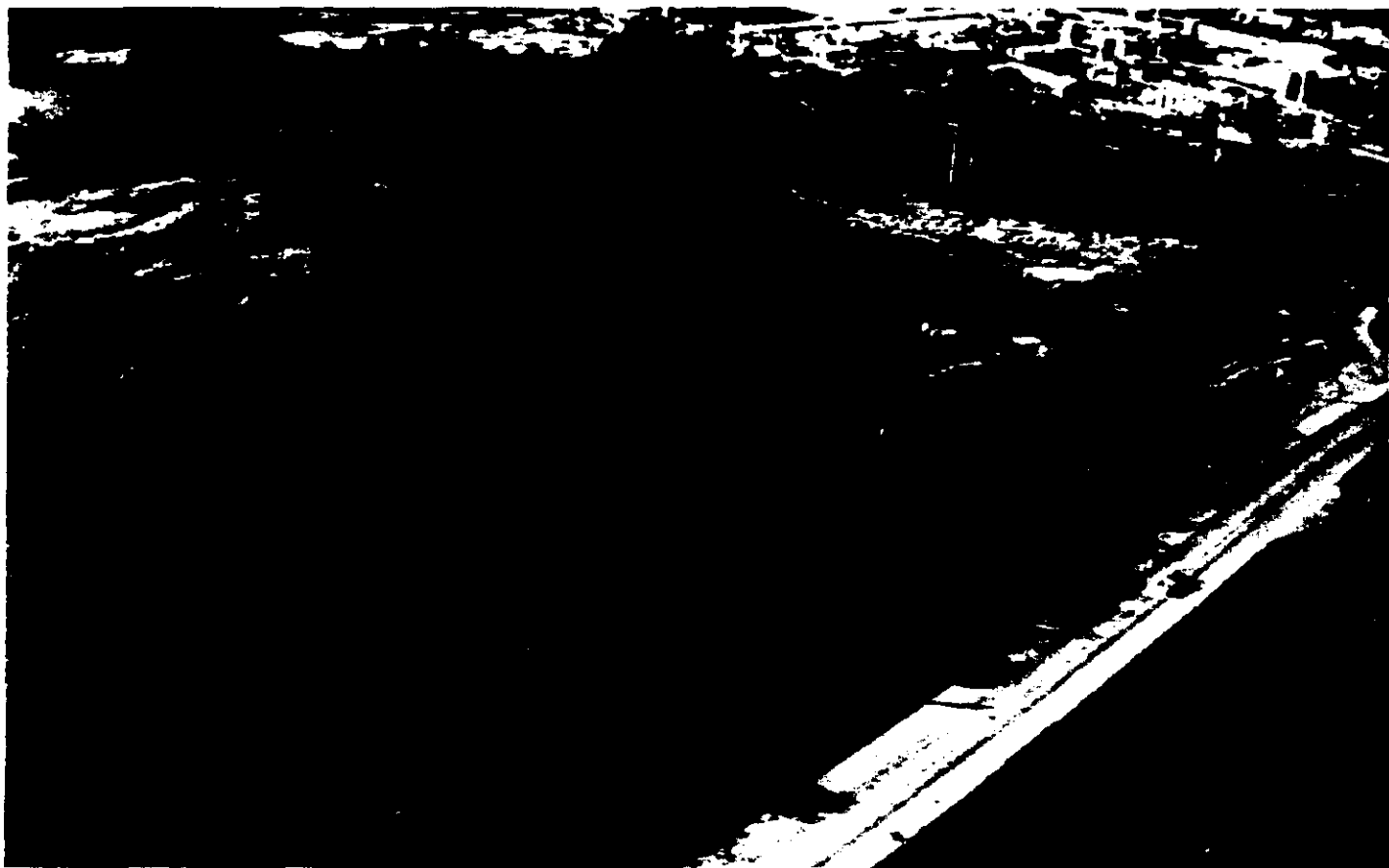

 Jim L. Aker
 Project Director

JLA:pbb

cc: K. Olinger, DNREC
 C. Clayton, USCOE
 P. Meitner, Legal

AR324731

FEASIBILITY ASSESSMENT AND PROPOSAL
PERMEABLE REACTIVE BARRIER REMEDY
NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE



January 2001

Project No. D1NE7105



CORPORATE REMEDIATION GROUP
*An Alliance between
DuPont and URS Diamond*

Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

AR324732

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Executive Summary

DuPont proposes utilizing a new, innovative technology for treating the South Landfill waste at the Newport Superfund Site: a permeable reactive barrier (PRB) coupled with an impermeable slurry wall and an engineered cap. This technology is proposed as a protective and cost-effective alternative to both the treatment remedy described in the 1993 Record of Decision (ROD) and the in-situ chemical treatment remedy described in the 1995 Explanation of Significant Differences (ESD). This proposal supports adopting the PRB treatment technology, which has been demonstrated in both laboratory and field trials, for application at the Newport Site.

The National Contingency Plan (NCP) indicates a preference for innovative technologies that offer comparable or superior performance, fewer adverse impacts, and/or lower costs for similar levels of performance as achieved by demonstrated technologies. When compared with the 1993 ROD and 1995 ESD remedies, the proposed PRB alternative offers at least equal (and in many ways superior) performance in terms of controlling contaminants migrating from the South Landfill at a significantly lower cost.

- ❑ The 1993 ROD required treatment of the South Landfill waste materials using soil mixing and in-situ stabilization. New data indicate that the cost of the 1993 ROD remedy exceeds \$17MM.
- ❑ The 1995 ESD remedy specified in-situ chemical treatment. The ESD remedy would cost over \$23MM.
- ❑ DuPont estimates that the cost of implementing the PRB alternative is \$5MM.

In addition to this clear cost advantage, DuPont believes that the proposed PRB remedy ranks significantly higher than the original 1993 ROD and 1995 ESD remedies with respect to the nine EPA criteria used to evaluate remedies (see Section 3). DuPont believes this PRB remedy protects human health and the environment, complies with ARARs, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. It also minimizes total waste volumes and provides protectiveness for centuries. This remedy is equal to or better than the prior technologies with respect to meeting relevant performance standards and has demonstrated an exceptionally high capacity for meeting the standards well into the future.

1.1 SITE BACKGROUND

The DuPont Newport Superfund Site (Site) occupies approximately 120 acres on the banks of the Christina River at James and Water Streets in Newport, Delaware. The Site includes land currently occupied by the Ciba Specialty Chemicals plant (a paint pigment production facility), the former DuPont Holly Run facility, the North and South Landfills (separated by the Christina River), and a former employee recreational area, known as the ballpark. On August 22, 1988, DuPont entered into an Administrative Order of Consent with EPA and agreed to perform a Remedial Investigation and Feasibility Study for the Site, which led to the 1993 ROD.

As a part of earlier pigment operations, off-specification products were disposed in the North and South Landfills. The South Landfill, which operated from 1902 to 1953, was used for the disposal of Lithopone wastes. Waste slurries from the purification of zinc and barium ores were pumped from the plant and discharged into a bermed area, creating the South Landfill. In the 1970s, the South Landfill was covered with soils from excavations for the construction of the Delaware Highway 141 Christina River Bridge.

1.2 REMEDY HISTORY AND PROPOSED CHANGE

The 1993 ROD called for the portion of the South Landfill owned by the State of Delaware (including the roadway) to be excavated and placed in the portion of the landfill owned by DuPont. Original estimates of the total amount of materials to be excavated were approximately 37,000 cubic yards. Data developed by the Delaware Department of Transportation (DelDOT) and recently refined by DuPont indicated that 85,000 cubic yards would require excavation because the contamination was deeper than originally anticipated, representing a 230% increase in cost.

In 1994, DelDOT and DuPont independently submitted alternate remedy proposals to the EPA in an effort to address the contamination in a less costly manner. In 1995, EPA selected an alternate remedy for the South Landfill and issued an Explanation of Significant Differences (1995 ESD) to modify the 1993 ROD. The revised remedy changed the treatment technology from in-situ stabilization to chemical precipitation with sodium sulfide and sodium sulfate. The 1995 ESD also upgraded the containment system from a soil cover to a low permeability cap, a circumscribing groundwater barrier wall, and a groundwater pump and treat system.

Since the 1995 ESD was issued, considerable additional information has been collected that impacts prior assessments and supports a new, innovative, cost-effective treatment technology (DuPont, 2000). These new data indicate that a permeable reactive barrier (PRB) and engineered cap will provide a better remedy than either the 1993 ROD or the 1995 ESD remedies. The proposed PRB remedy is more permanent, implementable, and cost effective than the prior two remedies. In addition, the PRB remedy will provide equal or better protection of human health and the environment and will not increase the waste volume. This technology can be applied simply and effectively using proven construction methods, and it will reduce the required implementation time to less than one year.

The following table presents a summary of the major design elements of the 1993 ROD, the 1995 ESD, and the current proposed PRB remedy.

Comparison of Remedy Design Elements			
Element	1993 ROD Remedy	1995 ESD Remedy	Current Proposed PRB Remedy
Cap	Soil Cap (10^{-5} cm/s)	Dual Layer Cap with Geomembrane and Liner	Single Layer Cap with HDPE Geomembrane Liner
Treatment	In-Situ Soil Stabilization	Soluble Sodium Sulfide and Sulfate	PRB with Gypsum, Iron, & Magnesite along two sides of landfill
Groundwater Barrier Wall	None	10^{-7} cm/s Wall Circumscribing Entire Landfill, south of NCCo Sewer Line	10^{-7} cm/s Wall south of NCCo Sewer Line along one side of landfill
Groundwater Pump and Treatment	None	Maintain Inward Gradient and Treat Water on-site	None
James Street	Remove and Rebuild	Remove and Rebuild	Tie Cap into the Roadway
Riverbank	Contain with Armoring	Contain with Armoring	Contain with Armoring

The PRB remedy is equal to or better than the 1993 and 1995 remedies with respect to meeting relevant performance standards and has demonstrated an exceptionally high capacity for meeting the standards well into the future.

2.1 WASTE TREATMENT AND CONTAINMENT CONCEPTUAL APPROACH

The current proposed remedy for the South Landfill includes a complete barrier system to physically separate the waste material from the environment. The barrier system will consist of a low-permeability (10^{-7} cm/s or less) slurry wall coupled with a permeable reactive barrier wall, as shown in Figure 1. The slurry wall will be placed parallel to the Christina River along the south side of the New Castle County sewer main. The PRB wall will surround the remainder of the landfill. Both barriers will be vertically keyed into the relatively impermeable marsh deposit below the landfill (see Figures 2 and 3). The slurry wall and reactive barrier will contain, to the extent practical, all of the waste material within the South Landfill, including the portion on the State's property as shown in Figure 1, and treat migrating constituents at the landfill boundary.

The riverbank will be capped by clearing existing vegetation, extending the synthetic cap to the mean low tide (-1.6 feet MSL) elevation, and covering the riverbank with armor stone (per recent EPA discussions). The landward slurry wall, engineered landfill cap, and riverbank cap will prevent further migration through the waste material not contained within the circumscribing slurry/reactive wall structures. The riverbank cap will also prevent further erosion and complete the containment of the waste.

The slurry wall will be 36-inches wide with a 3-foot key into the clayey-silt marsh deposit. The permeable reactive barrier (approximately 18-inches wide) will be a mixture of treatment agents and clean sand in the weight ratio of 100:20:5:5 (DelDOT-grade mortar sand: gypsum: iron: magnesite). Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and magnesite ($\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{H}_2\text{O}$) are slightly soluble, and the iron (metallic, zero-valent), is insoluble in comparison to the highly soluble reactive materials used in the 1995 ESD remedy. Therefore, these materials will not be readily flushed from the wall should infiltration rates increase. Theoretically, the PRB will actively treat migrating groundwater for hundreds of years. Field and laboratory investigations are currently underway for confirm longevity.

All groundwater originating in the waste material will pass through the permeable barrier for treatment to the same low levels established in the 1995 ESD. The PRB is designed to treat soluble metals concentrations to below the following levels, providing equal treatment of the waste constituents.

Metal	Maximum Concentration (ppb)
Barium	7,800
Cadmium	4
Copper	18
Lead	15
Manganese	1,000
Nickel	730
Zinc	120

Within the reactive wall, the iron will treat soluble zinc via surface adsorption reactions. The gypsum and magnesite will precipitate soluble barium and manganese as barium sulfate and manganese carbonate, respectively. The treatment (while able to remove other dissolved metals) will not specifically target cadmium, copper, lead, and nickel because the concentrations for these metals already meet the performance standards. Section 3 and Appendices A and B present the laboratory and field data used to develop this remedy.

Two additional contaminants of concern, arsenic and chromium, are also not expected to be impacted by the PRB treatment. Chromium concentrations are already below levels considered protective and do not warrant further treatment. Recent sampling during the April, 2000 in-situ PRB field tests (DuPont, 2000) indicated that arsenic is also below levels considered protective of the environment and human health.

Monitoring wells placed inside the permeable reactive barrier (see Figure 3) will confirm groundwater treatment and provide an early warning against premature wall breakthrough to ensure protection of human health and the environment. Approximately 10 monitoring wells (on 200-foot centers) will be installed in the outside six inches of the barrier. In addition, downgradient wells will be installed to observe metals attenuation.

A single layer cap will cover all of the waste material and extend beyond the limits of the slurry wall and reactive barrier to the riverbank and wetlands areas, respectively. The cap will have a maximum permeability of 10^{-7} cm/sec and will be designed as shown in Figure 2. The design includes a single barrier synthetic geomembrane layer, a drainage layer, protective soil, and topsoil. The cap design is a change from the 1995 ESD requirement for a dual-barrier cap containing at least a synthetic geomembrane liner. The dual layer cap in the 1995 ESD remedy was essential for reducing groundwater infiltration to the maximum extent practical because the treatment agents were extremely soluble and could be flushed from the waste by infiltrating rainwater. Maximum reduction of infiltration is not as critical to the current proposed PRB remedy because the treatment agents are either sparingly soluble or insoluble and also because any infiltrated water will be treated as it flows through the PRB.

As in the 1995 ESD remedy, additional fencing and a vegetative barrier (perhaps thorny plants) will be installed around the entire South Landfill area to control trespassing. The institutional controls have already been established, including a notification attached to the deed regarding past land use, restrictions on future land use, and health and safety requirements for maintenance workers of the roadway and sewer main that run through the South Landfill. These steps will protect maintenance workers during future subsurface work.

The present worth cost of this remedy is \$5,050,000. Detailed cost estimates are provided in Appendix C. Appendix D presents recommended modifications to the Performance Standards as they apply to the proposed PRB remedy.

2.2 SOIL-BENTONITE SLURRY WALL AND PERMEABLE REACTIVE BARRIER

The South Landfill will be treated by directing groundwater through a 2,000 feet long permeable reactive barrier which borders two (of three) sides of the landfill. A slurry wall will contain groundwater on the third side of the landfill. The low-permeability marsh deposit confining layer will form the bottom of the containment system. This layer is continuous and at least 10 feet thick so that an adequate "key" can be made. As shown in the ESD proposal, the South Landfill site and subsurface conditions are ideal for a soil-bentonite slurry wall. The topography is relatively flat, and the depth to the confining layer is shallow enough (less than 30 feet) to use conventional backhoes for excavation. In addition, construction quality control and quality assurance procedures are well established for slurry walls to ensure continuity and low permeability.

The soil-bentonite slurry wall is proposed along the river side of the landfill because landfill materials have been previously found at the riverbank. Within this region it is infeasible to contain the waste within a reactive barrier; hence, the impermeable barrier will isolate the waste materials from the river via physical and hydraulic separation.

The slurry wall and reactive barrier will contain, to the extent practical, all of the waste material within the South Landfill, as shown on Figure 1. The alignment is based on EPA's agreement (EPA, 1996b) that the wall can be placed on the south side of the New Castle County sewer main. EPA approved this location because the residual risk from the untreated material covered by a geomembrane and stone along the riverbank was less than the risk of a catastrophic sewer line failure. The areal extent of the waste to the north and east was confirmed with recent Geoprobe® borings (DuPont, 2000).

The soil-bentonite slurry wall will be designed to have a maximum permeability of 10^{-7} cm/sec. The slurry wall will be a minimum 36-inch-wide wall with a 3-foot key into the clayey silt layer. The soil-bentonite backfill will consist of clean backfill mixed with bentonite slurry (EPA 1996a). The Pre-Final design and construction bid documents are currently being prepared.

The permeable reactive barrier will be 18 inches wide with a 3-foot key into the clayey-silt marsh deposit. The barrier will be a mixture of treatment agents and clean sand in the weight ratios of 100:20:5:5 (sand: gypsum: iron: magnesite). All groundwater passing through the waste material will pass through the permeable barrier. The PRB will contain slightly soluble gypsum and magnesite and insoluble iron. Laboratory column studies showed an eight-inch wall would

provide over 100 years of wall life when installed with an engineered single-barrier, synthetic cap, as described previously. Hence, an 18-inch width would provide a very high level of confidence of achieving all treatment goals and an effective treatment barrier life of several hundred years.

The low-permeability marsh deposit confining layer will form the bottom of the containment system. This layer is continuous and at least 10 feet thick so that an adequate "key" can be made. The existing cover soil and the low-permeability geomembrane cap on the South Landfill will completely separate the waste from the environment. The geologic occurrence (continuity and thickness) and hydraulic characteristics (permeability) of the confining layer found beneath the South Landfill waste material has previously been described (DERS 1995).

2.3 SINGLE BARRIER CAP

The cap will cover all of the waste material and extend beyond the limits of the slurry wall and reactive barrier. The cap will have a maximum permeability of 10^{-7} cm/sec. The cap will be designed as shown in Figure 2. The design includes a barrier layer (such as a synthetic geomembrane), a geotextile drainage layer, protective soil, and topsoil.

Infiltration through the cap was estimated with the Hydrogeologic Evaluation of Landfill Performance (HELP) model to determine cap performance (see Appendix D). The model indicates that the single barrier cap will reduce infiltration over 99.98 percent from current conditions (16 vs. 0.0031 in/yr). The difference between a single barrier and the dual barrier specified in the existing performance standard is negligible (0.94 gal/year).

The cap design is a change from the 1995 ESD requirement for a dual-barrier cap with both a synthetic geomembrane and a geocomposite clay liner. Reducing groundwater to the maximum extent practical was a critical element of the 1995 ESD remedy because the treatment agents were extremely soluble and could be flushed from the waste by infiltrating rainwater.

2.4 MONITORING TREATMENT EFFECTIVENESS

Monitoring wells placed inside the permeable reactive barrier will monitor treatment and provide an early warning to facilitate protection of human health and the environment. Approximately 10 monitoring wells (on 200-foot centers) are proposed within the permeable reactive barrier (see Figure 1). One-inch diameter wells will be installed in the outside 6 inches of the barrier (see Figure 2). In addition, monitoring wells will be installed downgradient of the South Landfill to monitor metals attenuation as groundwater migrates from the landfill (see Figure 2).

Installation of wells in the outer third of the permeable reactive barrier will monitor treatment conditions and metals capture. In addition, since laboratory and field tests have shown hundreds of years wall life with much thinner installations, placement of the wells in the outer third will provide adequate early warning, in the unlikely event that breakthrough occurs at some point in the future.

Multiple phases of laboratory studies and field tests have demonstrated the viability of a PRB for the treatment of metals of concern, most notably barium, zinc, and manganese. Initial studies achieved removal of all metals except manganese (DuPont, 2000). Subsequent laboratory batch tests using an additional treatment reagent (magnesite) have demonstrated excellent manganese removal. Confirmatory laboratory column studies and in-situ field tests confirm that the PRB technology described below treats the South Landfill with equal or better protectiveness than prior technologies.

3.1 PERMEABLE REACTIVE BARRIER

A permeable reactive barrier is an in-ground emplacement of chemically active materials in the path of groundwater movement. Laboratory and field tests showed aqueous contaminants will be removed as groundwater passes through the barrier. Metals were removed by precipitation and sorption. The barrier will be of sufficient width to provide adequate residence time and long-term capacity (hundreds of years), and deep enough to key into impermeable layers at the base of an aquifer (ensuring that all groundwater will pass through the reactive materials). Once installed, the barrier will require virtually no maintenance, only groundwater monitoring to confirm treatment.

To evaluate PRB technology for metals treatment at the Newport South Landfill, a series of batch and column experiments was performed focusing on barium and zinc treatment. These are the two metals which exceed the treatment performance standards in groundwater within the South Landfill. First, screening batch tests were conducted with materials, which potentially could remove the metals. Two materials, gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and zero-valent iron (iron), showed excellent removal properties for barium and zinc, respectively. Barium precipitated as barium sulfate; zinc is removed by adsorption.

Gypsum and iron were then used in continuous-flow column tests to demonstrate their effectiveness together with the sand that would make up the bulk of the PRB. Wall life projections were then made based on the column tests and flows through the PRB under assumptions of different landfill cap configurations. Hydraulic permeability tests were performed to ensure PRB permeability throughout the remedy's life.

As a final technology demonstration, in-situ field tests were constructed using a design previously used by the U.S. EPA and DuPont. A 12-inch diameter column of the PRB sand: gypsum: iron mix was placed in the ground in the presence of contaminated groundwater. A one-inch monitoring well was placed in the middle of the column prior to backfill. Performance was determined by sampling the water that had passed through 5.5 inches of reactive material. The results of these tests validated the laboratory projections (DuPont, 2000).

A second round of batch, column, and in-situ tests were then conducted, focusing on manganese removal. Batch tests showed the addition of magnesite (a slightly soluble form of magnesium carbonate) treated the manganese. (Manganese appears to be mobilized by the presence of iron in the PRB). Column and in-situ test borings with magnesite added to the sand-gypsum-iron mixture demonstrated effective treatment of the waste and removal of all dissolved metals to well below their performance standards.

3.2 LABORATORY EVALUATIONS FOR BARIUM AND ZINC TREATMENT

This section describes the laboratory evaluations that were performed to develop the permeable reactive barrier treatment technology. Appendix A describes the evaluations in detail.

3.2.1 Batch Tests for Barium and Zinc Treatment

Batch tests were used to screen potential treatment materials. Groundwater from two locations inside the South Landfill were tested, representing areas of high barium or zinc concentration. The barium-rich water was used to evaluate the gypsum treatment effectiveness. The zinc-rich water was used to evaluate the treatment effectiveness of zero-valent iron, millscale, steel slag (from BOF, basic oxygen furnace process), and iron sulfide.

These tests covered a broad range of concentrations for each active material. Groundwater and the reactants were put in 125 cc polypropylene bottles, the headspace purged with nitrogen, and then agitated end-over-end for 24 hours. Samples of the liquid phase were then passed through a 0.45-micron filter and analyzed for the constituents of interest. Control samples followed the same procedures except that no reactive material was added.

Barium concentrations were reduced from 290,000 ppb to less than 500 ppb by the addition of 0.5 weight percent of gypsum. The resulting concentration was substantially lower than the required 7,800-ppb standard (see Appendix A).

Zinc concentrations were readily reduced from approximately 1,000 ppb to less than 10 ppb (vs. a goal of 120 ppb) by several materials, including zero-valent iron (Peerless -8 +50 mesh), iron sulfide, steel mill scale, and steel slag. The first two showed exceptional activity. Zero-valent iron (iron) was chosen for further evaluation due to its high activity and DuPont experience at other sites.

Of the other metals of concern, cadmium, copper and lead were less than the detection limits of 4 ppb in both feeds and treated waters. Nickel was significantly less than the goal of 730 ppb in both feeds and all treated waters, and was reduced in all cases except mill scale. Manganese was generally not reduced by the materials, and in some cases manganese levels increased as a result of treatment, although final concentrations in the laboratory studies remained below the treatment performance standard of 1,000 ppb established in the ESD.

3.2.2 Column Tests for Barium and Zinc Treatment

Continuous-flow column tests were conducted with the selected reactive agents – gypsum and iron. The column tests were performed to assess wall life (capacity), synergistic (or antagonistic) effects of combining the materials, and potential performance limitations (such as plugging). Two independent tests were run, on barium-rich and zinc-rich samples from South Landfill wells with the elevated barium and zinc concentrations.

While the barium and zinc concentrations leaving the landfill vary along the perimeter, DuPont has chosen one wall composition which would ensure treatment of both barium and zinc at all locations. Based on the batch tests and a projection of reactant needs, a mix composition was chosen with parts by weight of:

Sand : Gypsum : Iron = 100 : 20 : 5

An inert material, mason sand – a standard Delaware Department of Transportation material, was chosen as the base material for the PRB. Permeability tests showed that 20 weight percent gypsum mixed with mason sand had a permeability of 6×10^{-4} cm/sec. Waste permeabilities ranged from 2×10^{-5} to 1×10^{-6} cm/sec (Kiber 2000). The permeable barrier will thus have a higher permeability than the landfill material, preventing a “bathtub” effect.

For the laboratory experiments, two independent column tests were run concurrently, one with barium-rich feed water and one with zinc-rich feed water. Each test consisted of a reactive column filled with the above mix, and a control column filled with sand alone. Pressure drop across the columns was measured to determine the permeability of the columns over time.

Barium removal was readily accomplished from both the barium-rich and zinc-rich groundwaters. With the barium-rich feed, 500,000 ppb barium was reduced to nominally 1,000 ppb. With the zinc-rich feed, 70,000 ppb barium was reduced to nominally 100 ppb. These results were consistent over the one-month test, and demonstrated barium removal to well below the 7,800 ppb limit.

Zinc removal was difficult to quantify due to analytical complexities (possible interferences, etc.), but the performance was clear. While the zinc-rich feed water varied from 100 to 1,000 ppb, zinc was consistently reduced to non-detect (25 ppb) in both the active and control columns over the one-month test. The mortar-sand backfill also has some limited affinity for metals adsorption. Thus zinc levels were well below the standard of 120 ppb.

Of the other metals of concern, cadmium, copper and lead were less than the detection level of 4 ppb in both feeds and treated waters. Nickel was less than 30 ppb in treated groundwater, well below the goal of 730 ppb. Manganese, up to 100 ppb in feeds, was observed in zinc water column effluents at 200 to 8,000 ppb. In barium-rich effluents, manganese was found at 200 ppb to non-detect (10 ppb) levels.

Reactive column flow and pressure drops were used to calculate the column material permeabilities after 45 days of flow. The hydraulic conductivity was 2.2×10^{-4} and 2.6×10^{-4} cm/sec for the zinc and barium columns, respectively, the same magnitude as the fresh mixture ($\sim 6 \times 10^{-4}$ cm/sec). No permeability decrease was thus observed over many simulated wall lifetimes, and wall plugging should not be expected to occur.

3.3 IN-SITU FIELD DEMONSTRATION FOR BARIUM AND ZINC TREATMENT

Two in-situ boring clusters, each consisting of a treatment well and a control boring, were placed in locations that had shown elevated levels of barium and zinc in the Geoprobe® groundwater sampling (DuPont, 2000). Each treatment boring consisted of a 12-inch diameter column of treatment material consisting of sand, gypsum, and iron in a weight ratio of 100, 20, and 5, respectively. A 1-inch PVC pipe was placed in the middle of the boring, surrounded by the treatment material.

Each control boring was placed about fifteen feet (up- or side-gradient) from their respective treatment pair and were similarly constructed except that clean sand was used in place of treatment material (see Figure 1). The PVC pipe was screened five feet from the bottom of each well. A standard bentonite seal was placed above the treatment material or clean sand.

The field demonstration supported the laboratory tests. Barium, zinc, cadmium, copper, nickel, and lead were treated to below their respective performance standards. Manganese levels, however, while below the performance standard in the zinc-rich well, were above the performance standard in the barium-rich well.

The manganese results indicated that the presence of iron reduced the oxidation potential of the groundwater and made manganese more mobile. The difference between the laboratory column results and in-situ results is due to the different groundwater and in-situ soil conditions and is very difficult to predict, confirming the importance of the in-situ test borings.

3.3.1 Field Tests Procedure

Water was pumped from the wells between sampling events to confirm treatment performance under field geochemical conditions and, secondarily, to simulate wall life. A maximum pumping rate for the field tests was calculated by multiplying the laboratory column test rate of 0.5 L/day by the ratio of the area of the field test (at the annular diameter midpoint) to the laboratory column test. The calculated maximum pumping rate was 8.125 L/hr; the average actual pumping rate was 4.5 L/hr with a range of 3.0 to 6.3 L/hr. The test and control wells in each well cluster were pumped at the same rate using a dual-head peristaltic pump. Filtered groundwater samples were analyzed each day the test columns were pumped.

3.3.2 Results

Barium removal was demonstrated in both the barium-rich and zinc-rich locations. At the barium-rich groundwater location, the barium concentration in the water from the control well ranged between 44,500 and 103,000 ppb, compared to a concentration range of 11 to 58 ppb from the treatment well. At the zinc-rich groundwater location, the barium concentration in the water from the control well ranged from 133,000 to 230,000 ppb, whereas the barium concentration in water from the treatment well ranged from 160 to 540 ppb (DuPont, 2000).

Zinc removal was difficult to observe because of the low zinc concentrations in both locations. The zinc concentrations in the zinc-rich control well ranged from 15 ppb to non-detect. All zinc concentrations in the water from the zinc-rich treatment boring were below 6 ppb and most were non-detect. In water from the barium-rich control well, the zinc concentration was never higher than 47 ppb. Zinc concentrations in the water from the treatment well were never above 9 ppb and were non-detect in all samples after the second day of the field test.

For other constituents of interest, cadmium, copper, lead, and nickel were nearly below their detection limits throughout the field tests. None were above the practical quantitation limit. Calcium was detected in water from the control wells, at an average of 20,000 ppb, and in much higher concentrations in water from the treatment wells (an average of 550,000 ppb). The higher calcium concentrations are the result of gypsum dissolution. Manganese was detected in water from the zinc-rich wells at levels below 1,000 ppb. Manganese was also below the treatment standard in the barium-rich control well. Water in the barium-rich treatment well was about 15,000 ppb, exceeding the treatment standard.

3.4 MANGANESE TREATMENT

The initial in-situ tests (and subsequent laboratory tests) confirmed that the presence of iron in the PRB created reducing conditions that mobilized manganese, which is naturally present in site soils and as a minor constituent in the iron, sand and gypsum. After additional testing, the addition of magnesite (magnesium carbonate) to the PRB composition was found to give excellent results in laboratory batch tests (see Appendix A). The terms "magnesite" or " $MgCO_3$ " are used here even though the actual composition is a more complex hydrate.

Barium-rich and zinc-rich groundwaters were independently spiked with soluble manganese chloride to give approximately 20,000 ppb of manganese. In separate tests, the waters were then all treated with the initial sand : gypsum : iron wall mixture of 100 : 20 : 5. To this mixture magnesite was added in a series of batch runs analogous to those of our other studies. Manganese solubility was dramatically decreased at even the lowest levels of magnesite addition. Even with the initial magnesite addition, manganese was below the required 1,000 ppb. No adverse effects were observed on the removal of other metals.

Manganese Concentrations (ppb) at Increasing Magnesite Levels		
Magnesite "Weight Ratio" *	Barium-rich feed water	Zinc-rich feed water
0.0	18,700	15,800
0.8	477	260
1.6	186	115
3.2	141	< 100
6.3	100 (dl)	< 100
* Magnesite "Weight Ratio" (WR) is the weight of magnesite with respect to sand, i.e., sand : gypsum : iron : $MgCO_3$ = 100 : 20 : 5 : WR		

To confirm these batch results, both laboratory column and field tests are currently being run. They use the weight ratio [sand : gypsum : iron : magnesite = 100 : 20 : 5 : 5] and followed the same protocols as previously described for the tests without the magnesite addition.

3.5 IMPACT OF SITE GEOCHEMISTRY ON METALS MOBILITY AND TREATMENT EFFECTIVENESS

The in-situ tests illustrated the sensitivity of metals mobility to geochemical conditions. The low levels of zinc at the landfill boundary and the elevated manganese in the treatment borings are directly attributable to soil and groundwater chemistry.

Clearly, zinc is immobile in a reduced environment where sulfides are present. Inside the landfill, high zinc levels (where found) are due to the nature of the wastes deposited in the landfill and low sulfide levels. Historic groundwater data show dramatically different pH and metals conditions across the landfill. As zinc migrates to the boundary, the levels are reduced by the metal sulfides present in other wastes. This explains the low levels of zinc found at the landfill boundary.

Barium is unaffected by oxidizing or reduced conditions. Hence, elevated barium levels have been detected throughout the landfill. The presence of sulfates in natural soils precipitates barium. Where present at the landfill boundary, barium levels are low.

Manganese (where present in soils) is more mobile in reduced conditions created by metal sulfides in waste ones. Iron (zero-valent iron) in the treatment barrier dramatically lowers the reduction potential and mobilizes manganese. The addition of a slightly soluble carbonate (magnesium carbonate) to the treatment mix precipitates manganese.

3.6 WALL LIFE PROJECTIONS

Three factors determine the wall life for the South Landfill PRB – groundwater contaminant levels, groundwater flow from the waste material, and reactant capacity. Groundwater contaminant levels are determined by waste characteristics and contact of groundwater with waste. Groundwater flow can be controlled by the design of the landfill cap permeability (and subsequent infiltration). Reactant capacity is a function of initial concentration and solubility (these constituents must dissolve at a level greater than that required for metal precipitation) and iron loading.

The only factor that cannot be controlled is the concentration of contaminants in groundwater. Groundwater flow (cap permeability) and reactant capacity can be designed to ensure adequate wall life and long-term performance. Cap infiltration was estimated using the HELP (Hydrologic Evaluation of Landfill Performance) Model for the current cover and the proposed HDPE cap. The proposed cap has such a low infiltration rate (0.0031 in/yr) that only a few weeks of testing are equivalent to hundreds of years of treatment. In-situ data are included in Appendix B, and the HELP model calculations are included in Appendix D.

SECTION THREE

PRB Technology Demonstration

In-situ testing has shown that the PRB with gypsum, iron, and magnesite meets the treatment standard, even after the equivalent of decades of infiltration as shown in the following table. Field and laboratory tests are continuing to extend the wall life prediction.

Permeable Reactive Barrier Wall Life Predictions from In-situ Tests				
Cap Type	Infiltration Rate, in/yr.	Wall Flux, $\text{cm}^3/\text{cm}^2/\text{day}$	Field Year/ gal treated	Wall Life, Years
Current Conditions (3 ft. soil)	6	1.24	0.001	0.041
Soil (18 in.) + Drainage Layer + HDPE + Basin Road	0.0031	0.00064	2.22	79

These cases represent a wall only 5.5 inches thick, the radius of the in-situ boring. In practice, the wall will be 18-inches thick, thus yielding an estimated wall life more than three times that predicted above (>250 years). This evaluation shows that the single barrier cap with drainage layer tied into the existing roadway ensures centuries of treatment.

The current proposed alternative was evaluated in detail and compared to the previously selected 1993 ROD and 1995 ESD remedies in order to determine which would be the most effective in achieving the goals of CERCLA and in achieving the remedial action objectives for the Site. The following nine EPA criteria were used during the evaluation to guide remedy selection:

- ☐ Overall protection of human health and the environment
- ☐ Compliance with applicable or relevant appropriate requirements (ARARs)
- ☐ Long-term effectiveness and performance
- ☐ Reduction of toxicity, mobility, or volume through treatment
- ☐ Short-term effectiveness
- ☐ Implementability
- ☐ Cost
- ☐ State acceptance
- ☐ Community acceptance

The first two criteria are threshold criteria and must be met by the chosen site remedy (except when an ARAR waiver is invoked). The next five criteria are the primary balancing criteria, and the remaining two criteria are referred to as modifying criteria. The following sections present a comparison of the current proposed PRB remedy to the previously selected remedies for the South Landfill using the nine EPA criteria.

4.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The current proposed PRB remedy offers a greater degree of overall protection to human health and the environment than either the original 1993 ROD remedy or the 1995 ESD remedy. In the original ROD remedy, the stabilized waste would continue to leach small amounts of contaminants to the river and wetlands because the waste would not be isolated from the surrounding environment.

Both the 1995 ESD and the current PRB remedies include complete containment systems that will isolate the waste materials from the surrounding environment. The difference between these two containment systems is that the PRB remedy incorporates a reactive barrier as part of the circumscribing wall. Contaminates in water from inside the landfill will be treated as it flows through the reactive barrier component of the wall. In the unlikely event that the soil cover and cap fail, the PRB would continue to treat fluids exiting the landfill, safeguarding against releases to the surrounding environment. Furthermore, the PRB remedy is a passive treatment system, relying upon natural processes to treat the landfill fluids. Unlike the 1995 ESD remedy, the PRB remedy is not dependent upon the continuous operation of a mechanical extraction and treatment system for optimal performance.

Sewer line workers and highway workers will continue to be protected by special health and safety measures. Institutional controls preventing new utilities in the landfill will protect other utility workers.

4.2 COMPLIANCE WITH ARARS

Most of the major ARARs for the South Landfill are related to the protection of wetlands, with the exception of Resource Conservation and Recovery Act (RCRA) Subtitle D closure requirements and Delaware Regulations Governing Solid Waste (see Table 12 in the ROD). All three remedies meet their respective ARARs. Care will be taken during the design and construction of the PRB remedy to prevent any adverse effects in the South Wetlands and the Christina River. The riverbank cap ensures long-term containment of landfill material outside of the slurry wall and sewer line. Experience with the wetlands and vertical barrier remedies at the site demonstrate that vegetation rapidly re-establishes in the armor stone, and the stone creates a diverse microenvironment for foraging fish and birds.

4.3 LONG-TERM EFFECTIVENESS AND PERFORMANCE

The PRB remedy has increased long-term effectiveness when compared to the 1993 ROD remedy because it isolates the waste materials from surrounding environmental receptors via a system of circumscribing walls, and it contains a cap that is less permeable than the soil cover contained in the original remedy. The 1993 ROD stabilization remedy does not isolate the waste materials from the environment and is susceptible to fracturing, caused by differential settling, which could create free pathways for unimpeded contaminant migration.

The PRB remedy also presents improved effectiveness over the 1995 ESD remedy because it is designed for long-term (decades) leachate migration through treatment materials that are either sparingly soluble (gypsum and magnesite) or insoluble (iron). The 1995 ESD treatment agents are extremely soluble, hence susceptible to flushing from the waste by infiltration. Due to the differences in solubility of the reactive materials in the two remedies, the PRB remedy performance is not as dependent upon the cap integrity as the 1995 ESD remedy. Should the PRB remedy cap fail, infiltrated water would merely flow through the PRB and be treated. Placing monitoring wells within the barrier provides decades of advance warning to ensure contaminants are treated and contained. Conversely, cap failure for the 1995 ESD remedy could result in flushing of the reactive agents and potential releases of waste materials to the surrounding environment.

The 1995 ESD remedy also requires the continuous operation of a groundwater extraction and treatment system to ensure waste containment and remedy success. Any downtime experienced by this pump-and-treat system could impact the performance and effectiveness of the 1995 ESD remedy. The effectiveness of the PRB remedy is not dependent upon external mechanical systems.

4.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

All three remedy options would significantly reduce the mobility of the metals through treatment. However, the original 1993 ROD remedy would increase the waste volume by approximately three percent (15,000 cubic yards) (Kiber, 2000), and the 1995 ESD remedy is estimated to increase the total waste volume by five percent (DuPont, 1999). Another disadvantage of the 1995 ESD remedy is that the groundwater treatment system will generate additional waste materials that would require off-site disposal. The current proposed PRB remedy will immobilize migrating metals via precipitation and adsorption reactions within the wall, with no net increase in waste volume. This will aid the design and construction of the treatment remedy and will minimize any decrease in floodplain volume.

The use of slightly soluble gypsum and magnesite in the PRB will add calcium, magnesium, sulfate, and carbonate to groundwater. Calcium and magnesium are common metals and "hardness" ions with no toxicity to humans or animals. In fact, hardness ions have been found to reduce the toxicity of other metals in surface water. Likewise, sulfates and carbonates will not have an adverse impact at these levels.

4.5 SHORT-TERM EFFECTIVENESS

While all remedies are equally effective in the short term, the PRB remedy will be faster to implement due to both its less invasive techniques and use of proven installation methods. Furthermore, the PRB remedy will not disturb the existing soil cover until the cap is installed, reducing potential risks for environmental releases and exposure to the waste materials. The 1993 ROD and 1995 ESD remedies both require two construction seasons for implementation, including over 50 weeks for the 1993 ROD soil mixing. The PRB remedy requires only one construction season to implement, thus minimizing impacts to traffic along South James Street/Basin Road.

4.6 IMPLEMENTABILITY

The PRB technology is easier to implement than either the soil stabilization or the in-situ chemical treatment methods due to its shorter construction period, use of proven construction methods, and inherent protection of the sewer line by less-intrusive equipment. Both the 1993 ROD soil mixing remedy and the 1995 ESD remedy must cover the entire landfill area, ensuring that all waste volume is treated in place. Conversely, the PRB remedy will be emplaced along the circumference of the landfill, and will need to treat only the volume of waste material leaching from the landfill. The 1993 ROD and 1995 ESD remedies would require a longer time frame to implement with greater interruptions to Basin Road traffic, even when multiple mixing units or chemical infiltration units were considered. The PRB remedy would only sporadically restrict traffic in one direction (at any time) for only a few weeks.

SECTION FOUR

Rationale for Selection

The PRB remedy is also easier to implement because it is a passive treatment remedy with an extended life span of several hundred years. Contaminants will be removed from the groundwater as it flows through the treatment materials. Treatment success is not contingent upon continuous operation of a containment system. The 1995 ESD chemical treatment remedy would require the continuous operation and maintenance of a groundwater extraction and treatment system to contain the waste materials.

4.7 COST

The cost for the 1993 ROD, 1995 ESD, and PRB remedies were investigated in detail (see Appendix C) and are summarized in the following table. Additional treatability studies were performed to confirm the cost of the 1993 ROD remedy (waste volume is approximately 500,000 cubic yards). As illustrated, the PRB remedy is the most cost-effective option.

COST COMPARISON (\$MM) ROD, ESD, and PRB Remedies			
Item	ROD Remedy	ESD Remedy	PRB Remedy
Site Preparation	0.2	0.2	0.25
Final Cover/Cap including Riverbank	0.5	2.8	1.97
Basin Road Excavation	1.8	0.0	0.0
Stabilization or Treatment (PRB)	9.8	14.3	0.98
Slurry Wall	0.0	0.2	0.15
Cost Subtotal	12.3	17.5	3.35
Other Direct Costs	3.8	3.1	1.08
Construction Subtotal	16.1	20.6	4.43
O&M (NPV)	0.4	1.4	0.38
Contingency (5%)	0.8	1.1	0.24
Total	17.3	23.1	5.05

4.8 STATE AND COMMUNITY ACCEPTANCE

DuPont expects that both the state and community will support the PRB remedy because it is cost-effective and reduces impact on the Basin Road traffic.

In summary, DuPont proposes changing the Newport South Landfill remedy from the 1995 ESD remedy to the current proposed PRB remedy. The PRB remedy includes a barrier-PRB wall system and cap that would isolate the waste materials from the surrounding environment and treat waste constituents at the landfill boundary. The PRB remedy changes the waste treatment from sodium sulfide/sulfate injection to the in-situ permeable reactive barrier treatment technology. This technology will remove soluble metals permanently from the groundwater via adsorption and precipitation reactions within the wall materials. The net present worth cost of the proposed PRB remedy for the South Landfill is \$5,050,000.

DuPont believes that this proposed remedy ranks significantly better than the original 1993 ROD and 1995 ESD remedies with respect to the nine criteria used to evaluate remedies. DuPont believes this PRB remedy would protect human health and the environment, would comply with ARARs, would be cost-effective, and would utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

SECTION SIX

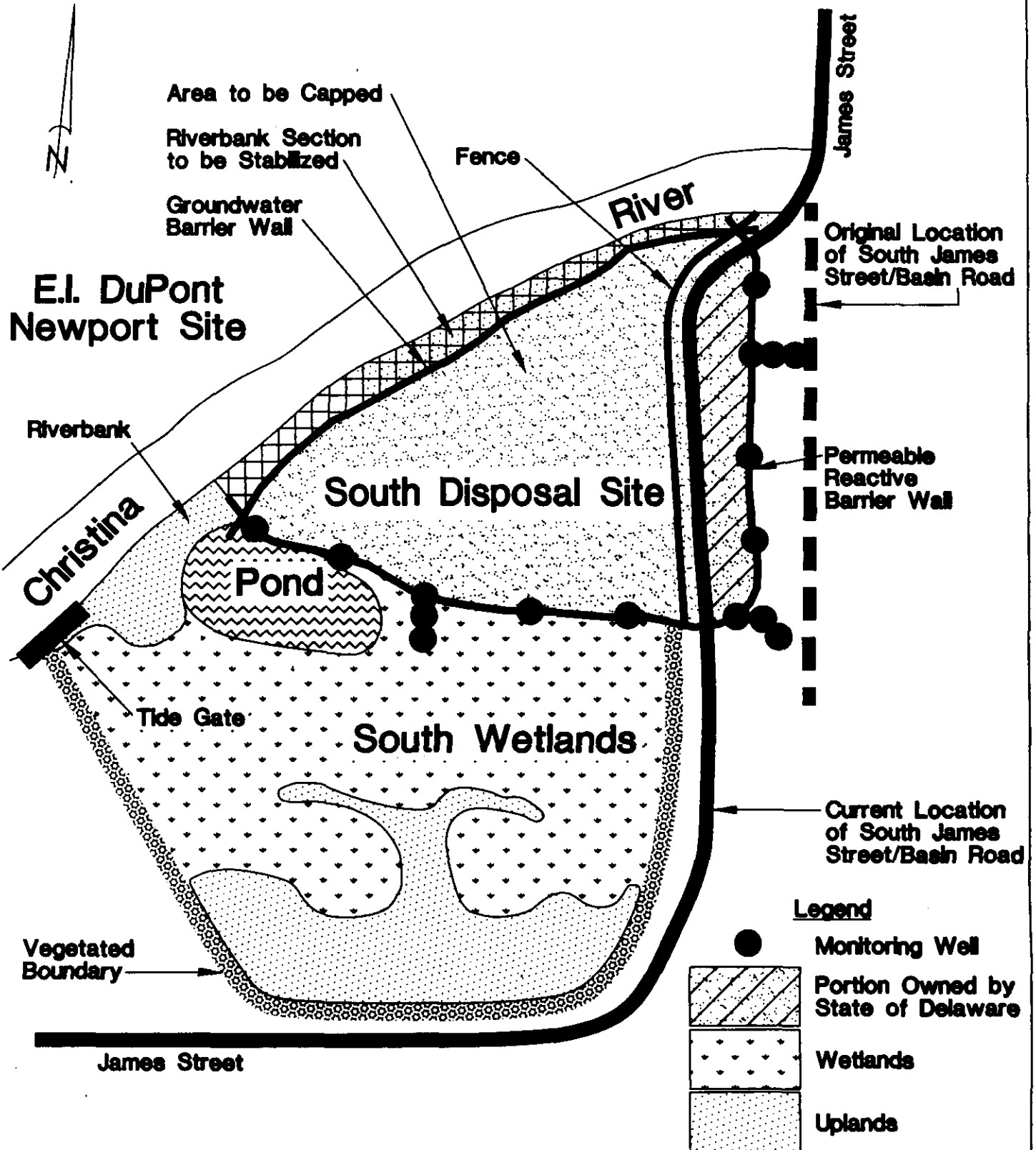
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- Kiber. February 2000. *South Landfill Site Stabilization/Solidification Treatability Study. Final Report.*

FIGURES

AR324755

PERMEABLE REACTIVE BARRIER REMEDY



AR324756



Corporate Remediation Group

*An Alliance between
DuPont and The W-C Diamond Group*

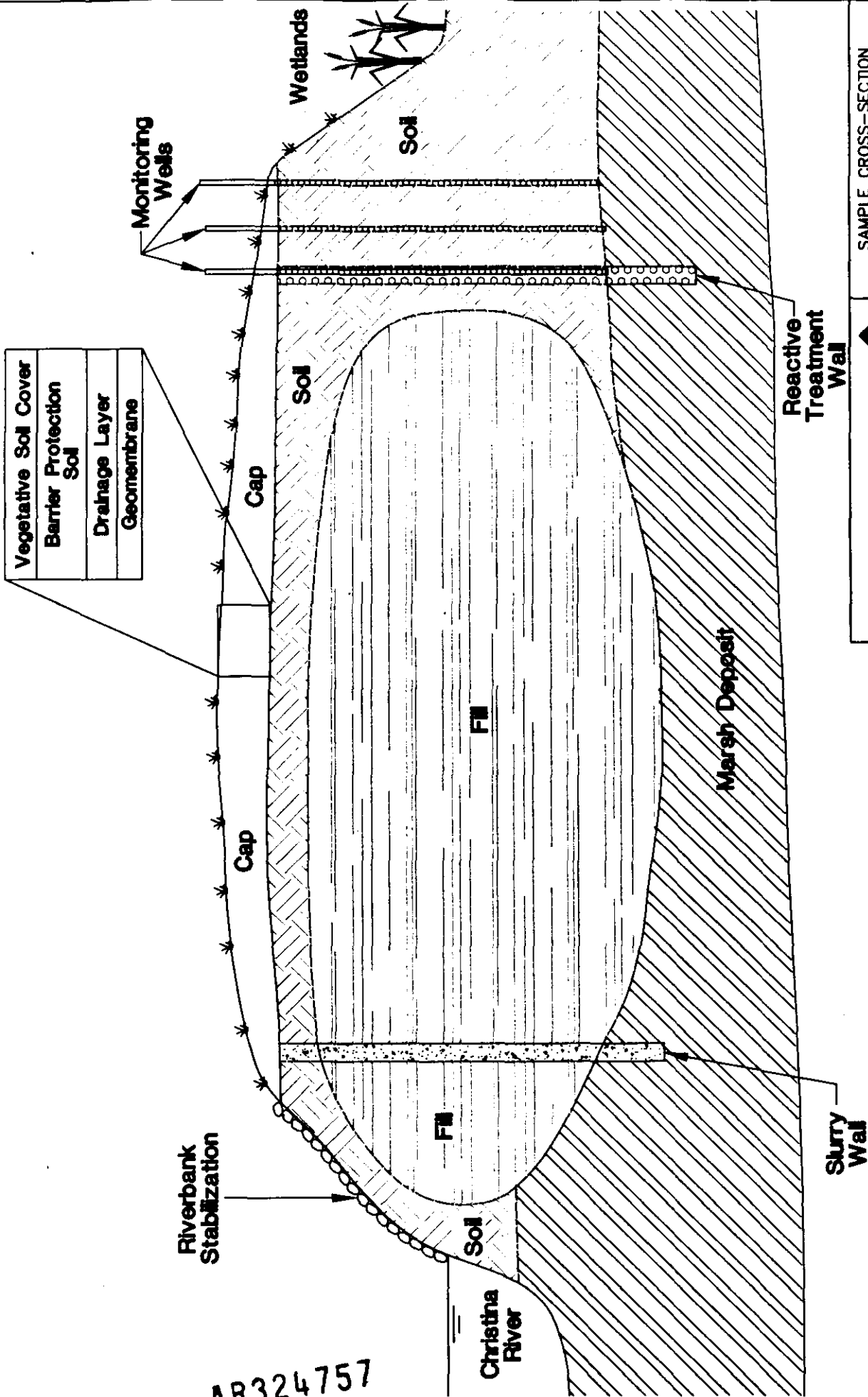
Barley Mill Plaza, Building 27
Wilmington, Delaware 19880-0027



Permeable Reactive Barrier Remedy

DuPont Newport South Landfill
Newport, Delaware

SCALE Not to scale	DESIGNED MNT	DRAWN OEL	CAD FILE NO. None_Remeddy
DATE 10/31/00	CHECKED	APPROVED	PAGE 1



AR324757



Corporate Remediation Group
An Alliance between
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 Barley Mill Plaza, Building 27
 Wilmington, Delaware 19880-0027

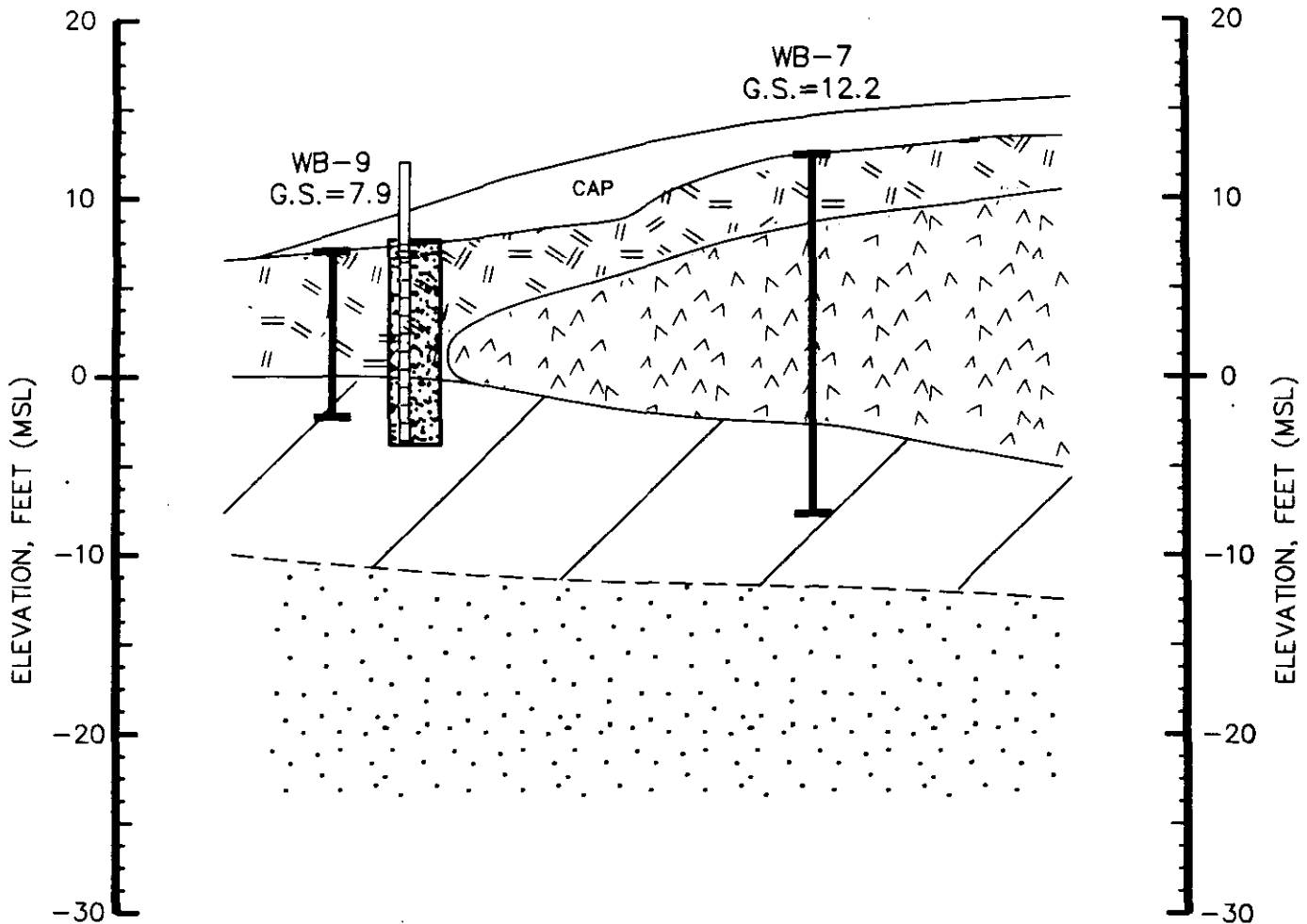
**SAMPLE CROSS-SECTION
OF SOUTH LANDFILL**

DuPont Newport South Landfill
 Newport, Delaware

SCALE Not to scale	DESIGNED 10/31/00	REVIEWED MKT	APPROVED PBB	DATE 10/31/00	BY New Remedy	FILE NO. 2

SOUTH

NORTH



LEGEND:



COVER SOIL, TYPICALLY GRAY TO BROWN, SILT TO SILTY CLAY



FILL MATERIAL



PRB WALL



SAND, COLUMBIA FORMATION, TYPICALLY ORANGE TO ORANGE BROWN, FINE TO COARSE SAND, SOME GRAVEL



CLAYEY SILT, MARSH DEPOSIT, TYPICALLY DARK TO OLIVE GREEN, CLAYEY SILT

AR324758



Corporate Remediation Group

*An Alliance between
DuPont and The W-C Diamond Group*

Barley Mill Plaza, Building 27
Wilmington, Delaware 19880-0027

Detail of PRB Wall

DuPont Newport Site
Newport, Delaware

SCALE As shown	DESIGNED MMT	DRAWN DEL	CAD FILE NO. 7105A002
DATE 11/28/00	CHECKED	APPROVED	FIGURE 3

APPENDICES

AR324759

10

AR324760

APPENDIX A

LABORATORY REPORT – DEVELOPMENT OF DATA FOR A PERMEABLE REACTIVE BARRIER

AR324761

A-1

BASIC DATA REPORT FOR BARIUM AND ZINC TREATMENT

AR324762

June 28, 2000

To: P. Brandt Butler
CRG/WCD

From: John A. Wilkens
CR&D

Newport South Landfill:
Laboratory Development of Data for a
Permeable Reactive Wall

Permeable Reactive Wall -- Developmental Basis

A permeable reactive wall (PRW), a.k.a. permeable reactive barrier, is an underground emplacement of reactive material in the path of flowing groundwater, such that aqueous contaminants are removed or destroyed as groundwater passes through the wall. Many metals can be removed by precipitation or sorption. Such a wall would be two- to three-feet thick, and deep enough to key into impermeable clay layers at the base of an aquifer. It would circumscribe the South Landfill except in the area where there would be a barrier slurry wall. Once emplaced, a wall requires virtually no routine maintenance, just monitoring of the external groundwater for performance confirmation.

To determine whether PRW technology would work for barium and zinc removal from the Newport South Landfill, a series of batch and column experiments was performed in the laboratory. First, scouting batch tests were made to see what materials had the capability to remove the metals. Two materials, gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and zero-valent iron showed excellent removal properties for barium and zinc, respectively. These were then used in continuous-flow column tests to demonstrate their effectiveness together and with the sand that would make up the bulk of the PRW. Wall life projections were then made based on the column tests and flows through the PRW under assumptions of different landfill cap configurations.

As a final technology demonstration, we employed a significant new in-situ field test that has been demonstrated by the U.S. EPA and DuPont. A 12-inch diameter column of the PRW sand:gypsum:ZVI mix was emplaced in the ground in the presence of contaminated groundwater. Central in the column was a one-inch monitoring well. Performance was determined by sampling the core water that had passed through six inches of reactive material. The results of this test further validate the laboratory projections.

AR324763

Laboratory Batch Tests -- Procedures

Batch tests were employed for screening reactive materials for use in a Permeable Reactive Wall. Two types of water were tested, representing areas of high barium or zinc concentration. Appropriate materials were used for each removal action:

- Water from a barium-rich zone within the South Landfill
 - Material: $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (gypsum)
- Water from a zinc-rich zone within the South Landfill
 - Materials: Zero-valent iron, millscale, steel slag, iron sulfide

These tests covered a broad range of concentrations for each reactive material, to determine the level at which each would potentially become effective. Reaction times were standardized at 24 hours; experience with kinetics experiments showed that this was a good measure of relative performance. Groundwater and materials were put in 125 cc polypropylene bottles, the headspace purged with nitrogen, and then agitated end-over-end for 24 hours. Samples of the liquid phase were then passed through a 0.45-micron filter and analyzed for the constituents of interest. Control samples followed the same procedures except that no material was added.

Analytical Procedures

Sample analyses were performed by DuPont's Corporate Center for Analytical Sciences:

- Barium and zinc were analyzed using ICP-AES (inductively coupled plasma -- atomic emission spectroscopy) down to 100 ppb and 25 ppb, respectively.
- Other metal concentrations were determined using ICP-MS to the following levels (ppb): aluminum 100, cadmium 4, calcium 100, copper 4, iron 100, lead 4, magnesium 100, manganese 100, nickel 100, potassium 100, and sodium 100.
- Anion concentrations were determined using IC (ion chromatography) down to 500 ppb: sulfate, chloride, fluoride, nitrate, nitrite, and phosphate.

Laboratory Batch Tests -- Results

Barium concentrations were reduced from 290,000 ppb to less than 500 ppb by the addition of 0.5 weight percent of $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, through the precipitation of BaSO_4 . This was substantially lower than the required 7,800 ppb standard. Additional gypsum concentrations decreased barium levels to a minimum of approximately 150 ppb; illustrative results are shown in the following table:

AR324764

Wt. % $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	Barium conc., ppb
0	290,000
.5	492
1	416
4	224
9	177
29	143

Zinc concentrations were readily reduced from approximately 1000 ppb to less than 10 ppb (vs. a goal of 120 ppb) by several materials, including zero-valent iron (Peerless -8 +50 mesh), iron sulfide, steel-process mill scale, and steel slag, with the first two showing exceptional activity. Zero-valent iron, used as a PRW additive for chromium removal and dechlorination of organics, performed very well for zinc removal. The mechanism is not the cementation as in copper removal, but is probably sorption onto hydrous iron oxides surfaces. The performance of zero-valent iron is shown in the table below:

Wt. % ZVI	Zinc conc., ppb
0	1020
.5	38
1	39
2 and higher	<10

Of the other metals of concern, cadmium, copper and lead were less than the detection limits of 4 ppb in both feeds and treated waters. Nickel was less than the goal of 73 ppb in feeds and all treated waters, and was reduced in all cases except mill scale. Manganese was generally not reduced by the materials, and in some cases showed increases, although below the limit of 1000 ppb.

Laboratory run sheets follow for the independent batch experiments with gypsum for barium removal and zero-valent iron for zinc removal. They give full details of the experimental conditions and the concentrations of metals found at all levels of gypsum and ZVI addition.

AR324765

Newport South Landfill -- Groundwater Ba Removal -- CaSO4

Bottle vol (cc)= 125
 Material mix density (g/cc) = 2.32
 Mix wt. Fract. ABC = 0.000
 Mix wt. Fract. XYZ = 1.000

Component XYZ: CaSO4

Calculation Date: 1/14/2000 By: JAW
 Lab Prep Date: 1/17/2000 By: WBB
 Notebook Number -- Page: E98123-32

Target										Laboratory Run									
Wt Rto	Wt %	Wt. Mix	Vol. Mix	Vol. Wtr	Total Vol	Smpl No.	Wt. ABC		Wt. Xyz		Wt. Water		pH at End of Run						
Mix/Wtr	Mix	g	cc	cc	cc		Target g	Actual g	Target g	Actual g	Target g	Actual g	Meter	Paper					
0.000	0.00	0.00	0.00	125.00	125	1	0.00	0.00	0.00	0.00	125.00	125.00	10.1	10.0					
0.005	0.50	0.62	0.27	124.73	125	2	0.00	0.00	0.624	0.63	124.73	124.70	11.1	10.0					
0.010	0.99	1.24	0.54	124.46	125	3	0.00	0.00	1.245	1.24	124.46	124.40	10.3	10.5					
0.020	1.96	2.48	1.07	123.93	125	4	0.00	0.00	2.479	2.49	123.93	123.90	10.3	10.5					
0.040	3.85	4.92	2.12	122.88	125	5	0.00	0.00	4.915	4.92	122.88	122.80	10.5	10.5					
0.080	7.41	9.67	4.17	120.83	125	6	0.00	0.00	9.667	9.67	120.83	121.00	10.5	10.5					
0.100	9.09	11.98	5.17	119.83	125	7	0.00	0.00	11.983	11.98	119.83	119.80	10.5	10.5					
0.200	16.67	23.02	9.92	115.08	125	8	0.00	0.00	23.016	23.02	115.08	115.00	10.5	10.5					
0.330	24.81	36.11	15.57	109.43	125	9	0.00	0.00	36.113	36.12	109.43	109.40	10.7	10.5					
0.400	28.57	42.65	18.38	106.62	125	10	0.00	0.00	42.647	42.67	106.62	106.60	10.6	10.5					

WHERE:

Wt. Ratio, Mix / Water g/g Input data
 Wt of Matl mix g = Botvol * RhoM / (1+RhoM / (Ratio*RhoW))
 Wt. CaSO4 g = Wt Mix * Mix wt. Fract. CaSO4
 Wt. XYZ g = Wt Mix * Mix wt. Fract. XYZ
 Wt. Water g = Wt Mix / Wt. Ratio
 Vol of Matl Mix cc = Wt Mix / Mix Density
 Vol of Water cc = Wt Water / Density of water
 Total Vol cc = Vol Mix + Vol Water

Notes:

"Water" is Newport South Landfill RDW-2 groundwater, used unfiltered in the experiments.
 Samples for analytical filtered through 0.45 um filter
 "CaSO4" is CaSO4.2H2O from ISG Resources (DuPont, Richmond)
 Tumbler contact time = 24 hours for all samples

Sample 1 is a control; the formulas do not apply.

J. A. Wilkens, W. B. Bazela

AR324766

Newport South Landfill -- Groundwater Ba Removal -- CaSO4

Run Summary -- p-2

Calculation Date: 1/14/2000 Notebook Number -- Page: F98123-32
Lab Prep Date: 1/17/2000 Component XYZ: CaSO4

Smpl No.	Wt. CaCO3 per Wt. H2O	Wt. XYZ per Wt. H2O	Results after Treatment						
			pH at End of Run		Anion Concentrations, ppb				
			Meter	Paper	Sulfate	Chloride	Fluoride	Nitrate	Phosphate
1	0.00	125.00	10.1	10.0	2,000	13,000	4,000	500	296
2	0.0000	0.0050	11.1	10.0	1,463,000	14,000	1,000	500	374
3	0.0000	0.0100	10.3	10.5	1,524,000	13,000	1,000	500	424
4	0.0000	0.0201	10.3	10.5	1,529,000	13,000	1,000	500	485
5	0.0000	0.0401	10.5	10.5	1,539,000	14,000	1,000	500	485
6	0.0000	0.0799	10.5	10.5	1,504,000	14,000	1,000	500	485
7	0.0000	0.1000	10.5	10.5	1,549,000	15,000	1,000	500	471
8	0.0000	0.2002	10.5	10.5	1,573,000	16,000	1,000	500	482
9	0.0000	0.3301	10.7	10.5	1,667,000	20,000	1,000	500	496
10	0.0000	0.4003	10.6	10.5	1,607,000	20,000	1,000	500	506

Smpl No.	Metal Concentrations, ppb										
	Ba	Zn	Al	Cd	Ca	Cu	Fe	Pb	Mg	Mn	Na
1	290,000	25	10	4	4,680	4	10	4	335	10	8,280
2	492	25	10	4	766,000	4	2,038	4	284	10	8,730
3	416	25	10	4	791,000	4	2,048	4	281	10	9,090
4	193	25	10	4	760,000	4	1,981	4	248	10	9,580
5	224	25	10	4	735,000	4	1,954	4	234	10	11,100
6	174	25	10	4	717,000	4	1,862	4	190	10	13,500
7	177	25	10	4	690,000	4	1,811	4	157	10	14,000
8	157	25	10	4	677,000	4	1,760	4	119	10	19,400
9	146	25	10	4	701,000	4	1,804	4	89	10	28,100
10	143	25	10	4	688,000	4	1,729	4	101	10	32,200

AR324767

Newport South Landfill -- Groundwater Zn Removal -- Peerless -8 +50 ETI Std

Bottle vol (cc)= 125
 Material mix density (g/cc) = 7.00
 Mix wt. Fract. CaSO4 = 0.000
 Mix wt. Fract. XYZ = 1.000

Component XYZ: Peerless -8 +50 ETI Std

Calculation Date: 1/17/2000 By: JAW
 Lab Prep Date: 1/1/1900 By: WBB

Notebook Number -- Page: E98123-35

Target						Laboratory Run									
Wt Rto	Wt %	Wt. Mix	Vol. Mix	Vol. Wtr	Total Vol	Smpl No.	Wt. CaSO4		Wt. Xyz		Wt. Water		pH at End of Run		
Mx/Wtr	Mix	g	cc	cc	cc		Target g	Actual g	Target g	Actual g	Target g	Actual g	Meter	Paper	
0.000	0.00	0.00	0.00	125.00	125	1	0.00	0.00	0.00	0.00	125.00	125.00	7.0	7.0	
0.005	0.50	0.62	0.09	124.91	125	2	0.00	0.00	0.625	0.625	124.91	124.90	7.4	7.0	
0.010	0.99	1.25	0.18	124.82	125	3	0.00	0.00	1.248	1.248	124.82	124.80	7.5	7.0	
0.020	1.96	2.49	0.36	124.64	125	4	0.00	0.00	2.493	2.493	124.64	124.60	7.4	7.0	
0.040	3.85	4.97	0.71	124.29	125	5	0.00	0.00	4.972	4.923	124.29	124.30	7.8	7.5	
0.080	7.41	9.89	1.41	123.59	125	6	0.00	0.00	9.887	9.889	123.59	123.60	8.5	8.0	
0.100	9.09	12.32	1.76	123.24	125	7	0.00	0.00	12.324	12.327	123.24	123.20	8.5	8.0	
0.200	16.67	24.31	3.47	121.53	125	8	0.00	0.00	24.306	24.306	121.53	121.50	8.9	8.0	
0.330	24.81	39.39	5.63	119.37	125	9	0.00	0.00	39.393	35.956	119.37	119.80	9.1	8.0	
0.400	28.57	47.30	6.76	118.24	125	10	0.00	0.00	47.297	47.297	118.24	118.20	9.4	8.0	

Data Updated: 2/4/2000

WHERE:

Wt. Ratio, Mix / Water g/g Input data
 Wt of Matl mix g = Botvol * RhoM / (1+RhoM / (Ratio*RhoW))
 Wt. CaSO4 g = Wt Mix * Mix wt. Fract. CaSO4
 Wt. XYZ g = Wt Mix * Mix wt. Fract. XYZ
 Wt. Water g = Wt Mix / Wt. Ratio
 Vol of Matl Mix cc = Wt Mix / Mix Density
 Vol of Water cc = Wt Water / Density of water
 Total Vol cc = Vol Mix + Vol Water

Notes:

"Water" is Newport South Landfill RDW-1 groundwater, used unfiltered in the experiments.
 Peerless Cast Iron -8 +50 mesh (ETI Standard)
 "CaSO4" is CaSO4.2H2O from ISG Resources (DuPont, Richmond)
 Reaction bottle headspace: Nitrogen
 Tumbler contact time = 24 hours for all samples
 Samples for analytical filtered through 0.45 um filter
 Sample 1 is a control; the formulas do not apply.

J. A. Wilkens, W. B. Bazela

AR324768

Newport South Landfill -- Groundwater Zn Removal -- Peerless -8 +50 ETI Std
Run Summary -- p.2

Calculation Date: 1/17/2000 Notebook Number -- Page: E98123-35
 Lab Prep Date: 1/1/1900 Component XYZ: Peerless -8 +50 ETI Std

Smp/No.	Wt.CaCO3 per Wt. H2O	Wt. XYZ per Wt. H2)	Results after Treatment							
			pH at End of Run		Anion Concentrations, ppb					
			Meter	Paper	Sulfate	Chloride	Fluoride	Nitrate	Nitrite	Phosphate
1	0.00	125.00	7	7	500	87,000	500	500	5,000	500
2	0.0000	0.0050	7	7	500	88,000	500	500	5,000	500
3	0.0000	0.0100	8	7	1,000	87,000	500	500	5,000	500
4	0.0000	0.0200	7	7	1,000	88,000	500	500	4,000	500
5	0.0000	0.0396	8	8	1,000	88,000	500	500	4,000	500
6	0.0000	0.0800	9	8	1,000	90,000	500	500	3,000	500
7	0.0000	0.1001	9	8	1,000	90,000	500	500	2,000	500
8	0.0000	0.2000	9	8	1,000	92,000	500	500	2,000	500
9	0.0000	0.3001	9	8	1,000	96,000	500	500	1,000	500
10	0.0000	0.4001	9	8	1,000	97,000	500	500	6,000	500

Smp/No.	Metal Concentrations, ppb										
	Ba	Zn	Al	Cd	Ca	Cu	Fe	Pb	Mg	Mn	Na
1	83,900	1,020	60	4	82,900	4	196	4	18,900	487	55,100
2	78,800	38	10	4	81,200	4	39,700	4	19,500	812	56,100
3	81,000	39	10	4	79,600	4	40,800	4	17,800	999	54,300
4	80,000	10	10	4	81,000	4	31,100	4	19,300	893	5,900
5	76,700	10	10	4	83,900	4	3,920	4	18,700	342	6,080
6	61,800	10	10	4	68,500	4	800	4	17,100	40	6,470
7	55,600	10	10	4	40,000	4	547	4	15,300	61	6,810
8	38,100	10	10	4	25,200	4	51	4	11,300	26	8,020
9	17,400	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
10	27,900	10	10	4	20,200	4	10	4	4,130	10	9,280

AR324769

Laboratory Column Tests - Procedures

Continuous-flow column tests were then run to determine the performance over time of a proposed reactive wall mix on the South Landfill groundwater. Two independent tests were run, on barium-rich and zinc-rich waters. These waters were taken from the highest-concentration wells for barium and zinc in the current field sampling, and differed from the sources (no longer available) used for the batch tests.

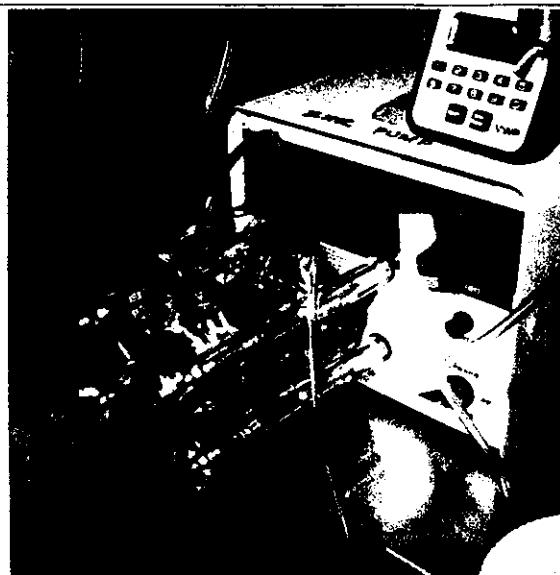
A standard Delaware Department of Transportation material, mason sand, was chosen as the base material for the PRW. From permeability data (developed by Kiber Environmental), it was determined that 20 weight percent gypsum could be mixed with the mason sand and maintain a permeability (6×10^{-4} cm/sec). This is greater than that of the landfill material, and thus will permit flow of groundwater out of the landfill. The composition of groundwater leaving the landfill at any point is not known with certainty, so that it is not possible to delineate zinc-removal and barium-removal portions of the PRW. Consequently, one wall composition was chosen to accommodate both the worst-case barium and zinc levels. Based on the batch tests and a projection of reactant needs, a mix composition was chosen with parts by weight of:

Sand : Gypsum : ZVI = 100 : 20 : 5.

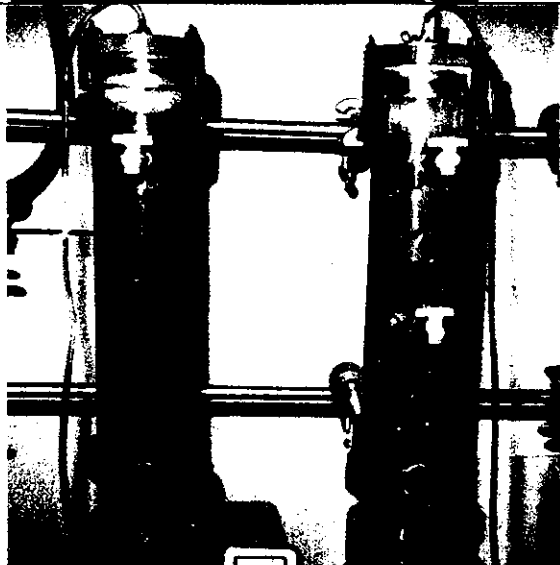
For the laboratory experiments two independent column tests were run concurrently, one with barium-rich feed water and one with zinc-rich feed water. The supply reservoirs were nitrogen blanketed with a positive-flow purge. Each test consisted of a reactive column filled with the above mix, and a control column filled with sand alone. The vertical Lucite® columns were 2-inches inside diameter. Reactive sections were eight inches long, with one inch of pure sand above and below the mix, and glass wool at the entrance and exit. The control columns contained ten inches of sand. An upward flow of groundwater was maintained at 500 cc/day through each column using low-flow peristaltic pumps, giving a throughput of four active void volumes per day.

Flow pressure drops across the reactive columns were measured to determine the permeability of the columns, and to project whether there would be a decrease in permeability as a PRW ages. For this, pressures were measured at the entrance and exit points of the reactive sections by independent manometers. This arrangement is illustrated in the drawing that follows.

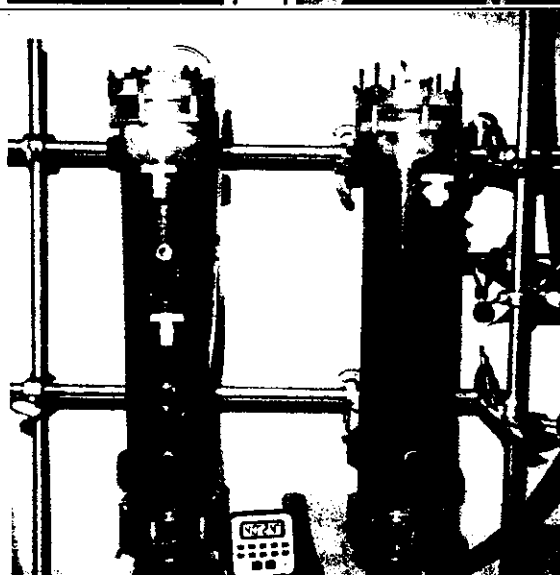
AR324770



The feed flow to each (Ba, Zn) system was maintained by a peristaltic pump with low-flow heads. A rate of 500 cc/day/column gave four reactive void volumes of flow per day.



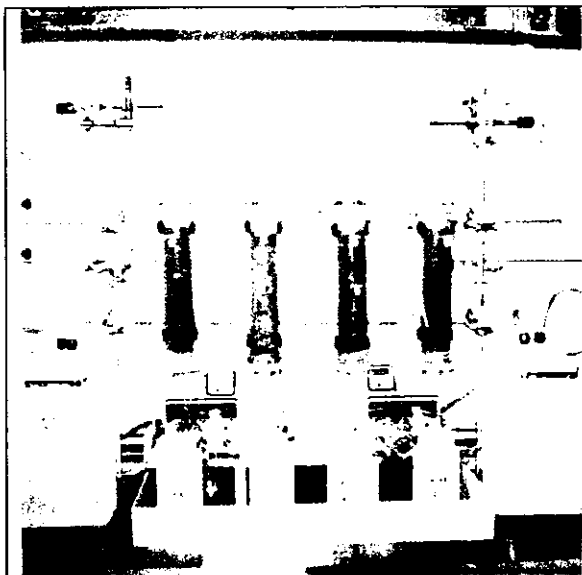
Zinc columns, with the reactive unit on the right. Eight inches of reactive mix was preceded and followed by one inch of pure sand. Plastic mesh spacers separated reactive mixes from pure sand, and glass wool was used at the inlets and outlets. For the control column, a sand bed 10 inches deep was used. A small amount of the gypsum formed small balls, seen as white spots, while most was uniformly dispersed throughout the column.



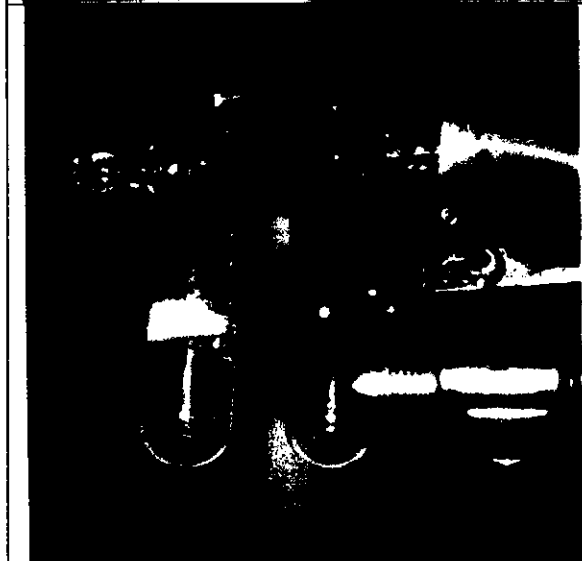
Barium columns quickly turned dark gray in operation; the water gave off a strong sulfide odor. Manometer tubes were later inserted in the upper and lower ports of the reactive columns to determine the pressure drop across the reactive bed.

AR324771

Laboratory Column Tests -- Apparatus



Overview of column apparatus, showing two independent, concurrent tests. Left (zinc-rich) water reservoir fed left two columns, right (barium-rich) reservoir fed right two columns.

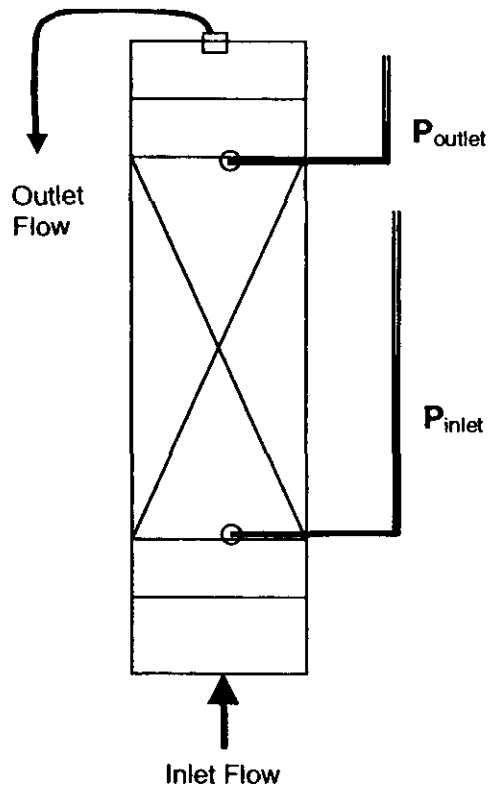


Nitrogen blanket over feed reservoirs was maintained by continuous low flow and exit bubblers filled with mineral oil.

AR324772

Newport South Landfill Column Test

Column Pressure Drop Measurements



Pressure drop across column $= P_{inlet} - P_{outlet}$

NOTES:

- Independent water manometers were used for pressure measurements at inlet and outlet taps
- Outlet flow is at the level of P_{outlet}
- Distance between P_{outlet} and P_{inlet} = 8 inches
- Sand beds: 8 inches of reactive bed, with 1 inch of sand above and below reactive section
- Inlet and outlet taps are within sand beds, as close as possible to the beginning and end of reactive sections

AR324773

Laboratory Column Tests -- Results

Barium removal was readily accomplished from both the barium-rich and zinc-rich groundwaters. With the barium-rich feed, 500,000 ppb Ba was reduced to 1,000 ppb. With the zinc-rich feed, 70,000 ppb Ba was reduced to 100 ppb. These results were consistent over the one-month test, and demonstrate barium removal to well less than the 7,800 ppb limit.

Zinc removal was difficult to quantify due to analytical complexities (possible interferences, etc.), but the performance was clear. The zinc-rich water feed varied erratically from 100 to 1000 ppb Zn. Regardless of the input level, the zinc was consistently reduced to non-detect (25 ppb) in both the active and control columns over the one-month test. Thus zinc levels were well below the standard of 120 ppb. With the barium-rich feed water, no zinc was detected in the feed or effluent streams. This was consistent with the strong sulfide odor of this water, which implied that zinc had been precipitated in-situ as the sulfide.

Of the other metals of concern, like with the batch tests, cadmium, copper and lead were less than the detection level of 4 ppb in both feeds and treated waters. Nickel, at about 10 ppb in feeds, was less than 30 ppb in effluents, well below the goal of 73 ppb. Manganese, up to 0.1 ppm in feeds, was observed in zinc water column effluents at 0.2 to 8 ppm, and in barium water column effluents at 0.2 ppm to non-detect (10 ppb).

Reactive column flow pressure drops were used to calculate the column material permeabilities after 45 days of flow. The hydraulic conductivities were 2.2×10^{-4} and 2.6×10^{-4} cm/sec for the zinc and barium columns, respectively, the same magnitude as the fresh mixture tested by Kiber Environmental, $\sim 6 \times 10^{-4}$ cm/sec. No permeability decrease was thus observed over many simulated wall lifetimes, and wall plugging should not occur.

Data sheets follow which show the progress through the continuous column tests. First is a table of the results from the zinc-rich water test, then one for the independent barium-rich water test. These follow zinc and barium removal, for which analysis was regularly done. Third is a pair of tables showing the full scan of metals analysis, which was done for a few days.

AR324774

**Newport South Landfill
Barium and Zinc Removal Column Tests**

Date	Run Day	Zinc Water Columns (from well RDW-1)					
		Feed		Control		Reactive	
		Ba ppb	Zn ppb	Ba ppb	Zn ppb	Ba ppb	Zn ppb
3-18	2	70,500	nr	4,830	nr	640	nr
3-19	3	68,500	nr	29,300	nr	480	nr
3-20	4	72,500	nr	53,500	nr	453	nr
3-21	5	70,000	nr	59,000	nr	nr	nr
3-22	6	74,600	168	61,800	nd	114	nd
3-23	7	74,600	158	64,000	nd	nr	nd
3-24	8	68,000	827	94,700	nd	183	nd
3-25	9	72,500	1,710	70,000	nd	109	nd
3-26	10	71,500	950	66,400	nd	113	nd
3-27	11	74,600	368	62,100	nd	87	nd
3-28	12	71,800	195	56,100	nd	173	nd
3-30	14	72,400	926	56,100	nd	173	nd
3-31	15	79,300	966	62,200	nd	91	nd
4-3	18	55,200	1,050	73,000	nd	96	nd
4-5	20	54,000	540	53,000	nd	80	nd
4-7	22	49,400	67	44,600	nd	133	nd
4-10	25	54,400	358	55,000	nd	66	nd
4-12	26	56,800	163	52,400	nd	48	nd
4-14	29	70,500	57	52,700	nd	<100	nd

KEY:

Feed = Supply reservoir for both Control and Reactive Columns

Control = Exit (top) concentration from column filled with 100% sand

Reactive = Exit (top) concentration from column filled with reactive materials in sand

nd = non-detect (25 ppb) for zinc

nr = no meaningful analytical result

AR324775

**Newport South Landfill
Barium and Zinc Removal Column Tests**

Date	Run Day	Barium Water Columns (from well RDW-2)					
		Feed		Control		Reactive	
		Ba ppb	Zn ppb	Ba ppb	Zn ppb	Ba ppb	Zn ppb
3-18	2	496,000	nd	214,000	nd	1,110	nd
3-19	3	518,000	nd	473,000	nd	1,100	nd
3-20	4	551,000	nd	509,000	nd	800	nd
3-21	5	601,000	nd	464,000	nd	1,000	nd
3-22	6	600,000	nd	564,000	nd	328	nd
3-23	7	417,000	nd	475,000	nd	344	nd
3-24	8	293,000	nd	281,000	nd	446	nd
3-25	9	421,000	nd	418,000	nd	609	nd
3-26	10	430,000	nd	377,000	nd	617	nd
3-27	11	441,000	nd	416,000	nd	661	nd
3-28	12	402,000	nd	363,000	nd	1,000	nd
3-30	14	426,000	nd	439,000	nd	1,160	nd
3-31	15	513,000	nd	546,000	nd	1,190	nd
4-3	18	617,000	nd	381,000	nd	1,000	nd
4-5	20	587,000	nd	549,000	nd	863	nd
4-7	22	392,000	nd	448,000	nd	692	nd
4-10	25	348,000	nd	348,000	nd	824	nd
4-12	26	372,000	nd	395,000	nd	824	nd
4-14	29	420,000	nd	nr	nd	nr	nd

KEY:

Feed = Supply reservoir for both Control and Reactive Columns

Control = Exit (top) concentration from column filled with 100% sand

Reactive = Exit (top) concentration from column filled with reactive materials in sand

nd = non-detect (25 ppb) for zinc

nr = no meaningful analytical result

AR324776

**Newport South Landfill laboratory Column Test
Full Metals Analysis, ppb**

Run Day 9

	Zinc Water			Barium Water		
	Feed	Control	Reactive	Feed	Control	Reactive
Na	54,345	83,379	83,349	8,218	10,526	11,300
Mg	18,393	30,026	27,821	118	<10	<10
Al	<10	19	17	<10	<10	20
K	4,875	6,363	6,480	300,088	33,456	33,863
Ca	69,008	65,235	606,986	7,058	8,726	592,178
Mn	114	<10	583	<10	<10	<10
Fe	<10	408	3,646	<10	<10	3,381
Ni	12	<4	22	<4	<4	19
Cu	<4	57	<4	<4	<4	<4
Cd	15	<4	<4	<4	<4	<4
Pb	<4	<4	<4	<4	<4	<4

Run Day 20

	Zinc Water			Barium Water		
	Feed	Control	Reactive	Feed	Control	Reactive
Na	41,450	66,207	67,420	7,699	11,193	11,984
Mg	15,252	22,040	23,177	153	<10	<10
Al	<10	15	<10	<10	<10	32
K	4,094	5,459	5,627	34,252	40,116	40,084
Ca	52,190	51,919	599,024	7,553	8,304	581,750
Mn	62	<10	209	<10	<10	<10
Fe	375	299	3,613	<10	<10	3,436
Ni	11	<4	19	<4	<4	19
Cu	<4	<4	<4	<4	<4	<4
Cd	<4	<4	<4	<4	<4	<4
Pb	<4	<4	<4	<4	<4	<4

AR324777

Wall Life Projections

Four components control wall life. Permeability maintenance, addressed above, was determined to be good. Gypsum levels must be adequate for both barium removal and to accommodate losses due to solubility in the effluent water. Iron levels must be adequate for removing zinc. The column tests were a definitive physical demonstration that all four parameters were more than adequate and would perform together as a whole.

The key to wall life projections is the amount of groundwater which will pass through the wall, requiring treatment. This groundwater flow is controlled by the nature of the landfill cap, and wall life was projected for different landfill cap configurations. The cap/infiltration performance was calculated using the HELP (Hydrologic Evaluation of Landfill Performance) Model. The table below shows rainwater infiltration rates to the landfill through the cap, the corresponding wall fluxes, the field years simulated by each day of laboratory operation, and the wall life projected after 29 days of laboratory column operation. These cases represent a wall only eight inches thick, the length of our active column. In practice, the wall will be two or three feet thick, thus giving an additional life factor of at least three times the lifetimes given below.

Cap Case	Infiltration Rate, in. H₂O/yr	Wall Flux, cm³/cm²/day	Field Years/ Lab Day	Wall Life, Years
Current Conditions (3 ft. soil) [base case -- no cap]	6	1.24	.054	1.5
Asphalt (4 in.) + Stone (8 in.)	0.1	.0207	3.27	90
Soil (18 in.) + Bentomat	0.02	.00413	16.4	450

Field Well-Column Test

As a final technology demonstration, we employed a significant new in-situ field test methodology that has been demonstrated by the U.S. EPA and DuPont. A 12-inch diameter column of the PRW sand:gypsum:ZVI mix was emplaced in the ground in the presence of contaminated groundwater. Central in the column was a one-inch monitoring well. Metals removal was determined by sampling the core water that had passed through six inches of reactive material. Accelerated wall life was simulated by drawing water from the central well. The results of this test further validate the laboratory projections. Detailed results of this field pilot are reported separately.

Acknowledgements

This program was carried out in conjunction with numerous people in DuPont's Corporate Remediation Group and Woodward Clyde Diamond, and Noel Scrivner of DuPont Engineering Technology.

The analytical services for this program were performed by the DuPont Corporate Center for Analytical Sciences. The primary CCAS personnel involved were Jane Ramsey and Mark McElwee.

The R&D program was performed by William Bazela and John Wilkens, of DuPont Central Research & Development.

A-2

BASIC DATA REPORT FOR MANGANESE TREATMENT

AR324780

December 15, 2000

To: P. Brandt Butler
CRG/WCD

From: John A. Wilkens
CR&D

Newport South Landfill:
Manganese Removal from Groundwater:
Laboratory Development of Data for
Permeable Reactive Barrier

Summary

This document summarizes our work demonstrating the removal of manganese from Newport South Landfill groundwater. Previous laboratory studies and field tests have demonstrated the viability of a permeable reactive barrier (PRB) for the removal of other metals of concern, most notably barium and zinc. The laboratory portions of this technology were summarized in my memo of June 28.

Those previous studies achieved removal of all metals to EPA-specified levels except for manganese. Subsequent laboratory batch tests have demonstrated excellent manganese removal by the addition of magnesium carbonate (hydromagnesite mineral) to the PRB mix. Laboratory column studies and field tests are under way to confirm the batch results presented here.

Permeable Reactive Barrier — Technical Basis for Manganese Removal

Previous work demonstrated the simultaneous removal of barium and zinc from groundwater using gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and zero-valent iron, respectively, in standard mortar sand from DelDOT, with a weight ratio:

Sand : Gypsum : ZVI = 100 : 20 : 5.

The presence of zero-valent iron in the PRB mix is believed to have made the groundwater more reducing, thereby creating more-soluble Mn^{+2} from the relatively insoluble Mn^{+4} . Various materials were investigated for suppressing manganese solubility. Great laboratory success was found using a form of magnesium carbonate closely related to its mineral hydromagnesite ($4\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 4\text{H}_2\text{O}$). This will subsequently be referred to as simply magnesium carbonate.

AR324781

Laboratory Batch Tests -- Results

Laboratory procedures are as presented in the June 28 memo.

Barium-rich and zinc-rich groundwaters were independently spiked with MnCl_2 to give approximately 20,000 ppb of manganese. In separate tests, the waters were then all treated with the initial wall mixture of "sand : gypsum : iron : : 100 : 20 : 5." To this mixture, MgCO_3 was added in a series of batch runs analogous to those of our other studies. Manganese solubility was dramatically decreased at even the lowest levels of MgCO_3 addition. Even with the initial MgCO_3 addition, manganese was below the required 1,000 ppb. No adverse effects were observed on the removal of other metals.

Manganese Concentration (ppb) of the Initial MgCO_3 Levels		
MgCO_3 "Weight Ratio"	Barium-rich groundwater (Run 126115-151)	Zinc-rich groundwater (Run 126115-159)
0	18,700	15,800
.8	477	260
1.6	186	115
3.2	141	100 (dl)
6.3	100 (dl)	100 (dl)
* MgCO_3 "Weight Ratio" is the weight with respect to sand, i.e.: sand : gypsum : iron : MgCO_3 : : 100 : 20 : 5 : WR		

Based on these results, a magnesium carbonate weight ratio of five has been chosen for the reactive barrier composition, giving a total PRB composition of:

sand : gypsum : iron : MgCO_3 : : 100 : 20 : 5 : 5.

Laboratory run sheets for the above runs follow. They give full details of the experimental conditions and the concentrations of metals found at all levels of magnesium carbonate addition.

AR324782

Bottle vol (cc) = 100
 Material mix density (g/cc) = 2.96
 Mix wt. Fract. CaSO₄ =
 Mix wt. Fract. XYZ = 1.000

Component XYZ: MaCO3

Calculation Date: 9/26/2000 By: JAW
 Lab Prep Date: 10/19/2000 By: WBB
 Notebook Number – Page: E98123-151 XL Tab: O

[illegible]

Data Updated: 12/13/2000

Notes:

Wt. Ratio, Mix / Water	g/g	Input data
Wt of Matti mix	g	= BotVol * RhoM / (1+RhoM / (Ratio*RhoW))
Wt. CaSO4	g	= Wt Mix * Mix wt. Fract. CaSO4
Wt. Xyz	g	= Wt Mix * Mix wt. Fract. Xyz
Wt. Water	g	= Wt Mix / Wt. Ratio
Vol of Matti Mix	cc	= Wt Mix / Mix Density
Vol of Water	cc	= Wt Water / Density of water
Total Vol	cc	= Vol Mix + Vol Water

"Water" is NSL RDW-2 water, spiked to 20 ppm Mn with MnCl₂

MgCO₃ from R & H
Nitrogen blanket all bottle headspaces
Samples for analytical filtered through 0.45 um filter
Samples #2 through 8 have the wall mix of 50 g sand,
10 g CaSO₄.2H₂O, and 2.5 g Fe
Sand = Del DOT Mortar sand; Fe = Peerless -8+50
"CaSO₄" is CaSO₄.2H₂O from ISG Resources (DuPont, Richmond)
Tumbler contact time = 24 hours for all samples
Sample 1 is a control; the formulas do not apply.

Vol of H₂O Vol of V₂O₅ Total Vol

24783 JAW

Newport South Landfill -- Manganese Removal -- MgCO₃ using Ba Water
Run Summary -- p. 2

Calculation Date: 9/26/2000 Notebook Number -- Page: E98123-151
Lab Prep Date: 10/19/2000 Component XYZ: MgCO₃

Smpl No.	Metal Concentrations, ppb											
	Ba	Zn	Al	Cd	Ca	Cu	Fe	Pb	Mg	Mn	Ni	K
1	180,000	int.*	100	100**	7,000	100**	100	100**	70,000	18,700	100**	29
2	185	int.*	100	100**	441,000	100**	169	100**	769,000	477	100**	52
3	100	int.*	100	100**	464,000	100**	123	100**	1,063,000	186	100**	59
4	100	int.*	100	100**	446,000	100**	100	100**	1,120,000	141	100**	54
5	100	int.*	100	100**	447,000	100**	100	100**	1,126,000	100	100**	57
6	100	int.*	100	100**	421,000	100**	119	100**	1,500,000	100	100**	56
7	100	int.*	100	100**	634,000	100**	100	100**	2,710,000	100	100**	60
8	208	int.*	100	100**	620,000	100**	3,600	100**	15,000	9,300	100**	53
9												

J. A. Wilkens, W. B. Bazela rev. 12/13/2000

* interferences prevented zinc analyses; however, zinc is never found in "barium water"

** 100 ppb detection limit in run analysis, however:

Cd, Cu, and Pb were all less than detection limit of 4 ppb in subsequent analysis, consistent with previous work

AR324784

Newport South Landfill -- Manganese Removal -- MgCO3 using Zn Water

Bottle vol (cc) = 100
 Material mix density (g/cc) = 2.96
 Mix wt. Fract. CaSO4 =
 Mix wt. Fract. XYZ = 1.000

Component XYZ: **MgCO3**

Calculation Date: 9/26/2000 By: JAW
 Lab Prep Date: 11/28/2000 By: WEBB
 Notebook Number -- Page: E98123-154 XL Tab: P

Target						Laboratory Run								
Wt Rto Mx/Wtr	Wt % Mix	Wt. Mix g	Vol. Mix cc	Vol. Wtr cc	Total Vol cc	Smpl No.	Wt. CaSO4		Wt. XYZ		Wt. Water		pH at End of Run	
							Target g	Actual g	Target g	Actual g	Target g	Actual g		Meter
0.000	0.00	0.00	0.00	100.00	125	1	0.00	0.00	0.000	0.000	100.00	100.00	7.5	
0.004	0.40	0.40	0.13	99.87	100	2	Samples 2 to 8		0.399	0.405	99.87	98.80	8.6	
0.008	0.79	0.80	0.27	99.73	100	3	contain wall		0.798	0.799	99.73	99.7	9.0	
0.016	1.57	1.59	0.54	99.46	100	4	mix as per notes		1.591	1.595	99.46	100.2	9.2	
0.032	3.10	3.17	1.07	98.93	100	5	below.		3.166	3.167	98.93	99.3	9.4	
0.064	6.02	6.28	2.12	97.88	100	6	(& lab sheet P&Q)		6.265	6.261	97.88	97.8	9.5	
0.128	11.35	12.27	4.15	95.85	100	7			12.269	12.269	95.85	95.8	9.6	
0.000	0.00	0.00	0.00	125.00	125	8			0.000	0.00	100.00	100	7.7	

Data Updated: 12/13/2000

WHERE:

Wt. Ratio, Mix / Water
 Wt of Matt mix
 Wt. CaSO4
 Wt. Xyz
 Wt. Water
 Vol of Matt Mix
 Vol of Water
 Total Vol

g/g
 g
 g
 g
 g
 cc
 cc
 cc

Input data
 = Botvol * RhoM / (1+RhoM / (Ratio*RhoW))
 = Wt Mix * Mix wt. Fract. CaSO4
 = Wt Mix * Mix wt. Fract. Xyz
 = Wt Mix / Wt. Ratio
 = Wt Mix / Mix Density
 = Wt Water / Density of water
 = Vol Mix + Vol Water

Notes:

"Water" is NSL RDW-1 water, spiked to 20 ppm Mn with MnCl2 and 1 ppm of additional Zinc
 MgCO3 from WC&D, NSL Pilot supply
 Nitrogen blanket all bottle headspaces
 Samples for analytical filtered through 0.45 um filter
 Samples #2 through 8 have the wall mix of 50 g sand, 10 g CaSO4.2H2O, and 2.5 g Fe
 Sand = NP Pilot Mortar sand; Fe = Peerless -8+50 Shiny NP Pilot
 "CaSO4" is CaSO4.2H2O from ISG Resources (DuPont, Richmond)
 Tumbler contact time = 24 hours for all samples
 Sample 1 is a control; the formulas do not apply.

JAW

AR324785

Newport South Landfill -- Manganese Removal -- MgCO3 using Zn Water
Run Summary -- p. 2

Calculation Date: 9/26/2000
Lab Prep Date: 11/28/2000

Notebook Number -- Page: E98123-154
Component XYZ: MgCO3

Smpl No.	Metal Concentrations, ppb										
	Ba	Zn	Al	Cd	Ca	Cu	Fe	Pb	Mg	Mn	Na
1	56,400	1,210	100	4	71,000	4	100	4	17,800	15,800	53,000
2	100	25	100	4	632,000	4	100	4	748,000	260	55,900
3	100	25	100	4	636,000	4	100	4	1,132,000	115	60,800
4	100	25	100	4	702,000	4	100	4	1,534,000	100	56,400
5	100	25	100	4	669,000	4	100	4	1,720,000	100	54,900
6	100	25	100	4	656,000	4	100	4	1,905,000	100	58,500
7	100	25	100	4	474,000	4	100	4	1,705,000	100	57,700
8	100	25	100	4	1,064,000	4	6,070	4	22,500	5,920	56,500
9											

J. A. Wilkens, W. B. Bazela rev. 12/13/2000

AR324786

Laboratory Column Tests

Continuous-flow column tests have begun, to determine the performance over time of the new reactive wall mix (100 : 20 : 5 : 5) on the South Landfill groundwaters. The two independent tests use barium-rich and zinc-rich waters. The zinc water comes from the new (November 2000) zinc control well where cuttings were used for backfill. This should give us a good source of zinc without any effects of control sand. The barium water comes from RDW-2 as in our previous work, and should give us the highest possible barium feed concentrations.

The laboratory apparatus and procedures follow the descriptions in the June 28 memo.

Wall Life Projections

Wall life projections will be made on the same basis as described in the June 28 memo, with one significant difference. The landfill cap will be changed from the previous Bentomat cap to a 40-mil HDPE cap. This will further decrease the rainfall infiltration by a factor of ten. This leads to a flow through the PRB of only ten percent of that used in earlier wall life calculations, and hence to a laboratory simulation rate of 160 wall-life-projection years per day of lab operation (vs. 16 years/day in June).

Wall life will not be limited by magnesium carbonate losses due to solubility in groundwater passing through the PRB. Based on such solubility losses, the wall life would be tens of millennia.

Field Reactive-Well-Column Test

A field test to confirm the laboratory results is also beginning, under the leadership of Rusty Kahl. This will follow the protocols of the previous field trial, with the addition of a third well. The additional well was back-filled with the original drilling cuttings to give us a benchmark and supply of water unaffected by any PRB materials, including the sand controls.

Acknowledgements

This program was carried out in conjunction with numerous people in DuPont's Corporate Remediation Group, the URS Diamond Group, and Noel Scrivner of DuPont Engineering Technology.

Analytical services were performed by the DuPont Corporate Center for Analytical Sciences under the direction of Jane Ramsey.

The R&D program was performed by William Bazela and John Wilkens, of DuPont Central Research & Development.

AR324787

AR324788

APPENDIX B

PRB IN-SITU FIELD DATA

AR324789

Appendix B – Field Investigations Table of Contents

Appendix B.1 – Geoprobe Investigation

- Figure B.1 Field test locations
- Figure B.2 Cross-section A-A'
- Figure B.3 Cross-section B-B'

Geoprobe Field Logs

Appendix B.2 – Permeable Reactive Barrier In-Situ Test Boring Results

Figure B.4 Permeable Reactive Barrier Test Boring

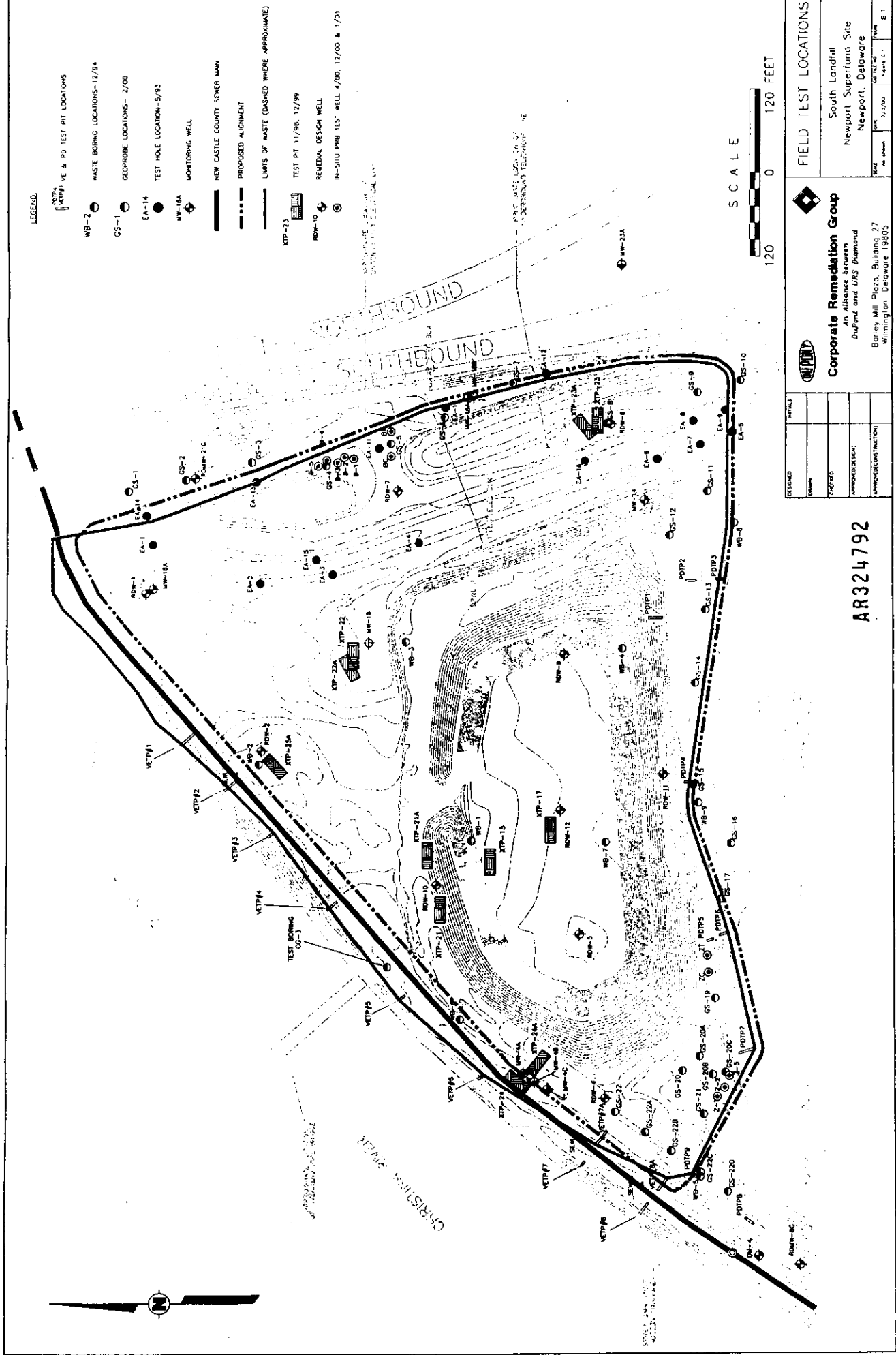
- Table B.1 Simulated Wall Life Calculations
- Table B.2 Zinc-Rich Control Well: Soil Cuttings
- Table B.3 Zinc-Rich Control Well: Mason Sand
- Table B.4 Zinc-Rich PRB Material Well: 5 Wt. Parts MgCO_3
- Table B.5 Barium-Rich Control Well: Soil Cuttings
- Table B.6 Barium-Rich Control Well: Mason Sand
- Table B.7 Barium-Rich PRB Material Well: 5 wt. parts MgCO_3
- Table B.8 Barium-Rich PRB Material Well: 5 wt. parts MgCO_3 ,
Rotosonic Installed
- Table B.9 Barium-Rich PRB Material Well: 15 wt. parts MgCO_3 ,
Rotosonic Installed

AR324790

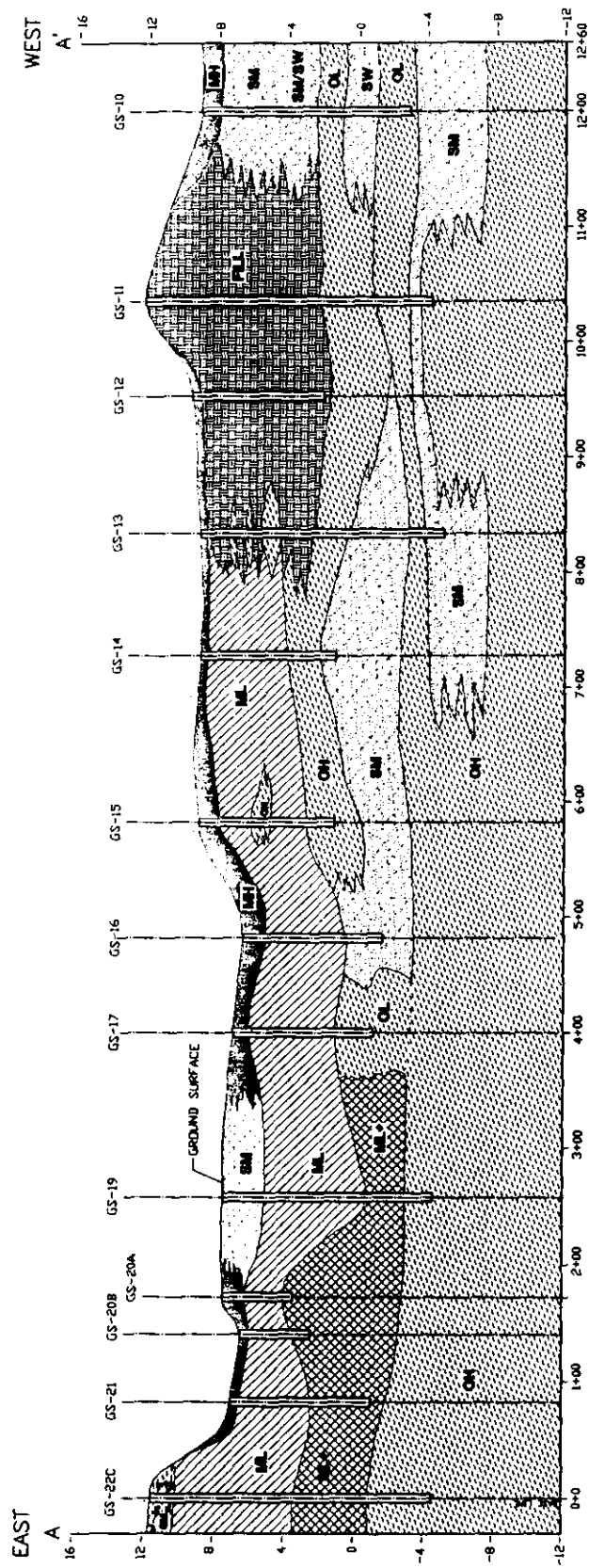
APPENDIX B.1

GEOPROBE ® INVESTIGATION

AR324791



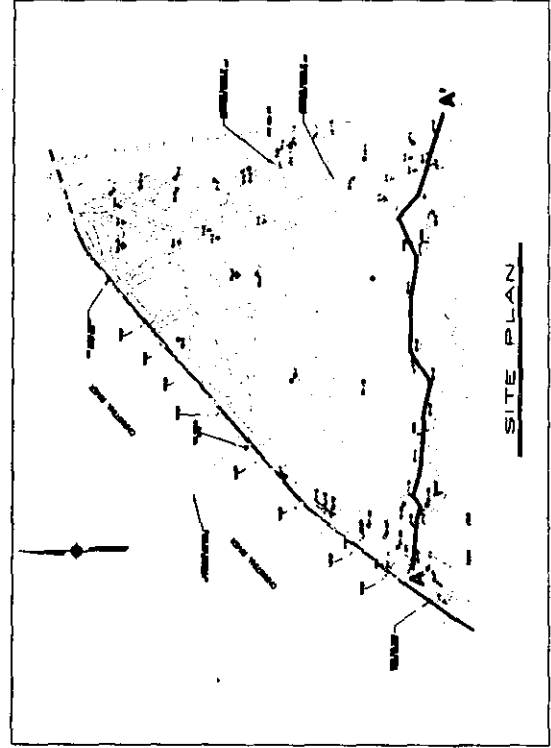
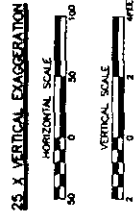
DESIGNED	DATE	BY	REVISION



SECTION A-A'

LEGEND

- [Pattern] = FILL
- [Pattern] = (ML) SILT
- [Pattern] = (MH) SILT OF HIGH PLASTICITY, ELASTIC SILT
- [Pattern] = (CL) OR ORGANIC SILT, ORGANIC CLAY MARSH DEPOSIT
- [Pattern] = (ML) SILT, SILTY SAND AND BARITE ORE WASTE
- [Pattern] = (GH) SILTY GRAVEL
- [Pattern] = (SV, SW) WELL-GRADED SAND, FINE TO COARSE SAND, SILTY SAND



SITE PLAN

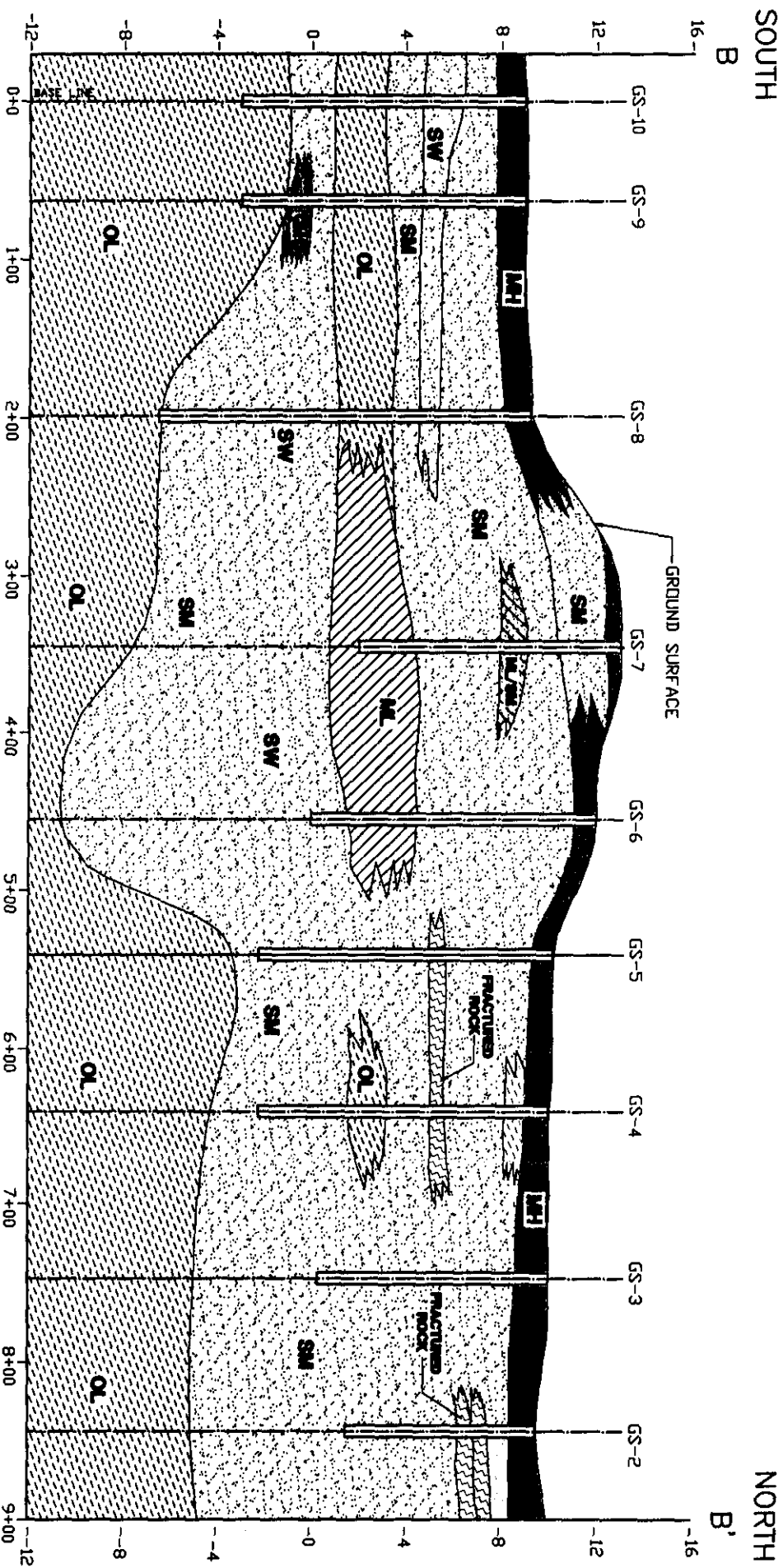
AR324793

Corporate Remediation Group
 1000 Corporate Center Drive
 Newark, Delaware 19702
 (302) 836-1000

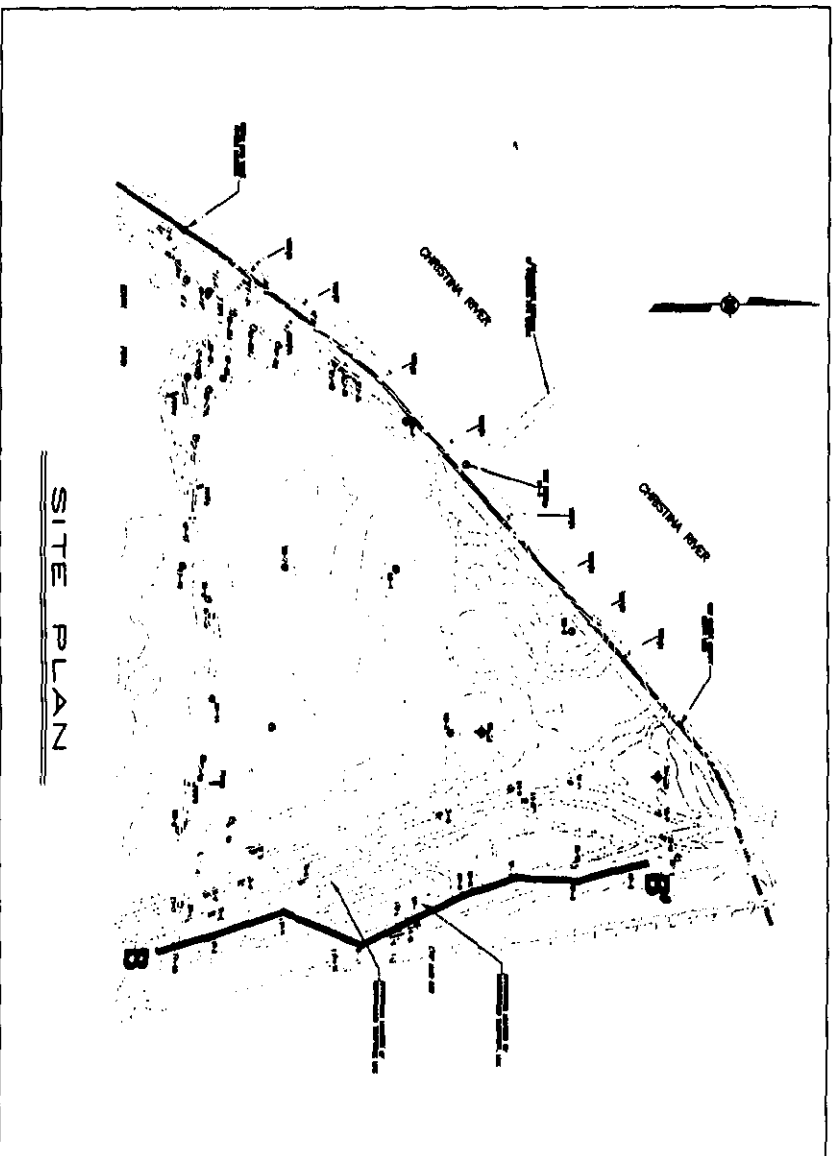
CROSS SECTION A-A'

DuPont Newport Facility
 South Landfill
 Newport, Delaware

Revised: 04/18/2000
 Drawn by: CS-1
 Scale: 8.2



SECTION B-B'



SITE PLAN

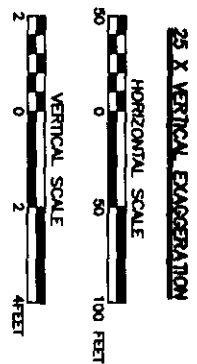
NORTH
B'

LEGEND

- [Hatched pattern] = FRACTURED ROCK
- [Diagonal lines] = (ML) SILT
- [Solid black] = (HML) SILT OF HIGH PLASTICITY, ELASTIC SILT
- [Dotted pattern] = (OL) ORGANIC SILT, ORGANIC CLAY MARSH DEPOSIT
- [Cross-hatched] = (ML/SM) SILT, SILTY SAND
- [Stippled pattern] = (GM) SILTY GRAVEL
- [Pattern with dots and lines] = (SW, SM) WELL-GRADED SAND, FINE TO COARSE SAND, SILTY SAND

NOTES

DEPTH TO MARSH DEPOSIT DATA FROM:
PRELIMINARY ENVIRONMENTAL INVESTIGATION
DELDOT BASIN ACCESS ROAD
NEWPORT SUPERFUND SITE, NEWPORT, DELAWARE.
PREPARED BY: E.A. ENGINEERING, SCIENCE AND
TECHNOLOGY, AUGUST 1993.



Corporate Remediation Group

An Alliance Between
DuPont and The W-C Diamond Group

Barley Mill Plaza, Building 27
Wilmington, Delaware 19860-0027

CROSS SECTION B-B'

DuPont Newport Facility
South Landfill
Newport, Delaware

DESIGNED	INITIALS
DRAWN	
CHECKED	
W.R.K.	
APPROVED (Geology)	
APPROVED (Construction)	

AR324794

LOG OF BORING NO. GS-1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
						DESCRIPTION		
				20"		6" top soil - dark brown w/organics		
						6" sand & soil - brown to dark brown		
						6" gravel & sand - light brown		
						4" black sandy material		
	4			24"		4" black sandy material		
						14" wood		
	8					6" wet, medium tan		
				24"		12" tan sandy silt		
						12" medium gray silty sand		
	12							
	16							
	20							
	24							
	28							
	32							

PROJECT NO.: 44DINE 7105.2K
 DATE BEGAN: 2/23/00 9:55
 DATE COMPLETED: 2/23/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: _____

GWL DEPTH _____ DATE/TIME _____
 GWL DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe with
4ft. sleeves

NOTES:
 All descriptions are
 visual only - cores were
 not removed from
 plastic sleeves

AR324795

LOG OF BORING NO. GS-2

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						SURFACE EL: _____		
						DESCRIPTION		
						Dark brown - orange brown, clayey SILT w tr. c-f sand & organics		
						7" Lt gray, silty F-C SAND w some f. gravel		
						12" Orange brown - Dark orange brown F-C SAND w some silt & f. gravel layers		
						14" 18" - Lt. gray rock fragment layer		
					42"	22" - 24" - Dark brown rock fragment layer		
						30" Orange brown w gray, silty c-f SAND w some c-f gravel & clay		
						48" Orange brown, clayey c-f SAND w some silt & f. gravel		
						72" Dark greenish gray, clayey SILT w some c-f sand, & tr. organics		
						84"		

AR324796

PROJECT NO.: Newport SLF
DATE BEGAN: 2/23/00
DATE COMPLETED: 2/23/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH 0 DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/4 ft
Sleeves

NOTES:
Hardy Env. drillers

LOG OF BORING NO. GS-2

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 5-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						Greenish Gray, silty C-F SAND w/tn clay & organics			
						Greenish gray, silty CLAY w/tn C-F sand, organic			
						- ASPHALT PEBBLE (5.1" thick)			
	8					END of SAMPLE			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324797

Field Log

LOG OF BORING NO. GS-3 $\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622614</u> E <u>602236</u> SURFACE EL: _____		
						DESCRIPTION		
						Dark brown, SILT w some clay & tr. f. gravel. high organic content (MH)		
	1					16" greenish gray, f. gravelly c-f SAND w tr. silt (SM/SW)		
	2			36"		21" Dark orange brown SAA		
	3							
	4					48" Dark orange brown, silty c-f SAND w some f. gravel & tr. clay (SM)		
	5							
	6			36"		72" Dark greenish gray, silty c-f SAND/ c-f sandy SILT w tr. f. gravel & clay (SM/ML)		
	7					84"		

PROJECT NO.: Newport SLFDATE BEGAN: 2/23/00DATE COMPLETED: 2/23/00FIELD GEOLOGIST: R. KahlCHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD:

Geoprobe w/ 4 ft. sleeves

NOTES:

Driller: Hardy Env.

AR324798

LOG OF BORING NO. 65-3

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						Dark greenish gray / Dark orange brown silty m-F SAND / m-F sandy SILT w some clay, organic (SM/ML)			
	8					96"			
						Dark orange brown, silty c-F SAND w tr. f. gravel & clay, very wet w mica (SM)			
	9					108"			
						Dark greenish gray ~~sandy~~ c-F sandy SILT, tr. f. gravel & organic & clay (ML)			
	10				24"	120"			
						Dark greenish gray, m-F sandy SILT w tr. f. gravel, s. sand, & clay, organic (OL)			
	11					132"			
						Orange brown w dark greenish gray mass, silty f. SAND w some m. sand & tr. f. gravel, c. sand & clay (SM)			
	12					144"			
						- 1/2" layer of asphalt on bottom			
						END OF SAMPLE @ 12'			
						9.5' WRK from field notes			

→ refusal at
9.5 ft

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324799

$$\frac{1}{2}$$
$$\frac{1}{2}$$

F-188 BORING NO. SHEET OF

LOG OF BORING NO. GS-4

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	8					Dark gray, ~~sandy~~ SILT, highly organic w tr. clay & f. gravel (OL) 96"			
	9					SAA _____ 100" orange brown - dark orange brown silty m. F SAND w tr. clay, c. sand & f. gravel (SM)			
	10			44"		_____ 126" Orange brown - light red brown, silty m. F SAND / m. F sandy CLAY w some silt (SC/SM)			
	11								
	12					_____ 144" END of sample @ 12'			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324801

Field Log

LOG OF BORING NO. GS-5

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N <u>622413.7</u>	E <u>602261.5</u>		
						SURFACE EL: _____			
						DESCRIPTION			
						Dark brown, m. f. sandy SILT, w. tr. clay, c. sand, & f. gravel (ML) w. tr. organics — 3'			
	1					Orange brown - dark orange brown, silty f. SAND / f. sandy SILT w. some m. sand & tr. f. gravel, c. sand, & clay (SM/ML)			
	2			46"					
	3								
	4					SAA — 48"			
	5					— 2" layer of quartz rock fragments — 60"			
	6			44"		Orange brown, silty f. sand w. some medium sand, tr. f. gravel, c. sand & clay (SM)			
	7					84"			

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/23/00
 DATE COMPLETED: 2/23/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Env.

AR324802

LOG OF BORING NO. 65-5

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						orange brown, silty m-f. SAND tr. c. sand & f. gravel (sm)			
	8					SAA, tr. clay (sm) 98"			
	9								
	10			30"		Dark orange brown, c-f. SAND, w/ some f. gravel & silt (sw/sm) 120"			
	11					Dark Gray/Black SAA (sw/sm) 138"			
	12					END OF SAMPLE @ 12' 144"			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324803

Field Log

LOG OF BORING NO. GS-6

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622336.3</u> E <u>602298.8</u> SURFACE EL: _____		
						DESCRIPTION		
						Dark Brown-Gray, Sandy SILT w some clay & c-f gravel, high organic content (ML/SM) ——— 6"		
	2			44"		Orange brown w some light gray layers, silty c-f SAND w some f. gravel & rock fragments, tr. clay (SM)		
	4					————— 48"		
	5					Orange brown, light. gray, silty m-f SAND / m-f sandy SILT w some c-sand, tr. f. gravel & clay (SM/ML)		
	6			46"				

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/23/00
 DATE COMPLETED: 2/23/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:

Driller: Hardy Environmental

AR324804

LOG OF BORING NO. GS-6

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					96" Light gray - blueish gray, clayey SILT w some c-f. sand, tr. f. gravel (ML)			
	9								
	10			44"		120" Light orange brown - dark orange brown, c-f. SAND w some s. lt, tr. f. gravel, & clay (SM)			
	11								
	12					END of Sample @ 12'			

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

AR324805

LOG OF BORING NO. GS-7

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622237.8</u> E <u>602347.1</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Gray, blueish gray, c-f sandy SILT w some f. gravel (ML)		
	2			40"		Orange brown, silty m-f SAND w some tr. f. gravel & c. sand (SM)		
	3					Blueish gray, c-f sandy SILT w some f. gravel (ML)		
	4					Orange brown - dark orange brown, m-f sandy SILT/ silty m-f SAND w tr. c. sand, f. gravel. (ML/SM)		
	5					SAA, tr. clay (ML/SM)		
	6			41"		Orange brown, silty m-f SAND w tr. c. sand & f. gravel (SM)		
	7					Lt. gray - orange brown, silty m-f SAND/ m-f sandy SILT w some f. gravel & tr. clay & c. sand (ML/SM)		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kahi
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4ft sleeves

NOTES:
driller: Hardy Ew.

AR324806

LOG OF BORING NO. GS-72/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SIAA			
	8					<u>96"</u> Orange brown, silty m-f SAND/ m-f sandy SILT w/ some f. gravel + tr. c. sand & clay, wet (ML/SM)			
	9								
	10			36"		<u>114"</u> Brown-orange brown, m-f sandy SILT w/ tr. f. gravel, c. sand & clay (ML)			
	11					<u>132"</u> END of SAMPLE @ 11'			
	12								

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

AR324807

Field Log

LOG OF BORING NO. GS-8

1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622103.7</u> E <u>602288.9</u> SURFACE EL: _____		
						DESCRIPTION		
						Dark brown, SILT w some clay & tr. c-f sand, high organic content (MH)		
	1					10" Dark orange brown - orange brown silty m-f SAND w tr. f. gravel & c. sand (SM)		
	2			40"				
	3					40" Dark orange brown, f. gravelly c-f sand w some tr. silt (SW/SM)		
	4					48" Orange brown, silty m-f SAND w tr. f. gravel & c. sand (SM)		
	5							
	6			20"		72" Dark greenish gray, Dark brownish gray silty CLAY/clayey SILT w tr. f. gravel & c-f sand. Very highly organic (OH/OL)		
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kah
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Env.

AR324808

LOG OF BORING NO. 65-82/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 96"			
	9					Dark orange brown, f. gravelly C-F SAND w tr.s: lt. (SW)			
	10			6"					
	11								
	12					_____ 144"			
						SAA _____ 150"			
	13					Dark orange brown, silty C-F SAND w some f. gravel, tr.cky (SM)			
	14			44"					

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

AR324809

Field Log

LOG OF BORING NO. GS-8

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	15					SAA			
	16					174' Grayish Brown, F. sandy SILT w/ some clay & tr. fine gravel & m-f sand (ML)			
						192" END of SAMPLE @ 161			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324810

LOG OF BORING NO. GS-91/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						SURFACE EL: _____		
						DESCRIPTION		
	1					Dark Brown clayey silt w/ tr. c.f. sand & f. gravel, high organic content (MH) — 8"		
	2			40"		Orange brown, silty m-f SAND w/ tr. f. gravel, c. sand, & clay (SM)		
	3							
	4					Dark orange brown fine-grained c.f. SAND w/ tr. silt (SW) — 42" — 48"		
	5					SAA w/ some f. gravel & some silt (SM)		
	6			34"		Very dark gray-black, silty CLAY/clayey silt w/ tr. c. sand & f. gravel highly organic (OH/OL) — 72"		
	7							

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/24/00
 DATE COMPLETED: 2/24/00
 FIELD GEOLOGIST: R. Kohl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:

driller: Hardy env.

AR324811

Field Log

LOG OF BORING NO. GS-9

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 96" Orange brown C-F SAND w some f. gravel & tr. silt (SW)			
	9					_____ 108" Orange brown C-F sandy F. GRAVEL w tr. silt (GM)			
	10		24"			_____ 120" Very dark gray, clayey SILT w tr. C. sand, highly organic (OL)			
	11								
	12					_____ 144" END of SAMPLE @ 12'			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324812

LOG OF BORING NO. GS-10A

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
						DESCRIPTION		
	1					Brown, SILT w tr. f. gravel, c-f sand, & clay, w organics (MH)		
	2			40"		Orange brown, silty m-f SAND w tr. c. sand & f. gravel (SM)		
	3					Orange brown, c-f SAND w tr. f. gravel & silt (SW)		
	4					SAA w some silt		
	5			24"		~~Blackish~~ gray, clayey SILT w tr. c-f sand & f. gravel, with organics (OL)		
	6					END OF SAMPLE @ 6'		refusal at 6ft concrete in shoe

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/24/00
 DATE COMPLETED: 2/24/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe w/ 4ft sleeves.

NOTES:

driller: Hardy Env.

AR324813

Field Log

LOG OF BORING NO. GS-10 $\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621914.4</u> E <u>602349.3</u> SURFACE EL: _____		
						DESCRIPTION		
						Brown, SILT w tr. f. gravel c. f sand & clay, organics (MH)		
	1					12'		
	2			40"		Orange brown silty m-f SAND w tr. f. gravel & c. sand (SM)		
	3					36"		
	4					Orange brown c-f SAND w tr. f. gravel & silt (SW)		
	5					48"		
	6					SAA w some silt		
	7			36"		72"		
						Blackish gray, clayey SILT, w tr. f. gravel (rat fragments) high organic content (OH)		

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/24/00
 DATE COMPLETED: 2/24/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe w/4ft sleeves

NOTES:
 driller: Hardy Env.

AR324814

LOG OF BORING NO. GS-10

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 96" Orangebrown, c-f SAND w some f. gravel & tr. silt (SW)			
	9								
	10					_____ 120" Dark gray, clayey SILT w tr. c. sand & f. gravel, organics (OL)			
	11								
	12					_____ 144" END of BORING @ 12'			
	13								

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324815

LOG OF BORING NO. GS-11

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621961.3</u> E <u>602190.9</u> SURFACE EL: _____		
						DESCRIPTION		
	1					orange brown, clayey SILT/ silty CLAY w tr. f. gravel & C-f sand & organics		
	2			46"				
	3							
	4							
	5							
	6			40"				
	7							

PROJECT NO.: <u>Newport SLF</u>	GWL: DEPTH _____ DATE/TIME _____	NOTES:
DATE BEGAN: <u>2/29/00</u>	GWL: DEPTH _____ DATE/TIME _____	driller: <u>Hardy Env.</u>
DATE COMPLETED: <u>2/29/00</u>	DRILLING METHOD: _____	AR324816
FIELD GEOLOGIST: <u>R. Kahl</u>	<u>Geoprobe w/ 4 ft sleeves</u>	
CHECKED BY: <u>T. Campbell</u>		

LOG OF BORING NO. GS-11

2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 98"			
						SAA			
	9					_____ 106"			
						Brown, silty CLAY/clayey SILT w some c-f sand & tr. f. gravel & brick fragments (CL/CH)			
	10			40"					
	11					_____ 132"			
						Blackish Gray, silty CLAY w very high organic content (OH)			
	12					_____ 144"			
						SAA w tr. m-f. sand & Blackish gray, orangebrown, gray, & greenish gray in color high organic content			
	13								
	14								

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324817

LOG OF BORING NO. GS-11

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						- 3" thick layer of silty clayey f. SAND			
	15					Gray, silty CLAY = high organic content. 180"			
	16					END of SAMPLE @ 16'			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324818

LOG OF BORING NO. GS-12

$\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						SURFACE EL: _____		
						DESCRIPTION		
	1					Brown, clayey silt $\approx$ high organic content (MH) 3'		
	2			40"		orange brown, silty m-f SAND $\approx$ some c. sand (SM)		
	3					24'		
	4					Brown & gray, silty f. SAND / f. sandy SILT $\approx$ some tr. clay tr. m. sand (SM/ML)		
	5					48'		
	6			40"		Brown, silty f. SAND $\approx$ tr. c-m sand (SM)		
	7					60'		
						Brown - gray, f. sandy SILT / clayey SILT $\approx$ tr m-c sand & f. gravel (ML/CL)		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.
AR324819

$\frac{2}{2}$

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

NOTES:

AR324820

LOG OF BORING NO. GS-13

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621964.1</u> E <u>602021.3</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Brown clayey SILT w organics (MH) <u>2"</u> Light orange brown silty m-f SAND (SM)		
	2			28"		— layer of gray silty CLAY (2") — layer of gray silty CLAY (1")		
	3					<u>36"</u> Gray silty CLAY w some orangebrown silty m-f sand tr. organics (OH) <u>48"</u>		
	4					Light brown, silty f. SAND w tr. m. sand (SM)		
	5							
	6			36"		<u>72"</u> Dark gray clayey SILT w high organics w light gray m-f sand layers < 1/4" thick ≈ 5 per foot (OL)		
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Enr
AR324821

Field Log

LOG OF BORING NO. GS-13

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 96'			
	9								No sample taken 8-10 ft
	10			~~24"~~		Dark brown, silty CLAY tr. organics (CH/OH)			
	11					_____ 132"			
	12			24"		Gray, silty F. SAND tr. m. sand (SM)			
	13								
	14					END of SAMPLE @ 14' 168"			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324822

LOG OF BORING NO. GS-14

$\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N <u>621979</u>	E <u>601916.1</u>		
						SURFACE EL: _____			
						DESCRIPTION			
						Brown, silty CLAY w organics (MH) #			
	1					Dark brown clayey SILT w some f. sand tr. m. sand & f. gravel (ML)			
	2			40"					
	3					36" Brown - lt. brown, silty f. SAND f. ~~clay~~ sandy SILT tr. clay & m. sand. (ML/SM)			
	4					48" SAA			
	5					60" Dark Gray, clayey SILT tr. f. sand ~~clay~~ organic & micaceous (OL)			
	6			40"					
	7					84"			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324823

$$\frac{2}{2}$$

BORING NO.

LOG OF BORING NO. GS-15 $\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621981.9</u> E <u>601770.2</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Orange brown - Brown SILT w/ tr. clay & high organic content (MH) 12"		
	2			40"		Brown, clayey SILT w/ tr. m-f. sand (ML)		
	3					Dark gray, silty CLAY w/ high organic content (OH) 30"		
	4					Brown f. sandy SILT w/ some clay (ML-OL) 48"		
	5							
	6			24"		Dark gray, silty CLAY w/ some f. sand & organic content (OH) 72"		
	7							

PROJECT NO.: Newport SLFDATE BEGAN: 2/29/00DATE COMPLETED: 2/29/00FIELD GEOLOGIST: R. KahlCHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

Geoprobe w/ 4ft sleeves

NOTES:

driller: Hardy Environ.

AR324825

Field Log

 $\frac{2}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	8					SAA			
						END OF SAMPLE @ 8'		96"	

PROJECT NO.:
DATE BEGAN:
DATE COMPLETED:
FIELD GEOLOGIST:
CHECKED BY:

GWL: DEPTH DATE/TIME
GWL: DEPTH DATE/TIME
DRILLING METHOD:

NOTES:

AR324826

LOG OF BORING NO. GS-16

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621922.3</u> E <u>601698</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Brown-orange brown, f. sandy SILT w some clay & organic content (MH) 12"		
	2			46"		Brown-gray, clayey SILT w tr. c-f. sand, micaceous & with organic content (ML/MH)		
	3							
	4							
	5							
	6			24"				
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Environmental

AR324827

Field Log

F-188

BORING NO.
SHEET OF

LOG OF BORING NO. GS-17

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (N.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621943.1</u> E <u>601608.1</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Dark Brown, SILT w tr clay & c-f. sand (MH) 6"		
	2			18"		Dark gray, = rust brown, clayey SILT w organics (OL)		
	3							
	4							
	5					Dark Brown - Dark Gray, m-f sandy SILT w tr. organics (ML) 48"		
	6			32"				
	7					Dark gray, clayey SILT w high organic content (OL) 72"		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy env.
AR324829

Field Log

LOG OF BORING NO. GS-17

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	8					SAA			
						96"			
						END of Sample @ 8'			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324830

BORING NO.
SHEET OF

LOG OF BORING NO. GS-19

$\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621951.5</u> E <u>601463.9</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Orange brown, silty mf SAND w tr. c sand & f. gravel (SM) w tr. organics		
	2			44"		_____ 24" Brown, clayey SILT w tr. c-f sand & f. gravel (ML)		
	3							
	4							
	5					SAA		
	6			5"				
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324831

Field Log

LOG OF BORING NO. 65-19

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	8					SAA			
	9					SAA = Barite Ore Waste			
	10			40"		Dark gray, silty CLAY w/ organics (OH)			
	11								
	12					END of SAMPLE @ 12'			
	13								
	14								

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324832

LOG OF BORING NO. GS-20

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621998.2</u> E <u>601360.1</u> SURFACE EL: _____		
						DESCRIPTION		
						Dark Brown, SILT w/ tr. f. gravel & c-f sand, organic content (MH) w/ tr. clay. 8"		
	1					Brown - redish brown, SILT w/ some clay & organics, tr. c-f sand (ML/MH)		
	2			46"				
	3					Black, clayey SILT w/ tr. f. gravel (ML) (Barite ore waste)		
	4					48"		
	5					END of SAMPLE @ 4'		
	6							
	7							

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/29/00
 DATE COMPLETED: 2/29/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:

Filler: Hardy Env.

AR324833

Field Log

LOG OF BORING NO. GS-20A

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621973.7</u> E <u>601380.7</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Brown, silty CLAY w tr C-F sand & organic content (MH) 12"		
	2			46"		Brown, gray, red brown, tan, mixed colored clayey SILT w tr. m-f. sand (CL/ML)		
	3					Black clayey SILT w tr. f. sand (CL/ML) (Barite ore waste) 36"		
	4					END OF SAMPLE @ 4' 48"		
	5							
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL DEPTH _____ DATE/TIME _____
GWL DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Environ.

AR324834

LOG OF BORING NO. GS-20B

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621955.1</u> E <u>601354.7</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Brown, clayey SILT w/ organics (MH) 6"		
	2			46"		Brown, tan, gray, & red brown mixed colored, clayey SILT, layered (ML)		
	3					Black, clayey SILT w/ tr. f. sand & f. gravel (ML) (Barite ore waste)		
	4					END of SAMPLE @ 4'		

PROJECT NO.: Newport SLFDATE BEGAN: 2/29/00DATE COMPLETED: 2/29/00FIELD GEOLOGIST: R. KahlCHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

Geoprobe w/ 4 ft. sleeve

NOTES:

Driller: Hardy Env.

AR324835

LOG OF BORING NO. GS-20C1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621937.4</u> E <u>601357.7</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Brown, clayey SILT w organics tr. f.-c sand (MH) <u>6"</u>		
	2				18"	Brown, tan, w white & black mixed colored, clayey SILT w tr. f. sand (ML)		
	3							
	4					<u>48"</u> Black - dark gray, silty f. SAND (SM) (Barite Ore Waste)		
	5					<u>60"</u> Black - dark gray, clayey SILT w tr. f. sand		
	6				36"	(Barite Ore Waste)		
	7							

PROJECT NO.: Newport SLFDATE BEGAN: 2/29/00DATE COMPLETED: 2/29/00FIELD GEOLOGIST: R. KahlCHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

Geoprobe 7/4 ft sleeve

NOTES:

driller: Hardy Enw.AR324836

Field Log

LOG OF BORING NO. GS-20C

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	8								
						96"			
						END OF SAMPLE @ 8'			

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324837

LOG OF BORING NO. 65-21

$\frac{1}{2}$

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621968.3</u> E <u>601298.3</u> SURFACE EL: _____		
						DESCRIPTION		
						Brown, clayey SILT w/ organics (MH) 6"		
	1					Gray, brown, red brown, tan, clayey SILT (ML)		
	2							
	3							
	4					~~Black, clayey SILT, highly organic~~ 48"		
						with (Barite ore waste) (ML)		
	5					Dark gray silty w-f. SAND 54"		
						(SM) 60"		
	6					Dark gray - gray, clayey SILT, organic & micaceous (ML/OL) with Barite ore waste		
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4ft sleeves

NOTES:

driller: Hardy Environmental

AR324838

LOG OF BORING NO. GS-21

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	8					SAA			
						96" END of SAMPLE @ 8'			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324839

LOG OF BORING NO. 65-22

1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622093.4</u> E <u>601302.3</u> SURFACE EL: _____		
						DESCRIPTION		
						Blueish gray, silty F. GRAVEL (GM)		
	1					_____ 12"		
	2					Brown, clayey SILT w tr. c-f. sand & f. gravel (ML)		
	3							
	4					_____ 48"		
	5					Brown, SILT w same clay & tr c-f. sand & f. gravel (MH)		
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/28/00
DATE COMPLETED: 2/28/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe 7/4ft sleeves

NOTES:
driller: Hardy Env.

AR324840

LOG OF BORING NO. GS-22

2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					SAA			
	9					Gray, clayey SILT w tr. c-f sand & f. gravel, tr. organics (OL/ML/CL) (Possible trace of Barite ore waste)			
	10								
	11								
	12					Brown silty f. SAND w organics (SM)			
	13					SAA, w tr. Barite Ore Waste			
	14								

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324841

LOG OF BORING NO. 65-22 3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
						DESCRIPTION		
	15					SAA		
	16					END of SAMPLE @ 16" 192"		

PROJECT NO.: _____	GWL: DEPTH _____ DATE/TIME _____	NOTES: AR324842
DATE BEGAN: _____	GWL: DEPTH _____ DATE/TIME _____	
DATE COMPLETED: _____	DRILLING METHOD: _____	
FIELD GEOLOGIST: _____	_____	
CHECKED BY: _____	_____	

LOG OF BORING NO. GS-22A

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622050.5</u> E <u>601273.2</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Greenish Gray, silty f. GRAVEL w some c-f sand (GM)		
	2					Orange brown, f. sandy SILT w tr. clay, c-m. sand & f. gravel (ML) 24"		
	3					Red brown, silty CLAY/ clayey SILT w tr. c-f sand & f. gravel (ML/CL) 36"		
	4					Brown, clayey SILT w tr. c-f sand & f. gravel (CL/ML) 48"		
	5							
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/28/00
DATE COMPLETED: 2/28/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL DEPTH _____ DATE/TIME _____
GWL DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
Driller: Hardy Env.
AR324843

LOG OF BORING NO. 65-22A

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 96"			
	9					Gray f. sandy SILT w some clay (M2)			
	10					_____ 120"			
	11					Dark gray, silty CLAY ~ tr. f. sand with high organic content (04)			
	12					END of SAMPLE @ 12'			
	13								
	14								

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

AR324844

LOG OF BORING NO. GS-22B

1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>622014.5</u> E <u>601246</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Greenish Gray, silty F. GRAVEL w some c-f sand (GM)		
	2					Orange Brown, c-f sandy SILT w some f-gravel (ML) 24"		
	3					Brown - red brown, clayey SILT w tr. c-f sand & f-gravel 30" (ML)/(CL)		
	4					48"		
						SAA		
	5							
	6							
	7					Red Brown, silty CLAY w some m-f sand (CL/CH) 78"		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/28/00
DATE COMPLETED: 2/28/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4ft sleeves

NOTES:

driller: Hardy Env.
AR324845

LOG OF BORING NO. GS-22B

2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
						DESCRIPTION		
	8					- layer of orangebrown silty f. SAND 2 1" thick 96"		
	9					* missing sample		
	10							
	11							
	12					~~Dark gray-brown, silty m.f. SAND~~ Dark gray-brown, silty m.f. SAND w/ some f. gravel & tr. c. sand (SM) 156"		
	13					Dark greenish gray, clayey SILT organic (OL/OT)		
	14							

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324846

LOG OF BORING NO. 65-22B

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	15'					SAA			
	16'					192"			
						END of SAMPLE @ 16'			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324847

LOG OF BORING NO. GS-22C1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621972.9</u> E <u>601216.4</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Blueish Gray, silty f. GRAVEL w/ some c-f. sand (GM) - layer of rock fragments (<1") 12"		
	2					Brown - Gray, clayey SILT w/ tr c-f. sand & f. gravel (ML)		
	3							
	4							
	5							
	6							
	7							
						SAA	48"	

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/28/00
 DATE COMPLETED: 2/28/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe w/ 4ft sleeves

NOTES:

AR324848
 BORING NO.
 SHEET OF

LOG OF BORING NO. GS-22C

2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL. _____		
						DESCRIPTION			
	8					SAA			
	9					9 1/2" Gray w some brown, clayey SILT, organic (OL)			
	10								
	11								
	12					12 0" Gray w brown, silty CLAY w packets of clayey SILT, w some organics, micaceous (OH/OL)			
	13								
	14								

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324849

Field Log

LOG OF BORING NO. GS-22C

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	15					SAA			
	16					END of SAMPLE @ 16' 192"			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324850

BORING NO.
SHEET OF

LOG OF BORING NO. GS-22D

1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES	USCS SYMBOL	REMARKS
						N <u>621935.1</u> E <u>601188.1</u> SURFACE EL: _____		
						DESCRIPTION		
	1					Blueish gray, silty f. GRAVEL w/ c-f sand (GM) some		
	2					Brown - Gray, clayey SILT w/ organics (CL/ML/OL)		
	3							
	4					SAA, micaceous w/ tr c-f. sand		
	5							
	6							
	7							

PROJECT NO.: Newport SLF
 DATE BEGAN: 2/28/00
 DATE COMPLETED: 2/28/00
 FIELD GEOLOGIST: R. Kahl
 CHECKED BY: T. Campbell

GWL DEPTH _____ DATE/TIME _____
 GWL DEPTH _____ DATE/TIME _____
 DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
 driller: Hardy Env.

AR324851

LOG OF BORING NO. 65-22-D

2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
						SAA			
	8					_____ 76"			
	9					SAA			
	10					- Thin layer of fine gravel (<1") 120"			
	11					Gray - Dark gray, silty CLAY / clayey SILT w/ organics (OL/OH)			
	12					_____ 144"			
	13					SAA w/ tr. F. gravel & c-f. sand.			
	14								

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

NOTES:

AR324852

BORING NO.
SHEET OF

LOG OF BORING NO. 65-22D

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES		USCS SYMBOL	REMARKS
						N _____ E _____	SURFACE EL: _____		
						DESCRIPTION			
	15					SAA			
	16					END of SAMPLE @ 16' 196"			

PROJECT NO.: _____
 DATE BEGAN: _____
 DATE COMPLETED: _____
 FIELD GEOLOGIST: _____
 CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
 GWL: DEPTH _____ DATE/TIME _____
 DRILLING METHOD: _____

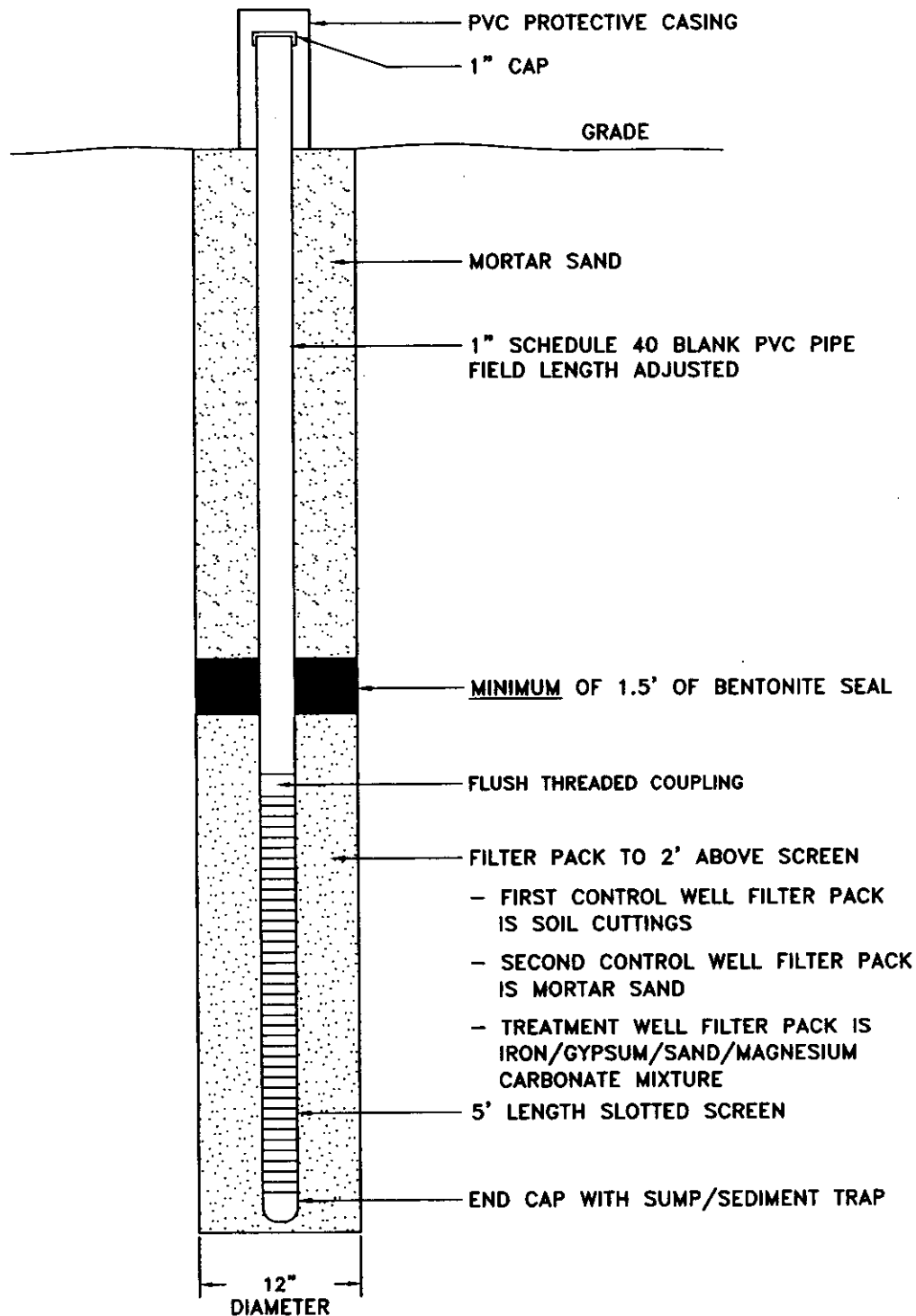
NOTES:

AR324853

APPENDIX B.2

PERMEABLE REACTIVE BARRIER IN-SITU TEST BORING RESULTS

AR324854



Corporate Remediation Group

*An Alliance between
DuPont and The URS Diamond*

Barley Mill Plaza, Building 27
Wilmington, Delaware 19805



**PERMEABLE REACTIVE BARRIER
TEST BORING**

DuPont Newport Facility
Newport South Landfill
Newport, Delaware

SCALE	DESIGNED	DRAWN DEL	CAD FILE NO. 7105A001
DATE 6/27/00	CHECKED WRK	APPROVED	FIGURE B.4

AR324855

Table B.1
Simulated Wall Life Calculations
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

Case	Cumulative Field Test Flow	Case Wall Flux	Simulated Wall Life
	(Liters)	(cm ³ /cm ² /day)	(Years)
Unit Wall Life Calculations			
Current Conditions (3' of soil)	1	1.24	0.000303 (0.11 days)
Asphalt (4") and Stone (8")	1	0.0207	0.018 (6.62 days)
Soil (18") and Bentomat	1	0.00413	0.091 (33.2 days)
Soil (18"), Drainage Layer, HDPE, and Basin Road	1	0.00064	0.587 (214 days)
Zinc-1, -2, -3			
Current Conditions (3' of soil)	265	1.24	0.080 (29.3 days)
Asphalt (4") and Stone (8")	265	0.0207	4.8
Soil (18") and Bentomat	265	0.00413	24.1
Soil (18"), Drainage Layer, HDPE, and Basin Road	265	0.00064	155
Barium-1, -2, -3			
Current Conditions (3' of soil)	209	1.24	0.063 (23.0 days)
Asphalt (4") and Stone (8")	209	0.0207	4
Soil (18") and Bentomat	209	0.00413	19
Soil (18"), Drainage Layer, HDPE, and Basin Road	209	0.00064	122
Barium-4, -5			
Current Conditions (3' of soil)	91.5	1.24	0.028 (10.2 days)
Asphalt (4") and Stone (8")	91.5	0.0207	2
Soil (18") and Bentomat	91.5	0.00413	48
Soil (18"), Drainage Layer, HDPE, and Basin Road	91.5	0.00064	54

The derivation of the wall life calculation is shown on the next page.

AR324856

Table B.1
Simulated Wall Life Calculations
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

Simulated wall life (T_w) is derived from the equality

$$X_i = X_w$$

in which X is the horizontal distance that groundwater travels through the in-situ test material (denoted by subscript i) or the permeable reactive barrier (denoted by subscript w). The distance terms can be separated in order to isolate the simulated wall life:

$$T_i \frac{V_i}{A_i t_i} = T_w q_w$$

in which T is total time of either the in-situ test or the simulated wall life in years, V/t_i is the flow rate of the in-situ test in L/d, A_i is the test flux area in cm^2 , and q_w is the case wall flux in $\text{cm}^3/\text{cm}^2/\text{day}$.

Because the volume for the in-situ test are taken from the total time of the test, the time unit t_i is the same as the total time and so cancels T_i . Solving for the wall life then gives the equation (with conversion factors):

$$T_w = \frac{1000V_i}{365A_i q_w}$$

The total volume of the in-situ test determines the simulated wall life because the other two terms are constants. The case wall flux is a constant for the cap condition being simulated. The test flux area is a cylinder with a length equal to the screened length of the well and a radius at the mid-point between the well screen and the bore hole radius. The ends of the cylinder are assumed to be impermeable and therefore not to contribute to the flux area. Thus the area is

$$A_i = \pi DL = 7,300\text{cm}^2$$

AR324857

Table B.2
Z-1 : Zinc-rich control well backfilled with soil cuttings
Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

"Zinc-1" Treatment Well		Units	13-Dec-00	15-Dec-00	18-Dec-00	20-Dec-00
Field Parameters	pH					6.4
	Redox	mV		-27.8	-46.5	
	Conductivity	µmho				0.156
	Turbidity	NTU				0
	Dissolved Oxygen	mg/L				0
	Temperature	°C				9.41
	Alkalinity to pH 8.3	mg/L	ND (0.37)			ND (0.37)
	Alkalinity to pH 4.5	mg/L	174			160
	Chloride	mg/L	374			360
	TSS	mg/L	106	126	60	94
	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Sulfate	mg/L	6.0			ND (7.5)
	Sulfide	mg/L	ND (0.53)			5.1
	Bicarbonate	mg/L	174			
	Carbonate	mg/L	ND (1)			
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	0.032 J	ND (0.0190)	0.0824	0.0914 J
	Barium	mg/L	12.5	13.1	12.4	12.6
	Cadmium	mg/L	ND (0.0036)	0.0042 J	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	68.3	68.3	66.6	66.3
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	ND (0.0071)			ND (0.0071)
	Copper	mg/L	0.005 J	0.0048 J	0.0035 J	ND (0.0027)
	Iron	mg/L	219	205	219	222
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	24.9	25.0	24.5	25.1
	Manganese	mg/L	31.1	32.2	31.3	31.5
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.82	3.97	3.98	4.08
	Sodium	mg/L	15.3	16.2	15.8	15.9
	Vanadium	mg/L	0.0061 J			ND (0.0026)
	Zinc	mg/L	0.139	0.123	0.0857	0.0814
Total	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	0.0501 J	ND (0.0190)	0.0457 J
	Barium	mg/L	12.0	12.3	12.6	12.5
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	66.6	62.7	66.3	65.7
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	ND (0.0071)			ND (0.0071)
	Copper	mg/L	0.0032 J	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	210	198	214	221
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	24.1	23.0	24.5	24.8
	Manganese	mg/L	30.1	29.8	32.1	30.7
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.71	3.78	3.97	4.04
	Sodium	mg/L	14.9	15.2	15.8	15.7
	Vanadium	mg/L	0.0049 J			ND (0.0026)
	Zinc	mg/L	0.107	0.0750	0.0857	0.0432
Dissolved	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	0.0501 J	ND (0.0190)	0.0457 J
	Barium	mg/L	12.0	12.3	12.6	12.5
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	66.6	62.7	66.3	65.7
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	ND (0.0071)			ND (0.0071)
	Copper	mg/L	0.0032 J	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	210	198	214	221
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	24.1	23.0	24.5	24.8
	Manganese	mg/L	30.1	29.8	32.1	30.7
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.71	3.78	3.97	4.04
	Sodium	mg/L	14.9	15.2	15.8	15.7
	Vanadium	mg/L	0.0049 J			ND (0.0026)
	Zinc	mg/L	0.107	0.0750	0.0857	0.0432

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324858

Table B.2

Z-1 : Zinc-rich control well backfilled with soil cuttings

Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

"Zinc-1" Treatment Well		Units	1-Dec-00	4-Dec-00	6-Dec-00	8-Dec-00	12-Dec-00
Field Parameters	pH				6.37		6.21
	Redox	mV					
	Conductivity	µmho			0.18		0.17
	Turbidity	NTU			1.5		4
	Dissolved Oxygen	mg/L			0		0
	Temperature	°C			10.5		12.3
	Alkalinity to pH 8.3	mg/L			ND (0.37)		
	Alkalinity to pH 4.5	mg/L			151		
	Chloride	mg/L			410		
	TSS	mg/L	94	90	94	86	72
	Mercury	mg/L			ND (0.00005)		
	Sulfate	mg/L			ND (3)		
	Sulfide	mg/L			ND (0.53)		
	Bicarbonate	mg/L			151		
	Carbonate	mg/L			ND (1)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0822 J
	Barium	mg/L	12.7	12.6	13.6	12.2	12.4
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	70.3	75.0	68.7	66.8	63.8
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			ND (0.0071)		
	Copper	mg/L	0.0056 J	ND (0.0027)	0.0047 J	ND (0.0027)	ND (0.0027)
	Iron	mg/L	206	223	216	191	202
	Lead	mg/L	0.0595 J	0.03 J	0.0481 J	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	27.2	26.5	26.0	24.8	23.7
	Manganese	mg/L	32.9	33.1	33.7	30.0	31.9
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			4.02		3.79
	Sodium	mg/L			16.4		15.6
	Vanadium	mg/L			0.0042 J		
	Zinc	mg/L	0.220	0.108	0.139	0.250	0.152
Dissolved	Mercury	mg/L			ND (0.00012)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0486 J
	Barium	mg/L	12.0	12.9	13.1	11.4	12.4
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	69.8	77.4	68.8	65.4	64.3
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			ND (0.0071)		
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	204	225	213	181	201
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	27.0	27.3	25.6	24.3	23.7
	Manganese	mg/L	32.4	34.0	33.6	29.5	32.3
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	0.0294 J	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			3.87		3.85
	Sodium	mg/L			16.0		15.8
	Vanadium	mg/L			0.0041 J		
	Zinc	mg/L	0.118	0.0991	0.0714	0.206	0.140

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324859

Table B.3
Z-2 : Zinc-rich control well backfilled with mason sand
Permeable Reactive Barrier Tests, Newport Superfund Site, Newport, Delaware

"Zinc-2" Treatment Well		Units	1-Dec-00	4-Dec-00	6-Dec-00	8-Dec-00	12-Dec-00
Field Parameters	pH			6.55	6.7		6.56
	Redox	mV					
	Conductivity	µmho		0.15	0.14		0.137
	Turbidity	NTU		0	0		0.2
	Dissolved Oxygen	mg/L		0	0		0
	Temperature	°C		13.2	7.2		9.96
	Alkalinity to pH 8.3	mg/L			ND (0.37)		
	Alkalinity to pH 4.5	mg/L			200		
	Chloride	mg/L			247		
	TSS	mg/L	201	55	96	61	89
	Mercury	mg/L			ND (0.0012)		
	Sulfate	mg/L			38.0		
	Sulfide	mg/L			ND (0.53)		
	Bicarbonate	mg/L			200		
	Carbonate	mg/L			ND (1)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0324 J
	Barium	mg/L	3.45	3.26	5.44	6.02	6.96
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	152	119	99.5	91.2	94.3
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			0.0347 J		
	Copper	mg/L	0.0112 J	ND (0.0027)	0.0038 J	ND (0.0027)	ND (0.0027)
	Iron	mg/L	30.7	76.1	90.2	97.3	96.4
	Lead	mg/L	0.0965 J	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	19.0	18.8	18.5	18.8	18.0
	Manganese	mg/L	11.6	17.9	19.6	17.5	18.5
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			7.24		7.17
	Sodium	mg/L			47.7		38.7
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L	0.334	0.416	0.500	0.425	0.441
Dissolved	Mercury	mg/L			ND (0.00012)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0336 J
	Barium	mg/L	1.18	3.54	5.17	6.60	6.30
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	152	120	100	90.6	91.2
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			0.0334 J		
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	35.8	78.6	92.6	88.6	82.8
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	19.5	19.2	18.9	18.1	16.5
	Manganese	mg/L	12.6	18.6	20.2	16.9	17.5
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			7.30		6.94
	Sodium	mg/L			45.4		36.4
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L	0.263	0.412	0.497	0.402	0.402

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324860

Table B.3

Z-2 : Zinc-rich control well backfilled with mason sand
 Permeable Reactive Barrier Tests, Newport Superfund Site, Newport, Delaware

"Zinc-2" Treatment Well		Units	13-Dec-00	15-Dec-00	18-Dec-00	20-Dec-00
Field Parameters	pH					6.47
	Redox	mV		-36.7	-47.5	
	Conductivity	µmho				0.12
	Turbidity	NTU				0.6
	Dissolved Oxygen	mg/L				0
	Temperature	°C				7.21
	Alkalinity to pH 8.3	mg/L	ND (0.37)			ND (0.37)
	Alkalinity to pH 4.5	mg/L	193			159
	Chloride	mg/L	230			210
	TSS	mg/L	107	111	154	94
	Mercury	mg/L	ND (0.0012)			ND (0.0012)
	Sulfate	mg/L	15.5			ND (7.5)
	Sulfide	mg/L	ND (0.53)			ND (1.1)
	Bicarbonate	mg/L	193			
	Carbonate	mg/L	ND (1)			
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	0.0546 J	0.0565 J
	Barium	mg/L	6.84	6.81	3.88	5.4
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	91.1	80.5	80.9	84.6
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	0.0230 J			0.0204 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)	0.0027 J	ND (0.0027)
	Iron	mg/L	95.3	95.9	60.5	82.1
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	17.0	16.1	12.6	15.7
	Manganese	mg/L	17.5	16.8	13.7	16.4
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	6.92	6.53	7.14	7.06
	Sodium	mg/L	33.2	33.3	34.7	30.9
	Vanadium	mg/L	0.0032 J			ND (0.0026)
	Zinc	mg/L	0.393	0.400	0.477	0.556
Dissolved	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	0.0279 J	ND (0.0190)	0.0459 J
	Barium	mg/L	6.85	6.87	3.86	6.74
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	88.8	78.7	75.7	90.1
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	0.0220 J			0.0204 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)	0.0027 J	ND (0.0027)
	Iron	mg/L	96.0	96.7	59.9	97.0
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	16.9	15.7	12.2	16.9
	Manganese	mg/L	17.4	16.0	13.1	16.9
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	6.82	6.39	6.80	6.90
	Sodium	mg/L	33.8	31.8	34.4	33.2
	Vanadium	mg/L	0.0031 J			ND (0.0026)
	Zinc	mg/L	0.395	0.391	0.368	0.536

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324861

Table B.4
Z-3 : Zinc-rich PRB material well (5 wt. parts MgCO₃)
Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport Delaware

"Zinc-3" Treatment Well		Units	1-Dec-00	4-Dec-00	6-Dec-00	8-Dec-00	12-Dec-00
Field Parameters	pH			8.95		9.21	8.68
	Redox	mV					
	Conductivity	µmho		1		0.9	0.843
	Turbidity	NTU		0		0	2.6
	Dissolved Oxygen	mg/L		0		0	0
	Temperature	°C		11.6		6	8.78
	Alkalinity to pH 8.3	mg/L			16		
	Alkalinity to pH 4.5	mg/L			177		
	Chloride	mg/L			223		
	TSS	mg/L	137	14	10 J	8.4 J	19
	Mercury	mg/L			ND (0.00012)		
	Sulfate	mg/L			7,500		
	Sulfide	mg/L			ND (0.53)		
	Bicarbonate	mg/L			145		
	Carbonate	mg/L			32.1		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0483 J
	Barium	mg/L	1.56	0.135	0.426	0.225	0.0624 J
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	395	460	414	393	380
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			ND (0.0071)		
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	11.2	3.93	4.19	4.86	6.24
	Lead	mg/L	0.0455 J	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	2,080	1,956	1,860	1,460	1,610
	Manganese	mg/L	1.60	0.607	0.693	0.688	0.725
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			9.32		7.65
	Sodium	mg/L			56.4		48.9
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L	0.180	ND (0.0086)	ND (0.0086)	0.0265	ND (0.0086)
Dissolved	Mercury	mg/L			ND (0.00005)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0428 J
	Barium	mg/L	0.0780 J	0.0285 J	0.0489 J	0.0532 J	0.106
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	402	466	414	403	373
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			ND (0.0071)		
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	5.49	1.28	3.06	1.84	6.29
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	2,260	1,950	1,830	1,480	1,610
	Manganese	mg/L	1.24	0.689	0.659	0.754	0.820
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			9.05		7.55
	Sodium	mg/L			52.3		46.1
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L	0.0141 J	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324862

Table B.4

Z-3 : Zinc-rich PRB material well (5 wt. parts MgCO₃)

Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport Delaware

"Zinc-3" Treatment Well		Units	13-Dec-00	15-Dec-00	18-Dec-00	20-Dec-00
Field Parameters	pH					
	Redox	mV		-175.5	-190.1	
	Conductivity	µmho				
	Turbidity	NTU				
	Dissolved Oxygen	mg/L				
	Temperature	°C				
	Alkalinity to pH 8.3	mg/L	ND (0.37)			7.2
	Alkalinity to pH 4.5	mg/L	218			187
	Chloride	mg/L	199			250
	TSS	mg/L	15	21	201	40
	Mercury	mg/L	ND (0.00012)			0.00012 J
	Sulfate	mg/L	6,500			7,100
	Sulfide	mg/L	ND (0.53)			ND (0.53)
	Bicarbonate	mg/L	218			
	Carbonate	mg/L	ND (1)			
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	0.0561 J
	Barium	mg/L	0.0631 J	0.0358 J	0.0645 J	0.0251 J
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	397	399	420	365
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	ND (0.0071)			ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	6.43	7.83	2.6	4.64
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	1,480	1,170	1,660	1,720
	Manganese	mg/L	0.745	0.871	0.430	0.472
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	7.02	6.04	7.14	6.82
	Sodium	mg/L	41.8	40.1	34.7	32.3
	Vanadium	mg/L	ND (0.0026)			
	Zinc	mg/L	ND (0.0086)	0.0122 J	ND (0.0086)	ND (0.0086)
Dissolved	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	0.0293 J	ND (0.0190)	0.069 J
	Barium	mg/L	0.0430 J	0.0253 J	0.0171 J	0.0163 J
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	400	365	410	393
	Chromium	mg/L	ND (0.0066)			
	Cobalt	mg/L	ND (0.0071)			
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	5.36	6.16	2.48	3.2
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	1,490	1,130	1,630	1,620
	Manganese	mg/L	0.771	0.802	0.527	0.500
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	7.04	5.87	7.68	6.85
	Sodium	mg/L	43.0	37.4	45.5	34.0
	Vanadium	mg/L	ND (0.0026)			ND (0.0026)
	Zinc	mg/L	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324863

Table B.5

B-1 : Barium-rich control well backfilled with soil cuttings

Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

"Barium-1" Treatment Well		Units	1-Dec-00	4-Dec-00	6-Dec-00	8-Dec-00	12-Dec-00
Field Parameters	pH					5.98	
	Redox	mV					
	Conductivity	µmho				41.4	
	Turbidity	NTU				1.2	
	Dissolved Oxygen	mg/L				1.84	
	Temperature	°C				11.95	
	Alkalinity to pH 8.3	mg/L			ND (0.37)		
	Alkalinity to pH 4.5	mg/L			109		
	Chloride	mg/L			36.0		
	TSS	mg/L			8.0 J	6.8 J	5.2 J
	Mercury	mg/L			ND (0.00005)		
	Sulfate	mg/L			17.0		
	Sulfide	mg/L			ND (0.53)		
	Bicarbonate	mg/L			109		
	Carbonate	mg/L			ND (1)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0199 J
	Barium	mg/L			0.184	0.269	0.179
	Cadmium	mg/L			ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L			34.2	31.7	31.1
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			0.0106 J		
	Copper	mg/L			ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L			2.61	2.92	2.55
	Lead	mg/L			ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L			10.5	9.47	8.82
	Manganese	mg/L			10.2	8.62	8.60
	Nickel	mg/L			ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			3.13		2.83
	Sodium	mg/L			21.9		21.1
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L			ND (0.0086)	0.0142 J	0.0094 J
Dissolved	Mercury	mg/L			ND (0.00005)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L					
	Aluminum	mg/L					0.0320 J
	Barium	mg/L			0.160	1.09	0.185
	Cadmium	mg/L			ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L			30.7	33.5	33.6
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			0.0091 J		
	Copper	mg/L			ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L			1.93	7.23	2.61
	Lead	mg/L			ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L			9.33	10.3	9.24
	Manganese	mg/L			9.80	9.95	9.00
	Nickel	mg/L			ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			2.72		2.97
	Sodium	mg/L			19.9		22.2
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L			0.0088 J	0.0317	0.0150 J

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324864

Table B.5

B-1 : Barium-rich control well backfilled with soil cuttings

Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

"Barium-1" Treatment Well		Units	13-Dec-00	15-Dec-00	18-Dec-00	20-Dec-00
Field Parameters	pH		6.73			
	Redox	mV		126.6	12.5	
	Conductivity	µmho	4.42			
	Turbidity	NTU	2.7			
	Dissolved Oxygen	mg/L	0			
	Temperature	°C	7.2			
	Alkalinity to pH 8.3	mg/L	ND (0.37)			ND (0.37)
	Alkalinity to pH 4.5	mg/L	111			116
	Chloride	mg/L	42.0			39.6
	TSS	mg/L	ND (4.1)	ND (4.1)	6.0 J	ND (4.1)
	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Sulfate	mg/L	15.2			14.5
	Sulfide	mg/L	ND (0.53)			ND (0.53)
	Bicarbonate	mg/L	111			
	Carbonate	mg/L	ND (1)			
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	0.0448 J	0.0540 J
	Barium	mg/L	0.180	0.185	0.189	0.195
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	34.4	33.4	33.9	33.9
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	0.0088 J			0.0080 J
	Copper	mg/L	ND (0.0027)	0.0035 J	ND (0.0027)	ND (0.0027)
	Iron	mg/L	2.65	2.62	2.65	2.85
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	9.69	9.19	9.45	9.48
	Manganese	mg/L	9.05	9.14	8.80	8.56
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.01	3.04	3.13	3.22
	Sodium	mg/L	22.1	22.6	24.2	24.2
	Vanadium	mg/L	ND (0.0026)			ND (0.0026)
	Zinc	mg/L	0.0123 J	0.0163 J	ND (0.0086)	0.0234 J
Dissolved	Mercury	mg/L	ND (0.00012)			ND (0.00012)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	0.0483 J
	Barium	mg/L	0.177	0.189	0.194	0.214
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	34.2	34.2	35.1	36.8
	Chromium	mg/L	ND (0.0066)			ND (0.0066)
	Cobalt	mg/L	0.0086 J			0.0078 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	2.47	2.63	2.54	2.87
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	9.58	9.47	9.92	9.94
	Manganese	mg/L	8.94	9.28	9.24	9.58
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	2.97	3.01	3.26	3.21
	Sodium	mg/L	21.9	22.7	24.8	25.7
	Vanadium	mg/L	ND (0.0026)			ND (0.0026)
	Zinc	mg/L	0.0112 J	0.0112 J	ND (0.0086)	0.0119 J

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324865

Table B.6
B-2 : Barium-rich control well backfilled with mason sand
Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-2" Treatment Well	Units	1-Dec-00	4-Dec-00	6-Dec-00	8-Dec-00	12-Dec-00
Field Parameters	pH					6.93	
	Redox	mV					
	Conductivity	µmho				40.1	
	Turbidity	NTU				6	
	Dissolved Oxygen	mg/L				0	
	Temperature	°C				11.21	
	Alkalinity to pH 8.3	mg/L			ND (0.37)		
	Alkalinity to pH 4.5	mg/L			145		
	Chloride	mg/L			27		
	TSS	mg/L			65	93	ND (4.1)
	Mercury	mg/L			ND (0.00005)		
	Sulfate	mg/L			20.8		
	Sulfide	mg/L			ND (0.53)		
	Bicarbonate	mg/L			145		
	Carbonate	mg/L			ND (1)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0327 J
	Barium	mg/L			4.63	8.61	7.50
	Cadmium	mg/L			ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L			44.5	37.4	32.6
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			0.0092 J		
	Copper	mg/L			ND (0.0027)	0.0120 J	ND (0.0027)
	Iron	mg/L			1.74	44.4	2.10
	Lead	mg/L			ND (0.0300)	0.0390	ND (0.0300)
	Magnesium	mg/L			9.40	8.74	7.25
	Manganese	mg/L			5.62	5.62	5.58
	Nickel	mg/L			ND (0.0084)	0.0139 J	ND (0.0084)
	Potassium	mg/L			6.10		5.20
	Sodium	mg/L			20.2		18.9
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L			0.0158 J	0.0985	ND (0.0086)
Dissolved	Mercury	mg/L			ND (0.00005)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0201 J
	Barium	mg/L			4.56	5.54	7.23
	Cadmium	mg/L			ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L			44.1	43.5	33.1
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			0.0083 J		
	Copper	mg/L			ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L			1.04	1.72	2.01
	Lead	mg/L			ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L			9.43	9.55	7.32
	Manganese	mg/L			5.53	6.25	5.58
	Nickel	mg/L			ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			6.21		5.12
	Sodium	mg/L			20.1		18.4
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L			ND (0.0086)	0.0215 J	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324866

Table B.6
B-2 : Barium-rich control well backfilled with mason sand
reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-2" Treatment Well	Units	13-Dec-00	15-Dec-00	18-Dec-00	20-Dec-00	3-Jan-01 12:00 Bottom	
Field Parameters	pH			6.82				
	Redox	mV		44.2	9.4			
	Conductivity	µmho		38.8				
	Turbidity	NTU		0.1				
	Dissolved Oxygen	mg/L		0				
	Temperature	°C		9.37				
	Alkalinity to pH 8.3	mg/L	ND (0.37)			ND (0.37)	ND (0.37)	
	Alkalinity to pH 4.5	mg/L	114			112	116	
	Chloride	mg/L	33			25.4	23.6	
	TSS	mg/L	10.0 J	8.8 J	14.0	9.6 J	410	
	Mercury	mg/L	ND (0.00012)			ND (0.00012)	ND (0.00012)	
	Sulfate	mg/L	8.7			18.3	6.7 J	
	Sulfide	mg/L	ND (0.53)			ND (0.53)	ND (0.53)	
	Bicarbonate	mg/L	114			112	116	
	Carbonate	mg/L	ND (1)				ND (1)	
	Total	Arsenic	mg/L	ND (0.0320)			ND (0.0320)	ND (0.0320)
Selenium		mg/L	ND (0.0600)			ND (0.0600)	ND (0.0600)	
Aluminum		mg/L	0.0345 J	0.0506 J	0.047 J	0.0376 J	0.410	
Barium		mg/L	7.50	5.59	4.31	4.93	4.80	
Cadmium		mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	
Calcium		mg/L	33.3	31.8	33.7	32.8	31.0	
Chromium		mg/L	ND (0.0066)			ND (0.0066)	ND (0.0066)	
Cobalt		mg/L	0.0141 J			0.0190 J	0.0181 J	
Copper		mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	
Iron		mg/L	2.52	3.17	3.61	5.31	7.78	
Lead		mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	
Magnesium		mg/L	7.35	7.50	8.85	8.45	7.56	
Manganese		mg/L	5.66	6.32	6.49	5.46	4.16	
Nickel		mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	
Potassium		mg/L	5.08	4.69	4.32	4.20	2.90	
Sodium		mg/L	18.3	19.8	20.8	20.2	16.5	
Vanadium		mg/L	ND (0.0026)			ND (0.0026)	ND (0.0026)	
Zinc		mg/L	ND (0.0086)	0.0126 J	ND (0.0086)	0.0147 J	0.0090 J	
Dissolved		Mercury	mg/L	ND (0.00012)			ND (0.00012)	ND (0.00012)
		Arsenic	mg/L	ND (0.0320)			ND (0.0320)	ND (0.0320)
		Selenium	mg/L	ND (0.0600)			ND (0.0600)	ND (0.0600)
		Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	0.0402 J	ND (0.0190)
		Barium	mg/L	7.34	6.30	5.71	5.82	4.35
		Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
		Calcium	mg/L	33.0	32.2	33.0	34.4	30.0
		Chromium	mg/L	ND (0.0066)			ND (0.0066)	ND (0.0066)
		Cobalt	mg/L	0.0141 J			0.0202 J	0.0167 J
		Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	2.45	3.08	3.64	5.56	6.97	
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	
	Magnesium	mg/L	7.35	7.66	8.52	8.50	7.39	
	Manganese	mg/L	5.64	6.27	6.29	5.96	4.05	
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	
	Potassium	mg/L	5.00	4.82	4.43	4.12	2.87	
	Sodium	mg/L	18.0	20.2	20.4	20.8	16.5	
	Vanadium	mg/L	ND (0.0026)			ND (0.0026)	ND (0.0026)	
Zinc	mg/L	0.0095 J	ND (0.0086)	ND (0.0086)	0.0092 J	ND (0.0086)		

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324867

Table B.6
B-2 : Barium-rich control well backfilled with mason sand
Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-2" Treatment Well	Units	3-Jan-01 15:00 Bottom	3-Jan-01 12:00 Top	3-Jan-01 15:00 Top	11-Jan-01	12-Jan-01
Field Parameters	pH			J	J		
	Redox	mV					
	Conductivity	µmho					
	Turbidity	NTU					
	Dissolved Oxygen	mg/L					
	Temperature	°C					
	Alkalinity to pH 8.3	mg/L	ND (0.37)	ND (0.37)	ND (0.37)	ND (0.37)	ND (0.37)
	Alkalinity to pH 4.5	mg/L	111	123	113	102	107
	Chloride	mg/L	24.6	20.9	25.2	26	28
	TSS	mg/L	1,070	194	15	65	15
	Mercury	mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Sulfate	mg/L	ND (15)	8.9 J	12.4	9.0	8.9
	Sulfide	mg/L	ND (0.53)	ND (0.53)	ND (0.53)	ND (0.53)	ND (0.53)
	Bicarbonate	mg/L	111	123	113	102	107
	Carbonate	mg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	0.350	2.32	0.0608 J	2.59	0.487
	Barium	mg/L	4.36	5.23	4.34	5.44	4.60
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	29.8	30.6	29.2	27.7	25.9
	Chromium	mg/L	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	0.0160 J	0.0175 J	0.0157 J	0.0160 J	0.0151 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	7.70	10.5	7.23	12.4	9.94
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	7.32	7.54	7.20	6.92	6.52
	Manganese	mg/L	3.92	4.06	3.85	3.39	3.16
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.14	2.95	3.09	3.08	3.16
	Sodium	mg/L	17.2	16.6	16.8	16.5	17.4
	Vanadium	mg/L	ND (0.0026)	0.0029 J	ND (0.0026)	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	0.0090 J	0.0103 J	ND (0.0086)	ND (0.0086)	ND (0.0086)
Dissolved	Mercury	mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	ND (0.0190)	0.0290 J
	Barium	mg/L	4.28	4.37	4.26	3.85	4.36
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	30.0	30.2	29.7	29.3	25.4
	Chromium	mg/L	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	0.0156 J	0.0163 J	0.0155 J	0.0145 J	0.0136 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	6.70	7.15	6.73	7.94	8.38
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	7.36	7.40	7.26	6.82	6.38
	Manganese	mg/L	3.95	4.04	3.89	3.57	3.18
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.11	3.02	3.16	3.14	3.18
	Sodium	mg/L	17.1	16.5	16.1	16.3	16.9
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)	ND (0.0026)	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vittek

AR324868

Table B.6

B-2 : Barium-rich control well backfilled with mason sand
 Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-2" Treatment Well	Units	12-Jan-01	15-Jan-01
Field Parameters	pH			
	Redox	mV		
	Conductivity	µmho		
	Turbidity	NTU		
	Dissolved Oxygen	mg/L		
	Temperature	°C		
	Alkalinity to pH 8.3	mg/L	ND (0.37)	ND (0.37)
	Alkalinity to pH 4.5	mg/L	112	112
	Chloride	mg/L	27.1	27.1
	TSS	mg/L	15	19
	Mercury	mg/L	ND (0.00012)	ND (0.00012)
	Sulfate	mg/L	8.9	9.6
	Sulfide	mg/L	ND (0.53)	ND (0.53)
	Bicarbonate	mg/L	107	112
	Carbonate	mg/L	ND (1)	ND (1)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	0.487	1.14
	Barium	mg/L	4.60	5.34
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	25.9	29.3
	Chromium	mg/L	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	0.0151 J	0.0160 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)
	Iron	mg/L	9.94	10.5
	Lead	mg/L	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	6.52	7.05
	Manganese	mg/L	3.16	3.43
	Nickel	mg/L	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.16	2.79
	Sodium	mg/L	17.4	16.9
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	0.0175 J
Dissolved	Mercury	mg/L	ND (0.00012)	ND (0.00012)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	0.0290 J	ND (0.0190)
	Barium	mg/L	4.36	4.00
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	25.4	27.2
	Chromium	mg/L	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	0.0136 J	0.0141 J
	Copper	mg/L	ND (0.0027)	ND (0.0027)
	Iron	mg/L	8.38	7.98
	Lead	mg/L	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	6.38	6.75
	Manganese	mg/L	3.18	3.49
	Nickel	mg/L	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	3.18	3.18
	Sodium	mg/L	16.9	17.0
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	0.0095 J

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324869

Table B.7
B-3 : Barium-rich PRB material well (5 wt. parts MgCO₃)
Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-3" Treatment Well	Units	1-Dec-00	4-Dec-00	6-Dec-00	8-Dec-00	12-Dec-00
Field Parameters	pH					7.7	
	Redox	mV					
	Conductivity	µmho				0.31	
	Turbidity	NTU				0.2	
	Dissolved Oxygen	mg/L				0	
	Temperature	°C				5.08	
	Alkalinity to pH 8.3	mg/L			ND (0.37)		
	Alkalinity to pH 4.5	mg/L			120		
	Chloride	mg/L			72		
	TSS	mg/L			295	435	17
	Mercury	mg/L			0.00011 J		
	Sulfate	mg/L			2,150		
	Sulfide	mg/L			ND (0.53)		
	Bicarbonate	mg/L			120		
	Carbonate	mg/L			ND (1)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0711 J
	Barium	mg/L			4.42	6.50	0.263
	Cadmium	mg/L			0.0113	0.0071 J	ND (0.0036)
	Calcium	mg/L			330	269	229
	Chromium	mg/L			0.0295 J		
	Cobalt	mg/L			0.0421 J		
	Copper	mg/L			0.137	0.0816	ND (0.0027)
	Iron	mg/L			83.0	48.3	8.06
	Lead	mg/L			1.25	0.658	ND (0.0300)
	Magnesium	mg/L			413	183	188
	Manganese	mg/L			3.71	3.72	1.84
	Nickel	mg/L			0.0248 J	0.0183 J	ND (0.0084)
	Potassium	mg/L			3.09		1.67
	Sodium	mg/L			37.4		35.8
	Vanadium	mg/L			0.0739		
	Zinc	mg/L			1.19	0.852	ND (0.0084)
Total	Mercury	mg/L			ND (0.00005)		
	Arsenic	mg/L			ND (0.0320)		
	Selenium	mg/L			ND (0.0600)		
	Aluminum	mg/L					0.0287 J
	Barium	mg/L			0.107	0.107	0.275
	Cadmium	mg/L			ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L			325	252	241
	Chromium	mg/L			ND (0.0066)		
	Cobalt	mg/L			ND (0.0071)		
	Copper	mg/L			ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L			5.60	6.05	8.67
	Lead	mg/L			ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L			419	232	190
	Manganese	mg/L			1.97	1.85	2.00
	Nickel	mg/L			ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L			2.07		1.78
	Sodium	mg/L			39.9		37.6
	Vanadium	mg/L			ND (0.0026)		
	Zinc	mg/L			ND (0.0086)	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324870

Table B.7

B-3 : Barium-rich PRB material well (5 wt. parts MgCO₃)
 Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-3" Treatment Well	Units	13-Dec-00	15-Dec-00	18-Dec-00	20-Dec-00	3-Jan-01 12:00 Bottom
Field Parameters	pH			7.5			
	Redox	mV		75.7	-20.4		
	Conductivity	µmho		0.18			
	Turbidity	NTU		0			
	Dissolved Oxygen	mg/L		0			
	Temperature	°C		8.77			
	Alkalinity to pH 8.3	mg/L	ND (0.37)			ND (0.37)	ND (0.37)
	Alkalinity to pH 4.5	mg/L	131			128	132
	Chloride	mg/L	69.0			72.0	45.7
	TSS	mg/L	17	16	34	50	60
	Mercury	mg/L	ND (0.00012)			ND (0.00012)	ND (0.00012)
	Sulfate	mg/L	850			440	245
	Sulfide	mg/L	ND (0.53)			ND (0.53)	ND (0.53)
	Bicarbonate	mg/L	131				132
	Carbonate	mg/L	ND (1)				ND (1)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	0.0846 J	ND (0.0190)	0.195 J	1.97	0.582
	Barium	mg/L	0.302	0.235	0.459	0.936	1.39
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	206	189	167	132	100
	Chromium	mg/L	ND (0.0066)			ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)			ND (0.0071)	ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	9.09	9.27	10.6	11.9	12.0
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	129	105	67.7	62.2	32.8
	Manganese	mg/L	1.87	1.93	2.2	1.65	1.46
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	1.67	1.69	1.86	1.64	1.35
	Sodium	mg/L	36.2	35.5	37.1	33.5	31.8
	Vanadium	mg/L	ND (0.0026)			ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	0.0228 J	ND (0.0086)	0.0248 J	ND (0.0086)
Total	Mercury	mg/L	ND (0.00012)			ND (0.00012)	ND (0.00012)
	Arsenic	mg/L	ND (0.0320)			ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)			ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	0.0582 J	ND (0.0190)
	Barium	mg/L	0.230	0.431	0.362	0.582	0.637
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	221	194	157	157	103
	Chromium	mg/L	ND (0.0066)			ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)			ND (0.0071)	ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	8.85	9.56	9.63	9.63	10.9
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	142	111	69.6	70.0	35.7
	Manganese	mg/L	1.96	2.02	1.98	1.92	1.42
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	1.67	1.75	1.8	1.66	1.28
	Sodium	mg/L	36.3	35.7	37.2	36.6	31.7
	Vanadium	mg/L	ND (0.0026)			ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	ND (0.0086)	ND (0.0086)	0.0101 J	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324871

Table B.7
B-3 : Barium-rich PRB material well (5 wt. parts MgCO₃)
Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-3" Treatment Well	Units	3-Jan-01 15:00 Bottom	3-Jan-01 12:00 Top	3-Jan-01 15:00 Top	9-Jan-01	11-Jan-01
Field Parameters	pH						
	Redox	mV					
	Conductivity	µmho					
	Turbidity	NTU					
	Dissolved Oxygen	mg/L					
	Temperature	°C					
	Alkalinity to pH 8.3	mg/L	ND (0.37)	ND (0.37)	ND (0.37)	ND (0.37)	ND (0.37)
	Alkalinity to pH 4.5	mg/L	130	132	133	128	121
	Chloride	mg/L	46.4	47.6	43.0	46.2	54
	TSS	mg/L	15	24	17	183	24
	Mercury	mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Sulfate	mg/L	336	250	323	288	230
	Sulfide	mg/L	ND (0.53)	ND (0.53)	ND (0.53)	2.4 J	ND (0.53)
	Bicarbonate	mg/L	130	132	133	128	121
	Carbonate	mg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	13.4	0.188 J
	Barium	mg/L	0.687	0.661	0.673	6.82	0.894
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	114	106	123	105	92.9
	Chromium	mg/L	ND (0.0066)	ND (0.0066)	ND (0.0066)	0.0172 J	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)	ND (0.0071)	0.0132 J	ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	0.0352	ND (0.0027)
	Iron	mg/L	11.0	11.1	11.1	39.2	12.6
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	0.276	ND (0.0300)
	Magnesium	mg/L	41.9	34.7	41.3	34.7	25.3
	Manganese	mg/L	1.46	1.45	1.46	1.46	1.32
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	0.0109 J	ND (0.0084)
	Potassium	mg/L	1.28	1.29	1.26	1.96	1.38
	Sodium	mg/L	31.3	31.3	31.3	30.4	31.2
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)	ND (0.0026)	0.0269	ND (0.0026)
	Zinc	mg/L	0.457	ND (0.0086)	ND (0.0086)	0.255	ND (0.0086)
Total	Mercury	mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)	ND (0.0190)	ND (0.0190)	ND (0.0190)
	Barium	mg/L	0.637	0.685	0.625	0.373	0.627
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	120	105	124	109	99.4
	Chromium	mg/L	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)	ND (0.0071)	ND (0.0071)	ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	11.0	10.8	10.7	11.6	11.3
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	43.2	37.1	41.0	34.7	29.6
	Manganese	mg/L	1.50	1.43	1.46	1.32	1.26
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	1.28	1.26	1.35	1.49	1.32
	Sodium	mg/L	31.3	31.3	31.3	31.3	30.7
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)	ND (0.0026)	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324872

Table B.7

B-3 : Barium-rich PRB material well (5 wt. parts MgCO₃)

Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-3" Treatment Well	Units	12-Jan-01	15-Jan-01
Field Parameters	pH			
	Redox	mV		
	Conductivity	µmho		
	Turbidity	NTU		
	Dissolved Oxygen	mg/L		
	Temperature	°C		
	Alkalinity to pH 8.3	mg/L	ND (0.37)	ND (0.37)
	Alkalinity to pH 4.5	mg/L	129	142
	Chloride	mg/L	45	38
	TSS	mg/L	22	27
	Mercury	mg/L	ND (0.00012)	ND (0.00012)
	Sulfate	mg/L	238	211
	Sulfide	mg/L	ND (0.53)	ND (0.53)
	Bicarbonate	mg/L	129	142
	Carbonate	mg/L	ND (1)	ND (1)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	0.244	1.84
	Barium	mg/L	0.974	3.48
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	92.0	90.9
	Chromium	mg/L	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)
	Copper	mg/L	ND (0.0027)	0.0052 J
	Iron	mg/L	13.9	17.3
	Lead	mg/L	ND (0.0300)	0.0491
	Magnesium	mg/L	25.5	23.0
	Manganese	mg/L	1.37	1.38
	Nickel	mg/L	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	1.35	1.49
	Sodium	mg/L	30.1	31.0
	Vanadium	mg/L	ND (0.0026)	0.0033 J
	Zinc	mg/L	ND (0.0086)	0.0539
Total	Mercury	mg/L	ND (0.00012)	ND (0.00012)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	0.0318 J	ND (0.0190)
	Barium	mg/L	0.658	0.649
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	97.6	99.6
	Chromium	mg/L	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)
	Iron	mg/L	13.1	12.4
	Lead	mg/L	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	28.9	27.5
	Manganese	mg/L	1.28	1.27
	Nickel	mg/L	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	1.37	1.32
	Sodium	mg/L	31.2	30.0
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324873

Table B.8

B-4 : Barium-rich PRB material well (5 wt. parts MgCO₃), Rotosonic installed
 Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-4" Treatment Well	Units		11-Jan-01	12-Jan-01	15-Jan-01	17-Jan-01 10:00
Field Parameters	pH						
	Redox	mV					
	Conductivity	µmho					
	Turbidity	NTU					
	Dissolved Oxygen	mg/L					
	Temperature	°C					
	Alkalinity to pH 8.3	mg/L		39.8	41.1	33.2	37.2
	Alkalinity to pH 4.5	mg/L		162	153	121	119
	Chloride	mg/L		78	71	49	42
	TSS	mg/L		26	29	ND (4.1)	ND (4.1)
	Mercury	mg/L		ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Sulfate	mg/L		6,100	7,200	5,600	6,400
	Sulfide	mg/L		1.2 J	ND (0.53)	ND (0.53)	ND (0.53)
	Bicarbonate	mg/L		82.9	70.7	54.6	44.5
	Carbonate	mg/L		79.6	82.1	66.5	74.4
	Arsenic	mg/L		0.0322 J	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L		ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L		33.2	0.356	0.850 J	0.174 J
	Barium	mg/L		1.08	0.268	0.0826 J	0.119
	Cadmium	mg/L		0.0283	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L		800	393	418	465
	Chromium	mg/L		0.0296 J	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L		0.0147 J	ND (0.0071)	ND (0.0071)	ND (0.0071)
	Copper	mg/L		0.212	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L		30.6	0.517	0.242	0.356
	Lead	mg/L		1.49	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L		1,400	1,470	1,070	1,320
	Manganese	mg/L		1.12	0.343	0.248	0.178
	Nickel	mg/L		0.0182 J	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L		6.82	5.26	3.91	3.15
	Sodium	mg/L		34.1	35.7	32.2	22.6
	Vanadium	mg/L		0.0398	ND (0.0026)	ND (0.0026)	0.0030 J
	Zinc	mg/L		2.99	0.0168 J	ND (0.0086)	ND (0.0086)
Dissolved	Mercury	mg/L		ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Arsenic	mg/L		ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L		ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L		ND (0.0190)	0.0666 J	0.0445 J	ND (0.0190)
	Barium	mg/L		0.0756 J	0.0748 J	0.0584 J	0.0532 J
	Cadmium	mg/L		ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L		454	393	448	450
	Chromium	mg/L		ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L		ND (0.0071)	ND (0.0071)	ND (0.0071)	ND (0.0071)
	Copper	mg/L		ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L		0.0620 J	0.0903 J	0.1030	0.0540 J
	Lead	mg/L		ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L		1,410	1,440	1,120	1,260
	Manganese	mg/L		0.370	0.332	0.259	0.171
	Nickel	mg/L		ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L		5.32	5.05	3.86	3.13
	Sodium	mg/L		33.8	34.9	31.6	29.2
	Vanadium	mg/L		ND (0.0026)	ND (0.0026)	ND (0.0026)	0.0029 J
	Zinc	mg/L		ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324874

Table B.8

B-4 : Barium-rich PRB material well (5 wt. parts MgCO₃), Rotosonic installed
 Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-4" Treatment Well	Units	17-Jan-01 15:00	19-Jan-01			
Field Parameters	pH						
	Redox	mV					
	Conductivity	µmho					
	Turbidity	NTU					
	Dissolved Oxygen	mg/L					
	Temperature	°C					
	Alkalinity to pH 8.3	mg/L	30.7	25.2			
	Alkalinity to pH 4.5	mg/L	97.4	72			
	Chloride	mg/L	38	30			
	TSS	mg/L	ND (4.1)				
	Mercury	mg/L	ND (0.00012)				
	Sulfate	mg/L	4,800	3,300			
	Sulfide	mg/L	ND (0.53)				
	Bicarbonate	mg/L	36.0	21.6			
	Carbonate	mg/L	61.4	50.4			
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)			
	Selenium	mg/L	ND (0.0600)	ND (0.0600)			
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)			
	Barium	mg/L	0.0515 J	0.0536 J			
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)			
	Calcium	mg/L	488				
	Chromium	mg/L	ND (0.0066)	ND (0.0066)			
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)			
	Copper	mg/L	ND (0.0027)	ND (0.0027)			
	Iron	mg/L	0.108	0.321			
	Lead	mg/L	ND (0.0300)	ND (0.0300)			
	Magnesium	mg/L	862				
	Manganese	mg/L	0.130	0.115			
	Nickel	mg/L	ND (0.0084)	ND (0.0084)			
	Potassium	mg/L	2.67	2.16			
	Sodium	mg/L	24.5	21.8			
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)			
	Zinc	mg/L	ND (0.0086)	ND (0.0086)			
Dissolved	Mercury	mg/L	ND (0.00012)				
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)			
	Selenium	mg/L	ND (0.0600)	ND (0.0600)			
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)			
	Barium	mg/L	0.0504 J	0.0520 J			
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)			
	Calcium	mg/L	515				
	Chromium	mg/L	ND (0.0066)	ND (0.0066)			
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)			
	Copper	mg/L	ND (0.0027)	ND (0.0027)			
	Iron	mg/L	0.0440 J	0.1370			
	Lead	mg/L	ND (0.0300)	ND (0.0300)			
	Magnesium	mg/L	880				
	Manganese	mg/L	0.139	0.116			
	Nickel	mg/L	ND (0.0084)	ND (0.0084)			
	Potassium	mg/L	2.79	2.11			
	Sodium	mg/L	25.8	20.9			
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)			
	Zinc	mg/L	ND (0.0086)	ND (0.0086)			

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324875

Table B.9

B-5 : Barium-rich PRB material well (15 wt. parts MgCO₃), Rotosonic installed
 Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-5" Treatment Well	Units	9-Jan-01	11-Jan-01	12-Jan-01	15-Jan-01	17-Jan-01 10:00
Field Parameters	pH						
	Redox	mV					
	Conductivity	µmho					
	Turbidity	NTU					
	Dissolved Oxygen	mg/L					
	Temperature	°C					
	Alkalinity to pH 8.3	mg/L	40.9	50.2	43.9	43	38.9
	Alkalinity to pH 4.5	mg/L	157	154	131	111	106
	Chloride	mg/L	111	104	76	64	54
	TSS	mg/L	270	4.8 J	ND (4.1)	ND (4.1)	ND (4.1)
	Mercury	mg/L	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012)
	Sulfate	mg/L	5,900	7,500	6,900	6,400	7,000
	Sulfide	mg/L	ND (0.53)	ND (0.53)	ND (0.53)	ND (0.53)	ND (0.53)
	Bicarbonate	mg/L	74.8	53.3	42.9	25.2	28.4
	Carbonate	mg/L	81.9	100	87.8	86.1	77.9
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	11.2	0.157 J	0.0688 J	0.0505 J	ND (0.0190)
	Barium	mg/L	1.77	0.0914 J	0.0680 J	0.0478 J	0.0481 J
	Cadmium	mg/L	0.0079 J	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	590	395	403	436	447
	Chromium	mg/L	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	0.0071 J	ND (0.0071)	ND (0.0071)	ND (0.0071)	ND (0.0071)
	Copper	mg/L	0.0530	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	14.8	0.198	0.0637 J	0.116	0.188
	Lead	mg/L	0.297	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	1,250	1,740	1,580	1,350	1,190
	Manganese	mg/L	0.514	0.311	0.222	0.169	0.170
	Nickel	mg/L	0.0099 J	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	6.69	6.17	5.25	4.23	3.89
	Sodium	mg/L	45.1	54.5	44.0	44.6	82.6
	Vanadium	mg/L	0.0218	ND (0.0026)	ND (0.0026)	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	0.470	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)
Dissolved	Mercury	mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)	ND (0.0320)
	Selenium	mg/L	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)	ND (0.0600)
	Aluminum	mg/L	ND (0.0190)	0.0515 J	0.0611 J	0.0275 J	ND (0.0190)
	Barium	mg/L	0.0851 J	0.0571 J	0.0544 J	0.0435 J	0.0400 J
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)	ND (0.0036)
	Calcium	mg/L	438	395	417	445	466
	Chromium	mg/L	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)	ND (0.0066)
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)	ND (0.0071)	ND (0.0071)	ND (0.0071)
	Copper	mg/L	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)	ND (0.0027)
	Iron	mg/L	ND (0.0067)	0.0137 J	ND (0.0067)	0.0101 J	0.0169 J
	Lead	mg/L	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)	ND (0.0300)
	Magnesium	mg/L	1,460	1,570	1,530	1,320	1,420
	Manganese	mg/L	0.143	0.244	0.213	0.153	0.106
	Nickel	mg/L	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)	ND (0.0084)
	Potassium	mg/L	6.19	5.85	4.76	4.07	3.75
	Sodium	mg/L	44.6	48.6	43.9	40.2	54.7
	Vanadium	mg/L	0.0028 J	ND (0.0026)	ND (0.0026)	ND (0.0026)	ND (0.0026)
	Zinc	mg/L	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)	ND (0.0086)

ND

Analyte not detected at
concentration shown

J

Result was between the
MDL and the PQLTables prepared by W. R.
Kahl, checked by D. Vitek

AR324876

Table B.9

B-5 : Barium-rich PRB material well (15 wt. parts MgCO₃), Rotosonic installed
 Permeable Reactive Barrier Field Tests, Newport Superfund Site, Newport, Delaware

	"Barium-5" Treatment Well	Units	17-Jan-01 15:00	19-Jan-01			
Field Parameters	pH						
	Redox	mV					
	Conductivity	µmho					
	Turbidity	NTU					
	Dissolved Oxygen	mg/L					
	Temperature	°C					
	Alkalinity to pH 8.3	mg/L	36.2	35.2			
	Alkalinity to pH 4.5	mg/L	97.2	87.0			
	Chloride	mg/L	50	39			
	TSS	mg/L	ND (4.1)				
	Mercury	mg/L	ND (0.0012)				
	Sulfate	mg/L	5,800	3,600			
	Sulfide	mg/L	ND (0.53)				
	Bicarbonate	mg/L	24.7	16.7			
	Carbonate	mg/L	72.5	70.3			
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)			
	Selenium	mg/L	ND (0.0600)	ND (0.0600)			
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)			
	Barium	mg/L	0.0375 J	0.0375 J			
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)			
	Calcium	mg/L	487				
	Chromium	mg/L	ND (0.0066)	ND (0.0066)			
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)			
	Copper	mg/L	ND (0.0027)	ND (0.0027)			
	Iron	mg/L	0.0854 J	0.0524 J			
	Lead	mg/L	ND (0.0300)	ND (0.0300)			
	Magnesium	mg/L	1,120				
	Manganese	mg/L	0.102	0.0663			
	Nickel	mg/L	ND (0.0084)	ND (0.0084)			
	Potassium	mg/L	3.25	2.27			
	Sodium	mg/L	44.2	30.9			
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)			
	Zinc	mg/L	ND (0.0086)	ND (0.0086)			
Dissolved	Mercury	mg/L	ND (0.00012)				
	Arsenic	mg/L	ND (0.0320)	ND (0.0320)			
	Selenium	mg/L	ND (0.0600)	ND (0.0600)			
	Aluminum	mg/L	ND (0.0190)	ND (0.0190)			
	Barium	mg/L	0.0365 J	0.0376 J			
	Cadmium	mg/L	ND (0.0036)	ND (0.0036)			
	Calcium	mg/L	484				
	Chromium	mg/L	ND (0.0066)	ND (0.0066)			
	Cobalt	mg/L	ND (0.0071)	ND (0.0071)			
	Copper	mg/L	ND (0.0027)	ND (0.0027)			
	Iron	mg/L	0.0106 J	ND (0.0067)			
	Lead	mg/L	ND (0.0300)	ND (0.0300)			
	Magnesium	mg/L	1,110				
	Manganese	mg/L	0.102	0.0564			
	Nickel	mg/L	ND (0.0084)	ND (0.0084)			
	Potassium	mg/L	3.22	2.17			
	Sodium	mg/L	42.8	28.4			
	Vanadium	mg/L	ND (0.0026)	ND (0.0026)			
	Zinc	mg/L	ND (0.0086)	ND (0.0086)			

ND	Analyte not detected at concentration shown
J	Result was between the MDL and the PQL
	Tables prepared by W. R. Kahl, checked by D. Vitek

AR324877

APPENDIX C

AR324878

APPENDIX C
DETAILED COST ESTIMATES

AR324879

**SOUTH LANDFILL PROJECT REMEDY ALTERNATIVES
COST ESTIMATES**

**NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE**

prepared for:

**DUPONT CORPORATE REMEDIATION GROUP
WILMINGTON, DELAWARE**

prepared by:

**URS CORPORATION
282 DELAWARE AVENUE
BUFFALO, NEW YORK 14202**

DECEMBER 2000

AR324880

PERMEABLE REACTIVE WALL ESTIMATE

NEWPORT SUPERFUND SITE					
SOUTH LANDFILL REMEDY					
PERMEABLE REACTIVE WALL					
Description	Quantity	Unit	Unit Cost	Total Cost	
Site Preparation	19.7	Acre	\$ 12,610	\$	248,417
Permeable Reactive Wall					
Iron Filings - 5 parts per weight	120	Ton	\$ 400	\$	48,000
Gypsum - 20 parts per weight	450	Ton	\$ 22	\$	9,900
Magnesium Carbonate - 5 parts per weight	120	Ton	\$ 3,140	\$	376,800
Sand - 100 parts per weight	2,310	Ton	\$ 9.30	\$	21,483
Prepare and Handle Wall Mix	27,000	SF	\$ 5.60	\$	151,200
Continuous Trench Excavation and Placement	2,000	LF	\$ 170.00	\$	340,000
Subtotal				\$	947,383
Slurry Wall					
Bentonite	135	Ton	\$ 135	\$	18,225
Common Fill	2,700	CY	\$ 11.25	\$	30,375
Mixing & Placing Wall	21,800	SF	\$ 4.60	\$	100,280
Subtotal				\$	148,880
Landfill Cap - geomembrane, geocomposite, 12" cover soil, 6" top	16.1	Acre	\$ 105,629	\$	1,700,627
Riverbank Protection	1,350	LF	\$ 155.00	\$	209,250
Road Crossings	2	Each	\$ 1,637	\$	3,275
Performance Monitoring Wells along PRB Wall	1	LS	\$ 30,000	\$	30,000
Cap Tie-in to South James Street	1	LS	\$ 57,000	\$	57,000
Direct Cost Subtotal				\$	3,344,831
General Conditions	100%	Lump Sum	Nec.	\$	250,000
Main Office Overhead	7.7	Percent	\$3,344,831	\$	257,552
Profit	10	Percent	\$3,344,831	\$	334,483
Engineering and Project Support	7	Percent	\$3,344,831	\$	234,138
Monitoring and Maintenance	100%	Lump Sum	Nec.	\$	385,000
Contingency	5	Percent	\$4,806,005	\$	4,806,005
Subtotal				\$	240,300
TOTAL				\$	5,046,305

AR324882

**NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
PERMEABLE REACTIVE WALL**

Assumptions:

Permeable Reactive Wall (PRW) = 27,000 sf - ref. attached calcs.

Slurry Wall (SW): 1,450 lf*15' deep*3' thick => 65,250 cf or 2,417 cy, SAY 2,450 cy

Gypsum cost => \$0, ref. John Wilkens 12/1/99 e-mail & William Lacy Gray, Jr. Letter dated 2/11/00

Deliver gypsum => \$22/Ton, ref. John Wilkens 12/1/99 e-mail & William Lacy Gray, Jr. Letter dated 2/11/00

Magnesite=> Use 120 Tons, ref. URS backup

Gypsum => 450 Tons-ref. URS backup

Iron Filings => Use 120 Tons, ref. URS backup

Iron Filings => Use \$400/Ton, ref. URS backup & Peerless letter dated 4/7/00, use 5% iron filings, ref. Brandt Butler 2/16/00 e-mail

PRW Volume => 40500 CF / 27 cf per cy = 1,500 CY

Sand (PRW) volume => Use 2,310 ton per attached URS backup, sand cost is \$9.30/ton per Nancy Griskowitz, 2/24/00

Continuous Trench Excavation and Placement => Use \$170/lb per attached URS backup 12/14/00

The Landfill Cap consists of a geomembrane, 12" of cover soil, and 6" of topsoil

The cap costs identified in the URS backup are for the cap components only. The cap unit cost is increased by 51% to include the remaining closure components, e.g., surficial drainage features/structures (swales/downchutes), perimeter drainage (channels and/or pipes), gas collection system (vents), perimeter fencing, access roads, etc.

This is consistent with the URS North Landfill Closure estimate (\$ 69,953 x 151% = 105,629)

Assume 10 performance monitoring wells in wall. Also two sets (transect clusters) of 2 wells outside wall for downgradient monitoring

Assume \$25,000 per year per Brandt Butler telecon 4/20/00, Present Worth of 30 yrs @ i = 5%

Main Office Overhead @ 7.7% is from 2000 Means (Heavy Construction)

Engineering and Project Support: use 7% per URS average for work of this nature

Profit is assumed to be 10%

A 5% contingency has been added at the discretion of the estimator

All manpower, equipment, unit costs, productivity, quantities, etc. have been discussed with and verified by Geo-Con

NOTE: ANY POTENTIAL PATENT ROYALTY FEES FOR WALL CONSTRUCTION PROCESS NOT INCLUDED

AR324883

PERMEABLE REACTIVE WALL

Current Prevailing Labor/Wage Rates – New Castle County, Delaware

	<i>Hrly. Base Rate</i>	<i>PT & I</i>	<i>Loaded Hrly. Rate</i>
Labor Forman	\$25.68	35%	\$34.67
Laborer	\$24.58	35%	\$33.18
Operating Engineer	\$34.76	35%	\$46.93
Truck Driver	\$22.10	35%	\$29.84

Truck Rental Rates

	<i>2000 Means</i>	<i>Monthly rate ÷ hr./mo. = hrly. rate + hrly. op.cost = hrly. rate</i>
Concrete Truck	016-406-3300	\$9,225/mo ÷ 176 hrs. = \$ 52.50 + \$32.50/hr. = \$85.00/hr.
Dump Truck	016-408-5250	\$3,375/mo ÷ 176 hrs. = \$19.20 + \$17.40/hr. = \$36.60/hr.
Water Truck	016-420-6900	\$700/wk. ÷ 40 hrs. = \$17.50 + \$11.07/hr. = \$28.57/hr.

Equipment Rental Rates

	<i>2000 Means</i>	<i>Monthly rate ÷ hr./mo. = hrly. rate + hrly. op.cost = hrly. rate</i>
1½ cy Backhoe	016-408-0200	\$7,500/mo. + 176 hrs. = \$42.60 + \$26.60/hr. = \$69.20/hr.
1¼ cy Loader	016-408-4650	\$3,650/mo. ÷ 176 hrs. = \$20.75 + \$12.50/hr. = \$33.25/hr.
150 HP Dozer	016-409-4200	\$5,530/mo. + 176 hrs. = \$31.75 + \$17.00/hr. = \$48.75/hr.
Trash Pump – 4"	016-420-5600	\$870/mo. ÷ 176 hrs. = \$5.00 + \$2.00/hr. = \$7.00/hr.
Batch Plant Model 65-110 YPH Blue Book	\$5,190/mo. ÷ 176 hrs. = \$29.50 + \$8.25/hr. = \$37.75/hr.	

AR324884

PERMEABLE REACTIVE WALL

Site Preparation

The South landfill site is approximately 16 acres, ref. Nancy Griskowitz e-mail dated 2/3/00

16 acres x 43,560 sf/acre = 696,960 sf

Estimate cost based on 16 acres - CADD takeoff of 12/18/00 indicated 19.7 acres (limits of disturbance)

The site contains an earthen, bermed holding cell and a cleared area with stone roads including a parking area. Assume 1/3 of the site has medium trees that will be cut with the stumps chipped and grubbed. Brush hog 1/3 of the site to remove brush and small trees.

Site grading includes collapsing the earthen berms and grading the site to receive a double barrier geosynthetic cap

2-dozers w/ operators, 1-loader w/ operator, 2-trucks w/ drivers, 1-labor foreman, 2-laborers

696,960 sf ÷ 20,000 sf/day = 35 Days

Dozer	560 hrs. x \$48.75/hr.	= \$27,300
Loader	280 hrs. x \$33.25/hr.	= \$9,310
Truck	560 hrs. x \$36.60/hr.	= \$20,496
Operator	840 hrs. x \$46.93/hr.	= \$39,421
Truck Driver	560 hrs. x \$28.84/hr.	= \$16,151
Labor Foreman	280 hrs. x \$34.67/hr.	= \$9,708
Laborer	560 hrs. x \$33.18/hr.	= <u>\$18,851</u>
	Subtotal	\$140,966

AR324885

PERMEABLE REACTIVE WALL

Site Preparation (cont'd.)

	2000 Means		
Chip Trees	021-104-0200	6 acres x \$3,275/ac.	= \$19,650
Grub Stumps	021-104-0250	6 acres x \$2,180/ac.	= \$13,080
Brush Hog	021-108-0600	6 acres x \$3,094/ac.	= \$18,564
Erosion Control	022-704-1100	3,650 lf x \$2.60/lf	= \$ 9,490
		Subtotal	\$60,784
		Subtotal, previous page	<u>\$140,966</u>
		Total	\$201,750 ÷ 16 ac. = ~ \$12,609.38 per acre
		SAY	\$12,610 per acre

AR324886

PERMEABLE REACTIVE WALL

This estimate is based on the following installation procedure(s) for the permeable reactive wall wall.

- grade permeable reactive wall area
- mix the gypsum/iron filings/magnesite/common fill in concrete trucks, weigh materials
- install wall with continuous one pass excavation equipment
- advance the permeable reactive wall installation until complete
- haul & dispose of all trench excavated soils (waste) to a designated area within the South landfill

Wall mix based on weight:

Sand: 100 lbs	Sand: 100 lbs/130 lbs total = 77%
Gypsum: 20 lbs	Gypsum: 20 lbs/130 lbs total = 15%
Iron: 5 lbs	Iron: 5 lbs/130 lbs total = 4%
Magnesite: 5 lbs	Magnesite: 5 lbs/130 lbs total = 4%

AR324887

PERMEABLE REACTIVE WALL (cont'd.)

Material Quantities/Cost

Sand

27,000 sf x 1.5-ft. wide = 40,500 cf ÷ 27 cf/cy = 1,500 cy

1,500 cy x 110% = 1,650 cy, Say 1,800 cy

1,800 cy x 1.62 ton/cy = 2,916 ton, Say 3,000 ton Total Wall Weight

3,000 ton * 77% = 2,310 tons

Material Cost: \$9.30/ton for mason sand (concrete sand is \$8.80/ton) per Nancy Griskowitz on 2/24/00

Iron Filings

3,000 ton x 4% = 120 tons

Material Cost: \$394/ton, SAY \$400/ton, ref. Peerless letter dated 4/7/00

Gypsum

3,000 ton x 15% = 450 tons

Material Cost: \$0

Delivery Cost: \$22/ton, ref. DuPont (Wm. Lacy Gray, Jr.) letter dated 2/11/00

Magnesite

3,000 ton x 4% = 120 tons

Material Cost: \$1.55/lb = \$3,120/ton, ref. Brandt Butler/Michele Thomson telecon dated 11/21/00

Delivery Cost: Tractor Trailer – 40 tons/day * 6 days * \$700/day = \$4200/228 tons = \$18.50/ton SAY \$20/ton

AR324888

PERMEABLE REACTIVE WALL

Crew Assumptions

1. 5 days to grade the ditch & prepare haul road access for concrete trucks, assume 8 hrs. per day
 - 1-dozer, 1-operator, 1-laborer
2. Erect batch plant, assume 2 days
 - 1-backhoe, 1-labor foreman, 1-operator, 2-laborers
3. 20 days to install the permeable reactive wall, assume 10 hrs. per day (11 hrs./day for laborers & operators)
 - 2-loaders, 2-operators, 3-concrete trucks w/ drivers, 1-labor foreman, 2-laborers, 1 - batch plant
4. 4 days for site cleanup, assume 8 hrs. per day
 - 1-dozer, 1-loader, 2-operators, 1-dump truck w/ driver, 1-laborer

Unit Price Development

Dozer	40 hrs. x	\$48.75/hr.	=	\$1,950
Operator	40 hrs. x	\$46.93/hr.	=	\$1,877
Labor	40 hrs. x	\$33.18/hr.	=	\$1,327
Backhoe	16 hrs. x	\$69.20/hr.	=	\$1,108
Labor Foreman	16 hrs. x	\$34.67/hr.	=	\$555
Laborer	32 hrs. x	\$33.18/hr.	=	\$1,062
Operator	16 hrs. x	\$46.93/hr.	=	\$751

AR324889

PERMEABLE REACTIVE WALL (cont'd.)

Loader	400 hrs. x \$33.25/hr.	=	\$13,300
Operator	440 hrs. x \$46.93/hr.	=	\$20,650
Labor Foreman	220 hrs. x \$34.67/hr.	=	\$7,627
Laborer	440 hrs. x \$33.18/hr.	=	\$14,600
Concrete Truck	600 hrs. x \$85.00/hr.	=	\$51,000
Driver	600 hrs. x \$29.84/hr.	=	\$17,904
Batch Plant	200 hrs. x \$37.75/hr.	=	\$7,550
Dozer	32 hrs. x \$48.75/hr.	=	\$1,560
Operator	32 hrs. x \$46.93/hr.	=	\$1,501
Laborer	32 hrs. x \$29.84/hr.	=	\$955
Dump Truck	32 hrs. x \$36.00/hr.	=	\$1,171
Driver	32 hrs. x \$29.84/hr.	=	<u>\$955</u>

Total \$147,403 ÷ 27,000 sf => \$5.46 per sf

SAY \$5.60 per sf

AR324890



Memorandum

Date: December 14, 2000

To: File 05-00035849.00

From: Michael Azzarella

Subject: **DuPont South Landfill – Cost Estimate**

I have discussed the South Landfill project with Al Meyer who is the chief estimator at the URS Denver office. He has estimated many of these permeable reactive wall projects. We discussed the specifics of this project and he provided me with the following costs:

1. Continuous trench excavation and placement of wall. An 18-inch wall will require one pass at a cost of approximately \$160.00/LF. Need to add approximately \$10/LF (for a total of \$170/LF) for any required benching operations and backfill over top of wall to existing grade.
2. Performance monitoring wells. Assume at each monitoring location along the wall the following sets of wells to be installed: one 3-well cluster inside and outside the wall plus one well into the wall. Well sets are typically installed every 150 to 200 feet along the length of wall. Cost for each set equals approximately \$10,000.

AR324891

SLURRY WALL

This estimate is based on the following installation procedure(s) for the slurry wall.

- grade slurry wall area
- initiate trench excavation
- pump a 5% bentonite & water mixture into the trench excavation to stabilize the trench sidewalls
- mix 3% bentonite & common fill outside of the trench
- push the 3% bentonite and common fill mixture into the trench with a dozer after the design invert of the trench has been achieved & verified
- advance the slurry wall installation until complete
- haul & dispose of all trench excavated soils (waste) to a designated area within the South landfill

A productivity of ~1,500 sf per day for a 3-foot thick slurry wall can be achieved/maintained using the above installation procedures.

Slurry Wall Quantities:

Length x Height => PRW area

Wall area x Wall thickness => Wall volume

1,450 lf x 15 ft. => 21,750 sf

21,750 sf x 3 ft. => 65,250 cf ÷ 27 cf/cy => 2,417 cy, **SAY 2,450 cy**

Using a productivity of ~1,500 sf per day and a wall area of ~21,800 sf, it will take ~ 15 days to install the slurry wall.

21,800 sf ÷ 1,500 sf/day = ~ **15 Days**

AR324892

SLURRY WALL (cont'd.)

Crew Assumptions

1. 5 days to grade the ditch, assume 8 hrs. per day
 - 1-dozer, 1-operator, 1-labor foreman, 1-laborer
2. 15 days to install the slurry wall, assume 10 hrs. per day (11 hrs./day for laborers & operators)
 - 1-backhoe, 2-dozers, 1-loader, 3-operators, 1-dump truck w/ driver, 1-water truck w/ driver, 1-4" pump, 1-labor foreman, 2-laborers
3. 3 days for site cleanup, assume 8 hrs. per day
 - 1-dozer, 1-loader, 2-operators, 1-dump truck w/ driver, 1-laborer

Unit Price Development

Dozer	40 hrs. x	\$48.75/hr.	=	\$1,950
Operator	40 hrs. x	\$46.93/hr.	=	\$1,877
Labor Foreman	40 hrs. x	\$34.67/hr.	=	\$1,387
Laborer	40 hrs. x	\$33.18/hr.	=	\$1,327
Backhoe	150 hrs. x	\$69.20/hr.	=	\$10,380
Dozer	300 hrs. x	\$48.75/hr.	=	\$14,625
Operator	495 hrs. x	\$46.93/hr.	=	\$23,230
Labor Foreman	145 hrs. x	\$34.69/hr.	=	\$5,721
Laborer	330 hrs. x	\$33.18/hr.	=	\$10,949
Dump Truck	150 hrs. x	\$36.60/hr.	=	\$5,490
Driver	165 hrs. x	\$29.84/hr.	=	\$4,924
		Subtotal		\$81,860

AR324893

SLURRY WALL (cont'd.)

Pump - 4"	150 hrs.	x	\$7.00/hr.	=	\$1,050
Dozer	32 hrs.	x	\$48.75/hr.	=	\$1,560
Loader	32 hrs.	x	\$33.25/hr.	=	\$1,064
Operator	64 hrs.	x	\$46.93/hr.	=	\$3,004
Labor	32 hrs.	x	\$33.18/hr.	=	\$1,064
Dump Truck	32 hrs.	x	\$36.60/hr.	=	\$1,171
Driver	32 hrs.	x	\$28.84/hr.	=	\$955
Water Truck	120 hrs.	x	\$28.57/hr.	=	\$3,428
Driver	120 hrs.	x	\$29.84/hr.	=	<u>\$3,581</u>
			Subtotal		\$16,877
			Subtotal, previous page		<u>\$81,860</u>
			Total		\$98,737 ÷ 21,800 sf => \$4.53/sf
			SAY		\$4.60 per sf

AR324894

SLURRY WALL (cont'd.)

Material Quantities

The following mixing rates and material costs were obtained from Mike Cary of Geo-Con.

Mix 6 lbs/sf (of wall) of bentonite with water

1,450 lf x 15 ft. = 21,750 sf x 6 lbs/sf = 130,500 lbs. ÷ 2,000 lbs/ton = 65.8 ton, **SAY 66 ton**

Mix 55 #/cy of bentonite with backfill

21,750 sf x 3 ft. = 65,250 cf ÷ 27 cf/cy = 2,420 cy x 55 #/cy = 133,100 lbs. ÷ 2,000 lbs/ton = 66.5 tons, **SAY 67 ton**

Bentonite

Bentonite cost including delivery is \$135/ton

66 ton + 67 ton = 133 ton

SAY 135 ton

Common Fill

Limited displacement by bentonite

Wall volume x 10%

2,450 cy x 110% = 2,695 cy

SAY 2,700 cy

Material Cost: \$11.25/cy, ref. John Wolfe memo dated 1/24/00

AR324895

SOUTH LANDFILL CLOSURE COSTS

Case #	Description	Cost per Acre (cap components only)	Cost per Acre (total closure)
Case 1	6" topsoil	\$ 3,833	\$ 5,788
Case 2	6" topsoil	\$ 3,832	
	12" barrier soil	\$ 19,994	
	Total Cost	\$ 23,826	\$ 35,977
Case 2-1	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	12" barrier soil	\$ 19,994	
	Total Cost	\$ 49,812	\$ 75,216
Case 3	6" topsoil	\$ 3,833	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 25,177	\$ 38,017
Case 3-1	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 51,162	\$ 77,255
Case 3a	6" topsoil	\$ 3,833	
	drainage net	\$ 23,958	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 49,135	\$ 74,194

AR324896

SOUTH LANDFILL CLOSURE COSTS (cont'd.)

Case #	Description	Cost per Acre (cap components only)	Cost per Acre (total closure)
Case 3a-1	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	drainage net	\$ 23,958	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 75,120	\$ 113,431
Case 4	4" asphalt	\$ 30,928	
	8" stone	\$ 35,719	
	geosynthetic liner	\$ 16,177	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 104,168	\$ 157,294
Case 4-1	4" asphalt	\$ 30,928	
	8" stone	\$ 35,719	
	24" waste	\$ 15,633	
	Total Cost	\$ 82,280	\$ 124,243
Case 4a	4" asphalt	\$ 30,928	
	8" stone	\$ 35,719	
	drainage net	\$ 23,958	
	geosynthetic liner	\$ 16,177	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 128,126	\$ 193,470
Case 4a-1	4" asphalt	\$ 30,928	
	8" stone	\$ 35,719	
	drainage net	\$ 23,958	
	24" waste	\$ 15,633	
	Total Cost	\$ 106,238	\$ 160,419

AR324897

SOUTH LANDFILL CLOSURE COSTS (cont'd)

Case#	Description	Cost per Acre (cap components only)	Cost per Acre (total closure)
Case 5	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	geosynthetic liner	\$ 16,177	
	12" barrier soil	\$ 19,994	
	Total Cost	\$ 65,989	\$ 99,643
Case 5a	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	drainage net	\$ 23,958	
	geosynthetic liner	\$ 16,177	
	12" barrier soil	\$ 19,994	
	Total Cost	\$ 89,947	\$ 135,820
Case 6 PRW	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	drainage net	\$ 23,958	
	geosynthetic liner	\$ 16,177	
	Total Cost	\$ 69,953	\$ 105,629
Case 6a ESD	6" topsoil	\$ 3,833	
	12" cover soil	\$ 25,985	
	drainage net	\$ 23,958	
	geosynthetic liner	\$ 16,177	
	bentonite mat	\$ 21,344	
	Total Cost	\$ 91,237	\$ 137,768

AR324898

PROPOSED CAP COSTS

Material Costs

Topsoil

Unit price taken from DuPont North Landfill estimate dated 3/00
\$ 3,833.32 / acre

12" Barrier Soil (low permeable soil)

Material supplied by DuPont at a site 15 miles round trip from
work area. Placement cost same as fill cost at the North Landfill

load & transport	\$ 7.54/cy
placement	\$ 4.84/cy
cost/cy	\$ 12.38/cy

\$ 12.38/cy x 1,615 cy/acre = \$ 19,993.70 / acre

Bentonite Mat (geosynthetic clay liner)

Unit price taken from DuPont North Landfill estimate dated 3/00
bentonite mat **\$ 0.49/sf**

\$ 0.49/sf x 43,560 sf/acre = \$ 21,344.40 / acre

4" Asphalt Concrete

Price taken from DuPont North Landfill estimate dated 3/00

3" binder course cost	\$ 0.50/sf
1" top course cost	\$ 0.21/sf
cost/sf	\$ 0.71/sf

\$ 0.71/sf x 43,560 sf/acre = \$ 30,927.60 / acre

AR324899

PROPOSED CAP COSTS (cont'd.)

Material Costs

8" Stone

Unit price taken from DuPont North Landfill estimate dated 3/00
8" stone \$ 0.82/sf

\$ 0.82/sf x 43,560 sf/acre = \$ 35,719.20 / acre

Drainage Geonet (geocomposite)

Quote from Chanango Contracting \$ 0.55/sf

\$ 0.55/sf x 43,560 sf/acre = \$ 23,958.00 / acre

Geosynthetic Liner

Unit price taken from DuPont North Landfill estimate dated 3/00
geosynthetic liner \$ 0.37/sf

\$ 0.37/sf x 43,560 sf/acre = \$ 16,117.20 / acre

12" of Cover Soil

Unit price taken from DuPont North Landfill estimate dated 3/00

\$ 16.09/cy x 1,615 cy/acre = \$ 25,985.35 / acre

AR324900

PROPOSED CAP COSTS (cont'd.)

Material Costs

24" of Waste

Unit price taken from DuPont North Landfill estimate dated 3/00
placement cost same as placing barrier soil x 2 lifts

barrier soil	\$ 16.09/cy
deduct material	\$ 11.25/cy
	cost/cy
	\$ 4.84/cy

\$ 4.84/cy x 3,230 cy/acre = \$ 15,633.20 / acre

AR324901

RIVERBANK PROTECTION

Furnish and place 30" +/- of rip rap along the south bank of the Christina River from approximately the James Street bridge to approximately 40 feet upstream from the west end of the proposed slurry wall/permeable reactive wall junction.

Length 1350 lf
Depth 30" +/-

Rip Rap – 30"

Volume	=	(1,350 lf x 19 lf x 2.5) * 130 % for grade variation			
	=	83,365 sf			
	=	3,090 cy	Quantity	Unit	
			3,090	cy	
				Unit Price	\$58.45
				Total	\$180,611

80 Mil Textured Liner

60 mil liner from South Landfill Costs	=	\$0.37/sf
add 50% for 80 mil textured	=	<u>\$0.19/sf</u>
Cost for 80 mil textured	=	\$0.56/sf

Area: 1,350 lf * 19' width = 25,650 sf

AR324902

RIVERBANK PROTECTION (cont'd)

GDC

GDC from South Landfill costs = \$0.55/sf

Area: 1,350 lf * 19' width = 25,650 sf

Rip Rap Costs \$180,611

80 mil Textured Liner: 25,650 sf * \$0.56/sf = \$14,364

GDC: 25,650 sf * \$0.55/sf = \$14,108

Total Cost of Riverbank Protection \$209,083

\$209,083/1,350 lf = \$154.80/lf SAY \$155.00/lf

AR324903

ROAD CROSSINGS

T/O Sawcut 4 locations @ 45 lf/ea = 180 lf
 Excavation 2 ea. x 50 lf x 15' wide x 1.65' deep = 2,475 cf/27 cf/cy = 92 cy
 Filter fabric 2 ea. x 50 lf x 15' wide = 1,500 sf/ 9 sf/sy = 167 sy
 Subbase 2 ea. x 50 lf x 15' wide x 0.7' deep = 1,050 cf/ 27 cf/cy = 39 cy
 2-1/2" binder 2 ea. X 50 lf x 15' wide = 1,500 sf/ 9 sf/sy = 167 sy
 1" top same quantity as binder, Use 167 sy

Description	Means 2000	Unit Price	Quantity	Unit	Amount
Sawcut to 3"	02225-760-0010		\$0.91	180 lf	\$163.80
Added depth 2"	02225-760-0020		\$0.90	180 lf	\$162.00
Excavation	02315-200-4000		\$7.74	92 cy	\$712.08
Trucking	02320-200-0320		\$2.52	92 cy	\$231.84
Filter Fabric	02720-200-6000		\$0.92	167 sy	\$153.64
Stone Subbase	02720-200-0303		\$7.37	39 cy	\$287.43
2-1/2" Binder Course	02740-300-0160		\$4.49	167 sy	\$749.83
1" Top Course	02740-300-0300		\$1.88	167 sy	\$313.96
Restoration	allowance		\$500	1 ls	\$500.00

Total Cost \$3,274.58

Unit Cost \$3,474.58/2 ea = \$1,637/ea.

AR324904

Date: December 14, 2000
To: File 05-00035849.00
From: Michael Azzarella
Subject: **DuPont South Landfill – Cost Estimate**

I have discussed the South Landfill project with Al Meyer who is the chief estimator at the URS Denver office. He has estimated many of these permeable reactive wall projects. We discussed the specifics of this project and he provided me with the following costs:

1. Continuous trench excavation and placement of wall. An 18-inch wall will require one pass at a cost of approximately \$160.00/LF. Need to add approximately \$10/LF (for a total of \$170/LF) for any required benching operations and backfill over top of wall to existing grade.
2. Performance monitoring wells. Assume at each monitoring location along the wall the following sets of wells to be installed: one 3-well cluster inside and outside the wall plus one well into the wall. Well sets are typically installed every 150 to 200 feet along the length of wall. Cost for each set equals approximately \$10,000.

AR324905

DUPONT NEWPORT SOUTH LANDFILL
SOUTH JAMES ETREET TIE-IN ALTERNATIVES
COST ESTIMATE

ALTERNATIVE 3
INCORPORATE EXISTING ROAD AS A CAP COMPONENT
REPLACE SHOULDER

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization/Demobilization	LS	1	\$3,500	\$3,500
Shoulder Repair				
- shoulder sawcutting	LF	2,000	\$1.16	\$2,320
- remove shoulder, 8' width	SY	900	\$0.60	\$540
- install bedding stone, 8' width	CY	30	\$118	\$3,540
- install asphalt pavement, 2" shoulder	SY	900	\$3.57	\$3,213
Saw Cut Pavement for Barrier Wall	LF	268	\$5.96	\$1,597
Pavement and Base Course Removal	CY	25	\$65	\$1,620
Stone Base Course Installation	CY	15	\$99	\$1,481
Asphalt Pavement - 5" Total Depth	SY	60	\$20.94	\$1,256
Liner Installation Under Shoulder	SY	1,000	\$6.30	\$6,300
Surveying	DAY	7	\$1,125	\$7,875
Traffic Control	LS	1	\$18,200	\$18,200
Subtotal				\$51,443
Contingencies - 10%				\$5,144
Total				\$56,587
Say				\$57,000

Note: For shoulder replacement, sawcut, remove and replace approximately 8' (4' each side) of shoulder.

AR324906

GENERAL CONDITIONS

Project Schedule

- 1) Mobilization 5 days
- 2) Clear & Grub 6 days
- 3) Permeable Wall 20 days
- 4) Slurry Wall 15 days
- 5) Site Grading 35 days
- 6) Cap @ 4 days/acre 60 days
- 7) Demobilization 5 days

146 days ÷ 5 days/wk. = ~ 30 weeks

2000 Means

Office Trailer Means	015-904-0500	8 months x \$315/mo.	=	\$2,520
Telephone	010-034-0140	8 months x \$235/mo.	=	\$1,880
Light & Heat	010-034-0160	8 months x \$88/mo.	=	\$704
Office Supplies	010-034-0120	8 months x \$85/mo.	=	\$680
Office Equipment	010-034-0100	8 months x \$133/mo.	=	\$1,064
Port-a-John	016-420-6450	8 months x 4 ea. x \$165/mo.	=	\$5,280
Superintendent	010-036-0260	30 wks. x \$1,245/wk. x 135%	=	\$50,423
Project Manager	010-036-0200	30 wks. x \$1,320/wk. x 135%	=	\$53,460
Subtotal				\$116,011

AR324907

GENERAL CONDITIONS (cont'd.)

Survey	013-306-1200	20 days x \$575/day x 135%	=	\$15,525
Small Tools	010-082-0100	\$4,800,660 x 0.5%	=	\$24,003
Equipment & Mobilization	Geo-Con	Lump Sum	=	\$50,000
Handtools & Misc. Matl., moves @ 3 per wk.	022-274-1150	78 ea. x \$100/ea.	=	\$7,800
Insurance	010-040-0450	\$4,800,660 x 0.5%	=	\$24,003
Construction Photos 10/mo	013-803-0200	60 ea x \$190/ea.	=	\$11,400
		Subtotal		\$132,731
		Subtotal, previous page		\$116,011
		Total		\$248,742
		SAY		\$250,000

AR324908

DuPont Advanced Fibers Systems
Spruance Fibers
P.O. Box 27001
Richmond, VA 23261



DuPont Advanced Fibers Systems

FACSIMILE TRANSMITTAL COVER SHEET

TO: John C. Wokasien

LOCATION: _____

PHONE _____ FAX NO. 716-856-2545

.....

DATE: 2-11-00

FAX: 804-383-3327

FROM: _____ CHARLIE SIMMONS (804) 383-4086

X _____ LACY GRAY (804) 383-4459

_____ JANE AREHART (804) 383-2562

NUMBER OF PAGES (INCLUDING COVER SHEET): 2

IF TRANSMITTAL HAS NOT BEEN COMPLETED, CALL 804-383-2562

.....

NOTES: See Letter attached.

.....

*******CONFIDENTIALITY NOTE*******

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AR324909

DuPont Advanced Fibers Systems
Spruance Fibers
P.O. Box 27001
Richmond, VA 23281



DuPont Advanced Fibers Systems

CC: John Wilkens
Leslie Crocker - ISG Corp.

John C. Wokasien
Construction Manager
URS Greiner Woodward Clyde
282 Delaware Avenue
Buffalo, NY 14202-1805

Dear John,

DuPont Kevlar® agrees to provide the Newport South Landfill up to 200 tons of Gypsum at no charge F.O.B. our James River plant in Richmond, Virginia. Freight will be billed to your project at ~\$20-22/ton.

Please provide 30 days lead time when ordering. I understand from John Wilkens that the material will not be needed until 2001.

Very truly yours,

A handwritten signature in dark ink, appearing to read "Wm Lacy Gray, Jr.", written in a cursive style.

William Lacy Gray, Jr.
Contracted Manufacturing Manager
Advanced Fibers Systems
(804) 383-4459

WLG/jwa
ISGWokasien letter.doc
Kevlar® is a DuPont registered trademark

AR324910

**FACSIMILE
TRANSMITTAL
SHEET**

**Corporate
Remediation
Group
Newport Superfund
Site**

A DuPont and URS Alliance



To: John Wokasien

Company: URS Corp.

Phone: 716-856-5636

FAX: 716-856-2545

Total # of sheets faxed: 9

From: John H. Wolfe

Phone: 302-993-0490

FAX: 302-994-3481

Urgent () For review () Reply () Information Requested (X)

Message:

John

Attached are the rate sheets you requested.

**The price for Common Fill from Contractors Materials LLC is:
\$6.80 per Ton delivered, @ 1.5 ton per Cubic Yard.**

Allow 1.65T/cy. $6.80 \times 1.65 = 11.25 /cy$

WOLFIE

AR324911

Laborers Local No. 199

Management Unit	Allied Division, DCA		
Jurisdiction	New Castle County, Delaware		
Term of Agreement	7 June 99 thru 30 April 2002		
Wages & Contributions (hourly)	6/7/99	5/1/2000	5/1/2001
Schedule A	\$15.84	\$.80	\$.75
Schedule B	16.09	Total	Total
Schedule C	16.34	Economic	Economic
Schedule D	16.84	Increase	Increase
Schedule E	17.09		
Schedule F	19.09	24 ³⁸	
Health & Welfare	3.70		
Pension	1.65		
Training & Educ. Fund	.46		
Annuity	2.00		
Industry Advancement	0.84		

Form 25¹⁸

Deductions

*This percentage is multiplied by the total of wages and fringe contributions paid.

Premium Pay

*Pay entire day at highest rate worked during day.

Foremen

Union dues - \$.34 per hour worked.

Effective 5/1/93 - Laborers Political League - \$.02 per hour worked.

If working on stacks, silos, towers, etc. over 50 feet pay \$.25 over base wage for each additional 25 feet.

General Foremen

1 if 8 thru 19 employees on job, then 1 for every 19 employees. Pay \$1.00 per hour over highest paid employee supervised. Non-working.

Holidays

Pay \$1.00 per hour over highest paid employee supervised.

New Year's, Memorial Day, July 4, Labor Day, Thanksgiving, Christmas, General Election Day if declared by Building & Construction Trades Council. Holidays on Saturday or Sunday celebrate Friday and Monday, respectively.

Overtime & Holiday Pay

The first two hours of overtime worked Monday thru Friday and the first ten hours worked on Saturday will be paid at 1 1/2x wages, 1x contributions and 1x dues. All Sundays, holidays and over ten hours will be paid at 2x wages, 1x contributions and 1x dues. General Election Day, if worked, at straight time rates. 8 hours between 8:00 a.m. and 4:30 p.m., Monday thru Friday.

Straight Time Hours

Shifts & Differential If 2 shifts of over 8 hours each - equal

CBAS199 6/99

AR324912

Pay & Pay Day**Reporting Time****Meal Periods****Coffee Break****Transportation****Lay Off/Discharge**

pay and duration. Otherwise: 1st - midnight to 7:30 a.m. for 8 hours pay, 2nd - straight time hours and pay, 3rd - 4:30 p.m. to midnight for 8 hours pay. By check no later than quitting time Friday. Withhold 3 days. Make arrangements as to how and where checks to be cashed. No show up time if work not started due to weather. If work starts and is stopped, pay greater of 2 hours or actual time, unless stopped due to weather, then pay actual time only. If works 4 hours pay for 8 hours. If call for men in a.m. of day worked, pay 8 hours. If call for men to work in p.m. pay 4 hours. 1/2 hour (unpaid) each shift. On continuous overtime: 1/2 hour (paid) after 2 hours work and after each 4 hours worked thereafter, provided work continues after meal period. On non-scheduled overtime allow reasonable arrangement to get food. 15 minutes between 9:30 a.m. and 11:00 a.m. at work station. No payments provided job in Local's jurisdiction. If employed for more than 2 days on job, pay and allow 1/2 hour to pack tools.

Work Classifications By Schedule**Schedule A**

Laborers, general and construction
Dumpmen
Fire Watchmen
Flagmen
Salamanders
Truck Spotters

Schedule B

Caulkers; operators of pneumatic and electric tools; vibrating machines; concrete saws and pumps (which shall include the hook-up of hose and/or pipe); pot tenders; and sewer pipe layers
Demolition (where walls are required to be ridden down by hand tools)
Driller (except Core, Diamond, or Multiple Wagon)
Fork Lift Laborer
Gunite material and rebound workers
Mason and plaster tenders, and cement workers
Mobile buggy operators
Operators of power saws (portable)

Power and Sowing Machines

Scaffold builders

Shoring

Signal men and hookup men, including when working with digging and grading equip.

Stripping of flat arch and form work, and cleaning and oiling thereof

Tool room attendant

Schedule C

Burners and Welders

Caisson Workers, top men (when excavations for caissons are dug eight feet or more below the natural grade level adjacent to the starting point of the caisson hole, the rate shall apply at the ground level)

Concrete Specialist

Driller (Core, Diamond, or Multiple Wagon)

Guniting industrial fume stack, nozzle, and rod workers

Sandblaster (nozzleman)

Tunnelling

Underpinning Excavation (when an underpinning excavation is dug eight feet or more below the natural grade, or when an excavation for a pier hole of five feet square or less and eight feet or more deep is dug, the rate shall apply only when a depth of eight feet is reached)

Working under compressed air

Schedule D

Caisson workers, bottom men (see qualifications for top men in Schedule C above)

Schedule E

Blasters

Laborers engaged in unloading, placing, and assisting in the installation of wall point systems or deep well systems as long as needed on the job for such work

Schedule F

Asbestos and/or Toxic or Hazardous Waste Workers (tasks related to asbestos and/or toxic waste removal - certified and licensed workers only)

Lead Abatement Worker

Operating Engineers Local No. 542

Note: All information for State of Delaware Building & Heavy Work
Only.

Management Unit:	Allied Division, DCA		
Jurisdiction	State of Delaware		
Term of Agreement	1 May 99 thru 30 April 2002		
Hourly Base Wage	5/1/99	5/1/00	5/1/01
Wage Group I:			
Hourly Base Wage	\$22.45	\$22.69	\$22.94
Health & Welfare	4.29	4.53	4.67
Surcharge	.70	.90	1.00
Pension	2.36	2.38	2.41
Apprentice	.22	.23	.23
SUB	.45	.45	.46
Annuity	3.50	4.00	4.25

Wage Group II:			
Hourly Base Wage	\$22.25	\$22.36	\$22.62
Health & Welfare	4.24	4.48	4.62
Surcharge	.70	.90	1.00
Pension	2.33	2.35	2.38
Apprentice	.22	.22	.22
SUB	.44	.45	.45
Annuity	3.50	4.00	4.25

34⁷⁵

Wage Group III:			
Hourly Base Wage	\$20.19	\$20.35	\$20.56
Health & Welfare	3.93	4.16	4.29
Surcharge	.70	.90	1.00
Pension	2.12	2.14	2.16
Apprentice	.20	.21	.21
SUB	.40	.40	.41
Annuity	3.50	4.00	4.25

Wage Group IV:			
Hourly Base Wage	\$19.86	\$19.99	\$20.20
Health & Welfare	3.87	4.10	4.23
Surcharge	.70	.90	1.00
Pension	2.09	2.10	2.13
Apprentice	.20	.20	.20
SUB	.40	.40	.40
Annuity	3.40	4.00	4.25

Wage Group V:			
Hourly Base Wage	\$18.01	\$18.22	\$18.29
Health & Welfare	3.58	3.80	3.93
Surcharge	.70	.90	1.00
Pension	1.90	1.90	1.92
Apprentice	.18	.18	.18
SUB	.36	.26	.36
Annuity	3.50	4.00	4.25

MASTER MECH
34⁷⁵ + 1⁵⁰ = 36²⁵

Wage Group VI:

Hourly Base Wage	\$17.49	\$17.57	\$17.72
Health & Welfare	3.59	3.71	3.84
Surcharge	.70	.90	1.00
Pension	1.84	1.84	1.86
Apprentice	.17	.18	.18
SUM	.35	.35	.35
Annuity	3.50	4.00	4.25

Toxic/Hazardous Waste Removal Rate: 20% added to all classifications

Machines with booms, jibs, masts, and leads: 100 feet and over -
\$.50 per hour additional will be paid for each increment of
25 feet over 100 feet.

Apprentice Rates

Probation to 1 st 6 months	50%
2 nd six (6) months	55%
3 rd six (6) months	60%
4 th six (6) months	65%
5 th six (6) months	70%
6 th six (6) months	75%
7 th six (6) months	80%
8 th six (6) months	85%

Deductions

Union dues - 3.7% of wages. Political
Action Fund - 0.2% of wages.

Lead Engineer

1 for 7 or more engineers. Rate - \$1.50
per hour over rate on weekly basis of
highest paid engineer on same job.

Ass't Lead Engineer

1 for over 25 employees and for each
multiple of 25. Rate - \$.90 per hour
above rate on weekly basis of highest
paid engineer on same job.

Holidays (Paid)

New Year's, Memorial Day, July 4, Labor
Day, Thanksgiving, Day after Thanksgiving
Christmas or day so celebrated except when falls
on Sunday and provided employee works scheduled
work day before and after the holiday.

Overtime & Holiday Pay

The first two hours of daily overtime,
Monday thru Friday and the first eight
hours on Saturday shall be paid at 1 1/2x
wages plus contribution and deduction
percentages noted above. Sundays, holidays
and hours in excess of ten are to be paid
at 2x wages plus contribution and
deduction percentages as noted above.

Straight Time Hours

8 hours between 8:00 a.m. and 4:30 p.m.,
Monday thru Friday. Employer may vary
starting time by 1 hour.

Shifts & Differential

Time of starting 1st shift at employer's
option. No shift in excess of 8 hours

work. Discuss shift duration with Local.
 Pay straight time to shift closest to
 straight time hours and straight time plus
 5¢ to other shifts.

Pay & Pay Day By cash or check, at Local's option, by
 quitting time on regular pay day.
 Withhold 3 days pay.

Weekly Guarantee If employer's job continues for over 3
 days, guarantee 40 hours per week at
 weekly rate for the days the job lasts.

Reporting Time If on weekly guarantee see above. On daily
 basis, i.e. less than 3 days on job:
 4 hours show-up and if started to work,
 pay 8 hours. On Sundays and holidays
 6 hours show-up, 8 hours if start work,
 pay @ overtime rate. If not started to
 work within 1 hour, dismiss for the day.

Meal Periods 1/2 hour, unpaid. On single shift work,
 at noon. On multiple shift work between
 1st and 5th hours.

Lay Off/Discharge Pay in full upon termination.

Work Classifications By Group

Wage Group I

- Handling steel and stone in connection
 with erection
- Cranes doing hook work
- Any machines handling machinery
- Cable spinning machine
- Helicopters
- Concrete Pumps
- Machines similar to the above including
 remote control equipment

Wage Group II

- All types of cranes
- All types of backhoes
- Cableways
- Conveyor Loader
- Drag Lines
- Keystones
- All types of shovels
- Derricks
- Trench Shovels
- Trenching machines
- Pippin type backhoes
- Hoist with two towers
- All Pavers (Concrete and Blacktop)
- All types overhead cranes
- Building Hoists - double drum
 (unless used as single drum)
- Milling Machine
- Mucking machines in tunnel

Gradalls
 Front-end loaders
 Boat Captain
 Tandem Scrapers
 Tower type crane operation, erecting,
 dismantling, jumping, or jacking
 Drills self-contained (Drillmaster type)
 Chipper with Boom
 Tree Spade
 Concrete breaking machines (Guillotine
 type and remote type
 Fork Lift (20 feet and over)
 Motor Patrols (Fine Grade)
 Batch Plant with mixer
 Scrapers & Tournapulls
 Rollers (High Grade Finishing)
 Mechanic Welder
 Spreaders
 Bundle Puller Extractor
 Hydro Axle
 Side Boom
 Bob Cat Type (All attachments)
 Vermeer Saw
 Directional Boring Machine
 Bulldozers & Tractors
 Machines similar to the above

Wage Group III

Conveyors (Except Building Conveyors)
 Building Hoists (Single Drum)
 Asphalt Plant engineer
 High or low pressure boilers
 Well Drillers
 Fork Lift trucks of all types
 Ditch witch type trencher
 Motor Patrol
 Concrete breaking machines
 Rollers
 Fine Grade Machines
 Elevator Operator (new construction)
 Slump grinder
 Machines similar to the above

Wage Group IV

Seaman pulverizing mixer
 Tireman on Power Equipment
 Maintenance Engineer (Power Plant)
 Farm Tractors
 Farm Line Graders
 Road Finishing Machines
 Power Boom
 Seed Spreader
 Grease Truck
 Machines similar to the above

Wage Group V

Conveyors (Building)
Welding machines
Heaters
Wallpoints
Compressors
Pumps
Miscellaneous Equipment Operator
Elevator Operators (renovations)
House Car
Machines similar to the above

Wage Group VI

Fireman
Oilers and Deck Hands (Personnel
Boats)
Grease Truck Halper

Wage Group VII (A)
Toxic/Hazardous
Waste Removal

(See Wage Group I)

Wage Group VII (B)
Toxic/Hazardous
Waste Removal

(See Wage Group II)



"Nancy J Griskowitz" <Nancy.J.Griskowitz@USA.dupont.com> on 02/03/2000
12:30:08 PM

To: "Brandt Butler" <Brandt.Butler@USA.dupont.com>, John Wokasien/Bufalo@URSGreiner
cc:

Subject: Re: SLF Drawing

The area bounded by the limits of waste is approximately 15.9 acres as
calculated by AutoCAD.

AR324920

"Brandt Butler" <Brandt.Butler@USA.dupont.com> on 02/08/2000 04:33:35 PM

To: "Jim L Aker" <Jim.L.Aker@USA.dupont.com>, "Edward M Andrechak" <Edward.M.Andrechak@USA.dupont.com>, "Craig L Bartlett" <Craig.L.Bartlett@USA.dupont.com>, "Matthew P Brill" <Matthew.P.Brill@USA.dupont.com>, "Brandt Butler" <Brandt.Butler@USA.dupont.com>, "Nancy J Griskowitz" <Nancy.J.Griskowitz@USA.dupont.com>, "John L Guglielmetti" <John.L.Guglielmetti@USA.dupont.com>, "Richard H Jensen" <Richard.H.Jensen@USA.dupont.com>, "William R Kahl" <William.R.Kahl@USA.dupont.com>, "Richard C Landis" <Richard.C.Landis-1@USA.dupont.com>, "Edward J Lutz" <Edward.J.Lutz@USA.dupont.com>, Tom Nowocien/Bufalo@URSGreiner, "William B Pew" <William.B.Pew@USA.dupont.com>, "Noel C Scrivner" <Noel.C.Scrivner@USA.dupont.com>, "Stephen H Shoemaker" <STEPHEN.H.SHOEMAKER@USA.dupont.com>, "Marjorie E Vetter" <Marjorie.E.Vetter@USA.dupont.com>, "John E Vidumsky" <John.E.Vidumsky@USA.dupont.com>, "John A Wilkens" <John.A.Wilkens@USA.dupont.com>, "John H Wolfe" <John.H.Wolfe@USA.dupont.com>, John Wokasien/Bufalo@URSGreiner, robert@kiber.com, george@kiber.com

cc:

Subject: South Landfill Team Update - Current Tasks and Notes from February 2nd Meeting

Team,

Please note our new meeting schedule.

Upcoming Meetings 8:30am - 10:30am

February 14 27-2374 - Team - Review Kiber, Xsta Results, Finalize cost estimate assumptions, set date for CRG Peer Review (302)709-8000 + 2653#

AGENDA For February 14

- XSta Testing
- Kiber Testing
- Cost Estimates
- EPA Feedback
- Schedule and scope for Peer Review
- Schedule and scope for EPA Meeting
- Loose ends not covered
- Path Forward & Schedule

February ?? CRG Peer Review

Early March EPA-DuPont meeting to discuss path forward

March 8 Review status. Chose technology and design path. Scope next phase.

(Attached (in Adobe Reader) is a copy of the current project schedule - please review it, especially your dates - before our next meeting - I plan to use it to monitor progress.

[(See attached file: npt309.pdf)]

Current Tasks

Wilkens

- Gathering analytical data, proposing permeable wall composition
- Scope lab scale flow-through-test with target wall composition
- Issue note with non-delivery months for James River gypsum

AR324921

Kiber

- Issue draft report
- Complete gypsum/fill permeability tests and issue draft results

Kahl/Griskowitz

- Scope geo-probe type testing for groundwater outside of south landfill - develop requisite plans
- Scope in-situ treatability testing for PRW
- Calculate waste volume and wall depths based on topo maps

Butler

- Send out gw data package to team
- Draft EPA submittal for presentation of new data and path forward, emphasize low zinc release

Wokasien

- Finalize cost-estimates with proposed wall composition

Nowocien

- Develop shipping cost for lime from Montague, Michigan

Meeting Notes - 2/2/2000

Field Activities

- Issued drawings with new data
- Developing more info on geo-probe testing
 - field scope - determine depth to marsh, gw composition
 - pif
 - PSA/HASP/WMP
 - survey
 - schedule
- Develop scope while preparing for EPA presentation

Kiber

- Completed verification testing - portland (3%), lime (3%), or gypsum (5%) are effective - now its a matter of cost
- Set up permeability tests w/gypsum and common fill - expect results 2/9/2000
- Draft report to issue 2/11/2000

Wilkens

- Tests complete for screening dosages - awaiting analytical results
- Propose wall composition for -100 year wall life (if practical)
- Next phase - use proposed wall composition/ratio and retreat groundwater
- (Following the meeting, J. Aker requested a flow through test for next phase, rather than the shaker tests)
- GW flow analysis shows 0.8 ppm zinc at 200 ml/min -> 86 gm/day (a handful of Cold-Ease tablets)
- Likely some synergistic reaction with Ba-rich and Zn-rich water - future study emphasis should shift to gw outside the wall
- Suggest review of results with EPA and present geoprobe-type sampling plan (w/decision tree) to see if low zinc outside the landfill would eliminate need for treatment..
- Discussed need for sampling groundwater outside of landfill - Kahl will develop a scope for geo-probe-type testing - data needed - depth to top of marsh deposit and gw sample (~20 locations outside landfill on east and south sides)

Wokasien - Cost-Estimates

- Upgraded cost-estimates were presented
- Looking at cost comparison of various barium agents (Portland Cement - 3%, Hydrated Lime - 3%, and Gypsum - 5%) - will put lowest cost in estimate

AR324922

Must confirm shipping costs
Recalculating volume and depth of wall based on topo maps of
ground surface and top-of-march surface



- npt309.pdf

AR324923

General Requirements**R011****Overhead & Miscellaneous Data****R01100-050 General Contractor's Overhead**

The table below shows a contractor's overhead as a percentage of direct cost in two ways. The figures on the right are for the overhead, markup based on both material and labor. The figures on the left are based on the entire overhead applied only to the labor. This figure would be used if

the owner supplied the materials or if a contract is for labor only. Note: Some of these markups are included in the labor rates shown on Reference Table R01100-070.

Items of General Contractor's Indirect Costs	% of Direct Costs	
	As a Markup of Labor Only	As a Markup of Both Material and Labor
Field Supervision	6.0%	2.9%
Main Office Expense (see details below)	16.2	7.7
Tools and Minor Equipment	1.0	0.5
Workers' Compensation & Employers' Liability. See R01100-060	18.1	8.6
Field Office, Sheds, Photos, Etc.	1.5	0.7
Performance and Payment Bond, 0.7% to 1.5%. See R01100-080	2.3	1.1
Unemployment Tax See R01100-100 (Combined Federal and State)	7.0	3.3
Social Security and Medicare, See R01100-100	7.7	3.7
Sales Tax — add if applicable $42/80 \times \%$ as markup of total direct costs including both material and labor. See R01100-090		
Sub Total	59.8%	28.5%
*Builder's Risk Insurance ranges from .141% to .586%. See R01100-040	0.6	0.3
*Public Liability Insurance	3.2	1.5
Grand Total	63.6%	30.3%

*Paid by Owner or Contractor

Main Office Expense

A General Contractor's main office expense consists of many items not detailed in the front portion of the book. The percentage of main office expense declines with increased annual volume of the contractor. Typical main office expense ranges from 2% to 20% with the median about 7.2%

of total volume. This equals about 7.7% of direct costs. The following are approximate percentages of total overhead for different items usually included in a General Contractor's main office overhead. With different accounting procedures, these percentages may vary.

Item	Typical Range	Average
Managers', clerical and estimators' salaries	40 % to 55 %	48%
Profit sharing, pension and bonus plans	2 to 20	12
Insurance	5 to 8	6
Estimating and project management (not including salaries)	5 to 9	7
Legal, accounting and data processing	0.5 to 5	3
Automobile and light truck expense	2 to 8	5
Depreciation of overhead capital expenditures	2 to 6	4
Maintenance of office equipment	0.1 to 1.5	1
Office rental	3 to 5	4
Utilities including phone and light	1 to 3	2
Miscellaneous	5 to 15	8
Total		100%

AR324924

URS Greiner

282 Delaware Avenue
Buffalo, New York 14202
(716) 856-5636

MEMO OF TELECON

JOB NO.: 05000 3572900
JOB TITLE: De Dant
PERSON CALLING: Dick Davison
REPRESENTING: _____
TELEPHONE #: _____
SUBJECT: _____

DATE: 1/20/00
FILE UNDER: _____
PERSON CALLED: Mike Chan
REPRESENTING: Geo Con

SUMMARY OF CONVERSATION:

MIX Bentonite with water approx 5% of water
This is 6" / SF
Load Spoil to truck & DISPOSE

ADD approx 3 to 4% Dry Bentonite to Burrow w/DOZER
And push into Ditch. This is 55" / CY

HOE - 1 to 2 DOZER - LF 2 LBR Use 2000 SF/DAY
1500 TO 2000 SF TO
WET MIX

Cost should be \$6" to 8" / SF This is a SMALL
shallow Project

AR324925

URS Greiner

282 Delaware Avenue
Buffalo, New York 14202
(716) 856-5636

MEMO OF TELECON

JOB NO.: 05000 357 29 00
JOB TITLE: DUPONT
PERSON CALLING: DALE DAVIDSON
REPRESENTING: U.R.S.G.W.C
TELEPHONE #: 1-813-626-0751
SUBJECT: PERMEABLE RETAINING WALL

DATE: 1/20/00
FILE UNDER: _____
PERSON CALLED: BOB SCHLION
REPRESENTING: Geo CON

SUMMARY OF CONVERSATION:

Bob advised that Bio Slurry
would cost approx 1⁵⁰ / SF of 3' +/- wide trench plus
the cost of mixing. The Gyp & iron filling mix
should be started with a trim, and after a loading
edge of backfill is in ditch w/ a sloped end the matl
may be added at high end of backfill and allowed
to roll to bottom of ditch. This material will not
separate if placed in this manner

AR324926

URS Greiner

282 Delaware Avenue
Buffalo, New York 14202
(716) 856-5636

MEMO OF TELECON

JOB NO.: 65000 3572900 DATE: 1/19/00
JOB TITLE: DUPONT FILE UNDER: _____
PERSON CALLING: DICK DAVIDSON PERSON CALLED: MIKE CAGY
REPRESENTING: U.R.S. REPRESENTING: GOO CON
TELEPHONE #: 1-412-856-7700
SUBJECT: SLURRY WALL - PERMEABLE Retentive Wall

SUMMARY OF CONVERSATION:

To BUILD wall mix BIO SLURRY & pump into excavation while excavating. Place mixture of Gypsum 10% - IRON FILLING 1% & common fill 85% into excavation thru trim to bottom of excavation - BIO SLURRY will float out of excavation. Allow for EXC over RUN

MIX FILL - GYP - & FILL in concrete truck

BIO SLURRY & wall construction approx 2000 SF/DAY
with hoe - OPE - Pump - MIXER - 5 man crew
H.L.F. - 2 cone test - LDC MIX WALL RATE.

Need Hoppers to change concrete trucks

This is a patented procedure and there is a Royalty of approx. 15% to a CANADIAN company for its use.

Approx cost PERMEABLE Reactive wall 15¢/SF
" " Slurry wall 4 to 6 /SF

AR324927



Peerless Metal Powders & Abrasive

124 South Military Detroit, Michigan 48209
313 841-5400 Fax 313 841-0240

FAX TRANSMITTAL

We are transmitting a total of 2 pages including this cover sheet. Please contact sender if you do not receive the entire transmission.

PLEASE DELIVER THE FOLLOWING PAGES TO:

NAME John Wokasien

COMPANY URS Consultants

FAX # 716-856-2545 PHONE # _____

FROM James Wano DATE 4-10-00

MESSAGE:

AR324928

50.



April 7, 2000

John Wokasien
URS Consultants
282 Delaware
Buffalo, NY 14202

FAX: 716-856-2545

Dear John:

Thank you for the opportunity to quote on your requirements for Cast Iron Aggregate at the DuPont - Newport, DE site.

Cast Iron Aggregate Size 8/50-----\$330/NT

Plus packaging in 3000# bulk bags, palletized----\$ 14/NT (\$21/per bag)

Prices are FOB Detroit, MI. Terms - Net 30 Days.

I found the following freight rate Detroit, MI to Newport, DE:

Flatbed Truck-----\$1125 = \$50/NT (based on 22.5 tons)

Should you require us to prepay and add the freight, please add 15% to the above freight price.

We appreciate the opportunity to give you this quote. As you are aware the cost of producing and transporting iron is market driven and therefore can change over time; please contact us for a final quote at the time the iron is required for the project.

Very truly yours,

Paul W. Tousley
President & CEO

Norcen P. Warrens
Cast Iron Sales

PWT/npw

AR324929



Telecon Memorandum

Date: November 21, 2000
To: Files: 05-00035849.00
From: Michael Azzarella
Subject: **Newport South Landfill – Telephone Conversation with Brandt Butler**

Today, I spoke with Brandt Butler and Michele Thompson of the Wilmington office about the Newport South Landfill project. Based on our conversations, the following issue was discussed:

1. Brandt and Michele want us to revisit the ROD and PRB cost estimates to finalize them for their assessment report. We need to consider the following:
 - a.) We need to evaluate different installation alternatives. We also need to consider the installation method so that material separation does not take place during wall placement.
 - b.) We need to add magnesium carbonate to the PRB estimate. The material costs \$1.55 per pound plus shipping from the Port of Newark in northern New Jersey.

The new mix of the wall will be:

100 parts per weight sand
20 parts per weight gypsum
5 parts per weight iron
5 parts per weight magnesium carbonate

AR324930

To: John Wokasien

Location	Depth to Marsh deposit
GW-8	15
GW-9	5
GW-10	5.5
GW-11	9
GW-12	5
GW-13	5
GW-14	5
GW-15	5
CW-16	2
GW-17	5
GW-19	10
GW-20C	6
GW-21	6
GW-22A	16
GW-22B	15
GW-22C	8

Post-It Fax Note	7671	Date	3/27/00	# of pages	2
To	J. Wokasien	From	Rusty Kahl		
Co./Dept		Co.	WCD - Wilmington		
Phone #		Phone	302-892-0618		
Fax #	716-856-2545	Fax	302-892-7643		

these are the only locations ~~at which~~ in which I ~~have~~ found the marsh deposit.

~~GW-1~~
~~GW-3~~

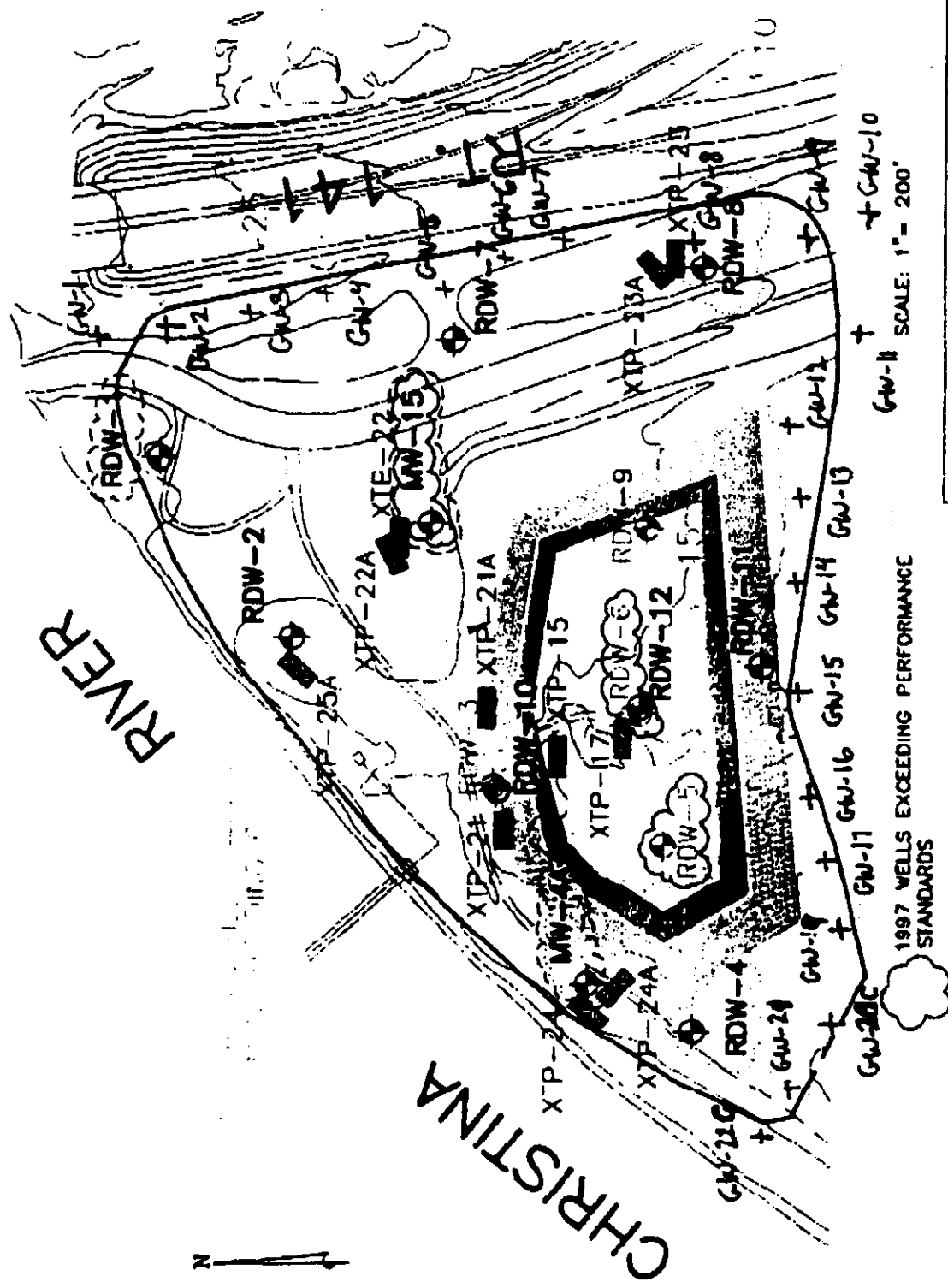
GW-1 ~ 11 ft
GW-3 ~ 15 ft
GW-4 ~ 12.5 ft
GW-6 ~ 22 ft
GW-7 ~ 19 ft

these are all estimates based on boring logs from a 1993 DelDOT report.

Please call 302-892-0618 if you have questions.

- Rusty

AR324931



Corporate Remediation Group
An Alliance between
Auffhauf and The F-C Diamond Group

Borley Mill Plaza Building 17
Wilmington, Delaware 19801-0027

**SOUTH LANDFILL
WELLS AND TEST PITS**

NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE

DATE	1-1-2000	1-1-2000	1-1-2000	1-1-2000
SCALE	1" = 200'			
DATE	1-1-2000			
BY				
CHK'D BY				
REVIEWED BY				

LEGEND

- TEST PIT
- ABANDONED WELL
- CURRENT WELL

1997 WELLS EXCEEDING PERFORMANCE STANDARDS

1998 WELLS EXCEEDING PERFORMANCE STANDARDS

1999 WELLS EXCEEDING PERFORMANCE STANDARDS

AR324932

URS Greiner Woodward Clyde

Job DUPONT - SOUTH LANDFILL
Description REMEDY ESTIMATE
QUANTITIES

Project No. 0500035735.00
Computed by TAO
Checked by ED

Page of
Sheet 1 of 1
Date 3/29/00
Date 3/30/00

Reference

PERMEABLE REACTIVE WALL VOLUME

- BASED ON BORING LOGS FROM A 1993 REPORT (GW-1 thru GW-7) AND THE GEOPHYSIC RESULTS 2000 (GW-8 thru GW-22c) FROM WCD, THE FOLLOWING VOLUME WAS QUANTIFIED:
- DIMENSIONS OF WALL:
 - WIDTH = 3 FT
 - DEPTH - VARIES, MUST "KEY" INTO MARSH DEPOSIT BY 2 FT
 - LENGTH = BASED ON SITE PLAN (NOT ATTACHED)

$$\left[\begin{array}{l} \text{DEPTH (FT)} \quad \text{LENGTH (FT)} \\ ((8 \text{ FT} \times 200 \text{ FT}) + (12 \text{ FT} \times 125 \text{ FT}) + (7 \text{ FT} \times 850 \text{ FT}) + (17 \text{ FT} \times 270 \text{ FT}) \\ + (21 \text{ FT} \times 135 \text{ FT}) + (24 \text{ FT} \times 140 \text{ FT}) + (15 \text{ FT} \times 145 \text{ FT}) \\ + (17 \text{ FT} \times 150 \text{ FT}) + (14 \text{ FT} \times 135 \text{ FT})) \times 3 \end{array} \right] / 27$$

WIDTH

= 2940 cy

SAY 3000 cy

WALL FACE = 9 SF / CY OR 27,000 SF

AR324933

ESD REMEDY ESTIMATE

**NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ESD REMEDY**

Description		Quantity	Unit	Unit Cost	Total Cost
Site Preparation		19.7	Acre	\$ 12,610	\$ 248,417
Slurry Wall					
Bentonite		135	Ton	\$ 135	\$ 18,225
Common Fill		2,700	CY	\$ 11.25	\$ 30,375
Mixing & Placing Wall		21,800	SF	\$ 4.60	\$ 100,280
	Subtotal				\$ 148,880
Treatment with Sodium Sulfide		920,700	Lbs.	\$ 0.40	\$ 368,280
Crew		100	Days	\$ 3,000	\$ 300,000
	Subtotal				\$ 668,280
Treatment with Sodium Sulfate		34,000	Ton	\$ 320	\$ 10,880,000
Crew		462	Days	\$ 3,000	\$ 1,386,000
	Subtotal				\$ 12,266,000
Landfill Cap - geomembrane, GCL, GDC, 12" of cover soil, and 6" of topsoil		16.1	Acre	\$ 137,768	\$ 2,218,065
Riverbank Protection		1,350	LF	\$ 155.00	\$ 209,250
Remove and Replace South James Street		1	LS	\$ 390,000.00	\$ 390,000
Chemical Delivery and Extraction System		1	LS	\$1,337,900.00	\$ 1,337,900
	Direct Cost Subtotal				\$ 17,486,792
General Conditions		1	Lump Sum	\$ 250,000	\$ 250,000
Main Office Overhead		7.7%	Lump Sum	\$ 7,354,792	\$ 566,319
Profit		10	Percent	\$ 17,486,792	\$ 1,748,679
Engineering and Project Support		7.0%	Lump Sum	\$ 7,354,792	\$ 514,835
Monitoring and Maintenance		1	Lump Sum	\$ 1,440,000	\$ 1,440,000
	Subtotal				\$ 22,006,625
Contingency		5	Percent	\$ 22,006,625	\$ 1,100,331
TOTAL					\$ 23,106,957

AR324935

**NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ESD REMEDY**

Assumptions:

Site Preparation Unit Cost: ref URS PRW Backup
Slurry Wall Unit Costs => ref. URS PRW Backup
Slurry Wall quantities from the URS PRW estimate
Sodium Sulfate quantity, ref: attached WCD estimates
Sodium Sulfate quantity => 67,500,000 lbs or 33,750 Ton, **SAY 34,000 Ton**
Sodium Sulfate Cost => \$320/Ton, ref. Brandt Butler 1/27/00 e-mail
Sodium Sulfide Costs/Crews from WCD estimates (see attached)
The Landfill Cap consists of a geomembrane, GDC, GCL, 12" of cover soil, and 6" of topsoil
The cap costs identified in the URS backup are for the cap components only. The cap unit cost is increased by 51% to include the remaining closure components, e.g., surficial drainage features/structures (swales/downchutes), perimeter drainage (channels and/or pipes), gas collection system (vents), perimeter fencing, access roads, etc.
This is consistent with the URS North Landfill Closure estimate (\$91,237 x 151% = 137,768) ref. URS PRW Backup
Riverbank Protection => ref: URS PRW backup
Remove and Replace South James Street => ref: URS estimate (attached)
Chemical Delivery and Extraction System=> cost per Brandt Butler 12/15/00 (memo attached)
Monitoring and Maintenance = \$1,440,000 per URS Diamond, 3/28/95 cost estimate, Present Worth of 30 yrs @ i = 5%
General Conditions Cost => ref. URS PRW backup
**Main Office Overhead @ 7.7% is from 2000 Means (Heavy Construction) (Changed to Lump Sum)
**Engineering and Project Support: use 7% URS average for work of this nature (Changed to Lump Sum)

Profit is assumed to be 10%

A 5% contingency has been added at the discretion of the estimator

** The costs for main office overhead and engineering and project support will only change between the previous ESD Remedy costs and this estimate for work not included in previous estimate. The costs associated with these activities will not be impacted by an increase in unit costs for changing the treatment chemicals from Calcium Sulfate (\$22/ton) to Sodium Sulfate (\$320/ton).

AR324936



"Nancy J Griskowitz" <Nancy.J.Griskowitz@USA.dupont.com> on 01/27/2000
02:27:38 PM

To: John Wokasien/Bufalo@URSGreiner
cc: "Brandt Butler" <Brandt.Butler@USA.dupont.com>

Subject: SLF Cost Estimate Information

John,

The attached file contains two spreadsheets. The information on these sheets replaces the groundwater pumping and chemical treatment sections of the ESD estimate.

In addition, the Engineering and Project Support percentage of 10% that we include with our estimates includes but is not limited to treatability studies, pilot studies, implementation design, contract administration, health and safety compliance and field supervision.

(See attached file: Cost Estimates 1-27.xls)

Please let me know if you have any additional questions.

Thanks,
Nancy



- Cost Estimates 1-27.xls

AR324937

COST ESTIMATE SUMMARY NEWPORT SOUTH LANDFILL

Remediation Cost Estimate -- Low End				
Site: Newport				
Size: 15 Acres				
Location: Newport, Delaware				
Description	Quantity	Units	Unit Cost	Total Cost (\$M)
Soil -- 15 Acre Site				
Treatment with Sodium Sulfate (Na_2SO_4)	67,500,000	lbs	\$0.16	\$10,800
Crew (231 days for 2 crews = 462 days)	462	days	\$3,000	\$1,386
SUBTOTAL				\$12,186
Engineering and Project Support	10%			\$1,219
TOTAL				\$13,405
Notes: 1) Approximately 1.35 billion lbs of soil to be treated. 2) Soil: 100lb/ft ³ 3) Treatment Ratio: 0.05 lb of Na_2SO_4 per lb of soil 4) Cost of Na_2SO_4 : \$0.16/lb				

AR324938

COST ESTIMATE SUMMARY **NEWPORT SOUTH LANDFILL**

Remediation Cost Estimate -- Low End				
Site: Newport				
Size: 3.3 Acres				
Location: Newport, Delaware				
Description	Quantity	Units	Unit Cost	Total Cost (\$M)
Soil -- 3.3 Acre Site				
Treatment with Sodium Sulfide (Na ₂ S)	920,700	lbs	\$0.40	\$368
Crew	100	days	\$3,000	\$300
SUBTOTAL				\$668
Engineering and Project Support	10%			\$67
TOTAL				\$735
Notes: 1) Treatment area for zinc only is 3.3 acres. 2) Soil: 100lb/ft ³ 3) Treatment Ratio: 0.0031 lb of Na ₂ S per lb of soil 4) Cost of Na ₂ S: \$0.40/lb				

AR324939

Zinc Only

60

DUPONT NEWPORT SOUTH LANDFILL
SOUTH JAMES STREET TIE-IN ALTERNATIVES
COST ESTIMATE

ALTERNATIVE 1
REMOVE AND RECONSTRUCT NEW ROAD
LINER UNDER ROAD

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization/Demobilization	LS	1	\$14,744	\$14,744
Temporary Road (Install & Remove)	SY	3,200	\$13.44	\$43,008
Excavation & Disposal of Existing Road (Disposal of Materials Onsite)	CY	6,000	\$8.26	\$49,560
Subbase Fill and Compaction	CY	4,000	\$15.13	\$60,520
<u>Asphaltic Pavement</u>				
- Base Course - Shoulders	SY	1,950	\$5.27	\$10,277
- Base Course - Lane	SY	3,100	\$9.07	\$28,117
- Binder Course - Shoulder	SY	2,300	\$3.57	\$8,211
- Binder Course - Lane	SY	2,750	\$8.38	\$23,045
Surveying	DAY	10	\$1,125	\$11,250
Striping	LF	3,000	\$0.24	\$720
Traffic Control	LS	1	\$37,955	\$37,955
Additional Cap Installation*	AC	1	\$77,255	\$77,255
Subtotal				\$364,662
Contingencies - 5%				\$18,233
Total				\$382,895
Say				\$390,000

* From DuPont North Landfill Cap Cost Estimate

AR324940



Memorandum

Date: December 15, 2000
To: File 05-00035849.00
From: Michael Azzarella
Subject: **DuPont South Landfill – Cost Estimate**

I discussed the updated costs with Brandt Butler today. I indicated that URS has never prepared cost estimates for the ESD alternative to include a pump and treat extraction system. Brandt indicated that URS Diamond had prepared a draft cost estimate in the amount of \$1,337,900. URS will place this cost in the ESD estimate and reference this cost per URS Diamond.

AR324941

ROD REMEDY ESTIMATE

**NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ROD REMEDY**

Description		Quantity	Unit	Unit Cost	Total Cost
Site Preparation		16	Acre	\$ 12,300	\$ 196,800
Soil Stabilization					
Soil Cement Shallow Auger Mixing		500,000	CY	\$ 16.00	\$ 8,000,000
Cement Additive		500,000	CY	\$ 3.50	\$ 1,750,000
	Subtotal			\$	\$ 9,750,000
Soil Consolidation and Backfill		77,000	CY	\$ 19	\$ 1,463,000
Remove and Replace South James Street		1	LS	\$ 390,000	\$ 390,000
Soil Cap		16	Acre	\$ 21,000	\$ 336,000
Riverbank Protection		1,350	LF	\$ 155.00	\$ 209,250
	Direct Cost Subtotal			\$	\$ 12,345,050
General Conditions		100%	Lump Sum	Nec.	\$ 760,000
Main Office Overhead		7.7	Percent	\$ 12,345,050	\$ 950,569
Profit		10	Percent	\$ 12,345,050	\$ 1,234,505
Engineering and Project Support		7	Percent	\$ 12,345,050	\$ 864,154
Monitoring and Maintenance		100%	Lump Sum	Nec.	\$ 385,000
	Subtotal			\$	\$ 16,539,277
Contingency		5	Percent	\$ 16,539,277	\$ 826,964
TOTAL				\$	\$ 17,366,241

AR324943

**NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ROD REMEDY**

Assumptions:

Assume 500,000 cy of soil to be treated, quantity furnished by WCD on 2/14/00
Assume 4 - 8' dia. shallow soil mixing augers will be used concurrently
Remove and Replace South James Street => ref: URS estimate (attached)
Riverbank Protection => ref: URS PRW backup
Assume \$25,000 per year per Brandt Butler telecon 4/20/00, Present Worth of 30 yrs @ $i = 5\%$
Main Office Overhead @ 7.7% is from 2000 Means (Heavy Construction)
Engineering and Project Support: use 7% URS average for work of this nature
Profit is assumed to be 10%
A 5% contingency has been added at the discretion of the estimator
All manpower, equipment, unit costs, productivity, quantities, etc. have been discussed and verified with Geo-Con

AR324944

ROD REMEDY

Current Prevailing Labor/Wage Rates - New Castle County, Delaware

	Hrly. Base Rate	PT & I	Loaded Hrly. Rate
Labor Forman	\$25.68	35%	\$34.67
Laborer	\$24.58	35%	\$33.18
Operating Engineer (crane)	\$34.76	35%	\$46.93
Operating Engineer (oiler)	\$28.55	35%	\$38.55
Operating Engineer	\$34.76	35%	\$46.93
Operating Engineer (medium)	\$32.16	35%	\$43.42
Truck Driver	\$22.10	35%	\$29.84

Equipment Rental Rates

	2000 Means	Monthly rate ÷ hr./mo.	= hrly. rate + hrly. op.cost =	hrly. rate
1½ cy Backhoe	016-408-0200	\$7,500/mo. ÷ 176 hrs.	= \$42.60 + \$26.60/hr.	= \$69.20/hr.
1¼ cy Loader	016-408-4650	\$3,650/mo. ÷ 176 hrs.	= \$20.75 + \$12.50/hr.	= \$33.25/hr.
50 HP Dozer	016-409-4200	\$5,530/mo. ÷ 176 hrs.	= \$31.75 + \$17.00/hr.	= \$48.75/hr.
Diesel Generator 30 KVA	016-420-2600	\$1,100/mo. ÷ 176 hrs.	= \$6.25 + \$6.86/hr.	= \$13.11/hr.
Watson Auger w/DBL Kelly Model 2500C	Blue Book	\$17,955/mo. ÷ 176 hrs.	= \$102.01 + \$39.55/hr.	= \$141.56/hr.
Link Belt Crawler Crane 136T Model LS278H	Blue Book	\$19,145/mo. ÷ 176 hrs.	= \$108.80 + \$51.85/hr.	= \$160.65/hr.

AR324945

ROD REMEDY (cont'd.)

Batch Plant Model 65-110 YPH	Blue Book	\$5,190/mo.	÷ 176 hrs.	= \$29.50	+	\$8.25/hr.	=	\$37.75/hr.
Pumps	Geo-Con	\$500/wk.	÷ 40 hrs./wk.				=	\$12.50/hr
Storage Silo	Geo-Con	\$500/wk.	÷ 40 hrs./wk.				=	\$12.50/hr

Truck Rental Rates

	2000 Means	Monthly rate ÷	hr./mo.	=	hrly. rate +	hrly. op.cost	=	hrly. rate
Concrete Truck	016-406-3300	\$9,225/mo.	÷ 176 hrs.	=	\$ 52.50	+	\$32.50/hr.	= \$85.00/hr.
Dump Truck	016-408-5250	\$3,375/mo.	÷ 176 hrs.	=	\$19.20	+	\$17.40/hr.	= \$36.60/hr.
Water Truck	016-420-6900	\$700/wk.	÷ 40 hrs.	=	\$17.50	+	\$11.07/hr.	= \$28.57/hr.

AR324946

ROD REMEDY

Site Preparation

The South Landfill site is approximately 16 acres
 16 acres x 43,560 sf/ac = 696,960 sf

The site contains a holding cell, constructed of earthen berms, and a cleared area with stone roads including a parking area. Assume 1/3 of the site is to have medium trees cut and chipped with stumps chipped and grubbed. Brush hog 1/3 of the site to remove brush and small trees.

Site grading includes the collapsing the earthen berms prior to soil stabilization and the installation of a soil cap.

2-dozers w/ operators, 1-loader w/operator, 2-trucks w/drivers, 1-labor foreman, 2-laborers

$$696,960 \text{ sf} \div 20,000 \text{ sf/day} = 35 \text{ Days}$$

Dozer	560 hrs. x \$48.75/hr.	=	\$27,300
Loader	280 hrs. x \$33.25/hr.	=	\$ 9,310
Truck	560 hrs. x \$36.60/hr.	=	\$20,496
Operator	840 hrs. x \$46.93/hr.	=	\$39,421
Truck Driver	560 hrs. x \$28.84/hr.	=	\$16,206
Labor Foreman	280 hrs. x \$34.67/hr.	=	\$ 9,708
Laborer	560 hrs. x \$33.18/hr.	=	<u>\$18,581</u>
	Subtotal		\$141,022

AR324947

ROD REMEDY (cont'd.)

Site Preparation

	2000 Means		
Chip Trees	021-104-0200	6 acres x \$3,275/ac. =	\$19,650
Grub Stumps	021-104-0250	6 acres x \$2,180/ac. =	\$13,080
Brush Hog	021-108-0600	6 acres x \$3,094/ac. =	\$18,564
Erosion Control	022-704-1100	3,650 lf x \$2.60/lf. =	<u>\$4,380</u>
		Subtotal	\$55,674
		Subtotal, previous page	<u>\$141,022</u>
		Total	\$196,696 ÷ 16 ac. = ~ \$12,293.50 per acre
		SAY	\$12,300 per acre

AR324948

SOIL CEMENT

Shallow Auger Mixing

The South Landfill site is ~16 acres, ref. Nancy Griskowitz e-mail dated 2/3/00

16 acres x 43,560 sf/ac = 696,960 sf

Area of caisson = $3.1417 \times 4^2 \times 80\%$ (overlap) = 40 sf/hole

Assume 2 holes/hr, therefore, assume 18 holes/day considering lost time and startup

18 holes/day x 40 sf/hole = 720 sf/day (10 hour per day)

696,960 sf ÷ 720 sf/day = 968 days to drill and inject cement

Allow crane and drill rig with operator & oiler, hoe with operator, batch plant

2-pumps, 2-silos with/ operator, 1-labor foreman, & 3-laborers for 968 days at 10 hr. per day (laborers & operators @ 11 hrs./day)

Crane	9,680 hrs.	x	\$160.65	=	\$1,555,092
Drill Rig	9,680 hrs.	x	\$141.56	=	\$1,370,301
Operator	10,648 hrs.	x	\$46.94	=	\$499,817
Oiler	10,648 hrs.	x	\$38.55	=	\$410,480
Backhoe	9,680 hrs	x	\$69.20	=	\$669,856
Operator	10,648 hrs.	x	\$46.93	=	\$499,711
Batch Plant	9,680 hrs.	x	\$37.75	=	\$365,420
Silo	19,360 hrs.	x	\$12.50	=	<u>\$242,000</u>
			Subtotal		\$5,612,677

AR324949

SOIL CEMENT (cont'd.)

Pump	19,360 hrs. x	\$12.50	=	\$242,000
Med. Operator	10,648 hrs. x	\$43.42	=	\$462,336
Labor Foreman	10,648 hrs. x	\$34.67	=	\$369,166
Labor	31,944 hrs. x	\$33.18	=	<u>\$1,059,902</u>
		Subtotal		\$2,133,404
		Subtotal, previous page		<u>\$5,612,677</u>
		Total		\$7,746,081 ÷ 500,000 cy = \$15.49/cy
		SAY		\$16 per cy

AR324950

CEMENT ADDITIVE

Use 3% cement by volume

500,000 cy x 3% = 15,000 cy

15,000 cy x 2,550 lbs/cy = 38,250,000 lbs ÷ 2,000 lbs/ton = 19,125 ton, SAY 19,200 ton

Telecon quote from St. Mary's Cement Co., Delaware Office on 2/11/00 => \$85/ton delivered to Newport Site (2001 price)

19,200 ton x \$85/ton = \$1,632,000 ÷ 500,000 cy = \$3.26/cy,

SAY \$3.50 per cy

HYDRATED LIME ADDITIVE

Use 3% hydrated lime by volume

500,000 cy x 3% = 15,000 cy

15,000 cy x 810 lbs/cy = 12,150,000 lbs ÷ 2,000 lbs/ton = 6,075 ton,

SAY 6,100 ton

There is no material cost for the hydrated lime, only shipping costs

Assume 800 mile haul distance (round trip) from Montague, Michigan

2/17/00 quote from Serafini Trucking, Tonawanda, NY - \$1.75 to \$2.00 per mile to haul lime

Use \$2.00 per mile for hauling

800 miles x \$2.00/mile => \$1,600 per truck per trip

\$1,600 per truck per trip ÷ 28 cy per truck per trip = \$57.14/cy, **SAY \$57 per cy**

28 cy x 810 lbs/cy = 22,680 lbs ÷ 2,000 lbs/ton = 11.34 ton, SAY 12 ton

\$1,600 per truck per trip ÷ 12 ton per truck per trip => \$133/ton, **SAY \$135 per ton**

AR324951

ROD REMEDY

Soil Consolidation and Backfill – Between Old Airport Road & Rte. 141

Area 1: 950 lf x 90 lf = 85,500 sf

Area 2: 1/2 x 950 lf x 110 lf = 52,250 sf

137,750 sf

137,750 sf x 15 ft. = 2,066,250 cf ÷ 27 cf/cy = 76,528 cy

SAY 77,000 cy

Equipment Rental

	2000 Means		
Backhoe 2 1/2 cy	016-408-0320	\$18,300/Mo. ÷ 176 hrs. = \$104.00 + \$59.00	= \$163.40/hr.
Off-Highway 35 ton	016-408-5600	\$11,700/Mo. ÷ 176 hrs. = \$66.50 + \$32.30	= \$98.80/hr.
Vibratory Roller	016-408-3320	\$6,900/Mo. ÷ 176 hrs. = \$39.20 + \$26.70	= \$65.90/hr.

Backhoe will load 10 trucks per hr. or 200 cy/hr

Three trucks will each make 3 1/3 trip/hr.

Cross Road – Short Haul
48 day required to excavate and move waste

This material would require soil treatment on west side of road. Assume treatment at 50% cost as auger would be in place.
Cement would still be required

Therefore excavate \$18.67/cy treatment credit (50% x \$16 = \$8 added/cy to excavate the eastside, \$16.67 - \$8.00 = \$10.67)

Excavation add 77,000 cy x \$10.67/cy = \$821,590, SAY \$821,600 cost savings to stabilize soil in place

AR324952

ROD REMEDY (cont'd.)

Soil Consolidation and Backfill - Between Old Airport Road & Rte. 141

- 1-2 1/2 cy backhoe, 1-operator, 3-off-road trucks w/ drivers, 1-labor foreman, 1-laborer; 48-days for excavation
- 2-laborers; 48-days for flagging @ road crossing
- 3-laborers; 6-days to erect, maintain, and remove traffic control
- 1-dozer w/ operator, 1-laborer; 48-days to grade soil
- 2-dozer w/ operators, 1-roller w/ operator, 1-laborer; 48-days to place borrow
- 1-dozer w/ operator, 1-roller w/ operator, 1-laborer; 3-days to grade and clean up

Unit Price Development

Construction sign	12 ea	x	16 sf	x	\$20.00/sf	=	\$3,840
Common Fill	77,000 cy	x	10% compaction	x	\$11.25/cy	=	\$952,875
Backhoe	384 hrs.	x	\$163.40/hr.			=	\$62,746
Off Road	1,152 hrs.	x	\$98.80/hr.			=	\$113,818
Operator	384 hrs.	x	\$46.93/hr.			=	\$18,021
Oilier Driver	1,152 hrs.	x	\$38.55/hr.			=	\$44,410
Labor Foreman	384 hrs.	x	\$34.67/hr.			=	\$13,313
Laborer	384 hrs.	x	\$33.18/hr.			=	\$12,741
Flag Laborer	768 hrs.	x	\$33.18/hr.			=	\$25,482
Laborer	144 hrs.	x	\$33.18/hr.			=	\$4,778
Dozer	384 hrs.	x	\$48.75/hr.			=	\$18,720
Operator	384 hrs.	x	\$46.93/hr.			=	\$18,021
Subtotal							\$1,288,765

AR324953

ROD REMEDY (cont'd.)

Soil Consolidation and Backfill – Between Old Airport Road & Rte. 141

Laborer	84 hrs. x	\$33.18/hr.	=	\$12,741
Dozer	768 hrs. x	\$48.75/hr.	=	\$37,440
Roller	384 hrs. x	\$65.90/hr.	=	\$25,306
Operator	1,152 hrs. x	\$46.93/hr.	=	\$54,063
Laborer	384 hrs. x	\$33.18/hr.	=	\$12,741
Dozer	24 hrs. x	\$48.75/hr.	=	\$1,170
Roller	24 hrs. x	\$65.90/hr.	=	\$1,582
Operator	48 hrs. x	\$46.93/hr.	=	\$2,253
Laborer	48 hrs. x	\$33.18/hr.	=	\$1,593
Subtotal				\$148,889
Subtotal, previous page				<u>\$1,288,765</u>
Total				\$1,437,654 ÷ 77,000 cy = 18.67/cy
SAY				\$19 per cy

AR324954

ROD REMEDY

Soil Cap

Soil cap consists of 6-inches of topsoil with seeding

16 acres x 43,560 sf/ac = 696,960 sf

696,960 sf x 6-inches = 348,480 cf ÷ 27 cf/cy = 12,907 cy

SAY 13,000 cy

Unit prices from Chautauqua County Landfill (project bid late 1999)

Place topsoil	13,000 cy x	\$4.00/cy	=	\$52,000
Topsoil Material	13,000 cy x	\$18.00/cy	=	\$234,000
Seeding	16 acre x	\$2,500/acre	=	<u>\$40,000</u>

Total \$326,000 ÷ 16 ac. = \$20,375 per acre

SAY \$21,000 per acre

AR324955

GENERAL CONDITIONS

Project Schedule

1) Mobilization	15 days
2) Clear and Grub	6 days
3) Soil Cement (968 days ÷ 4 rigs)	242 days
4) Site Grading	33 days
5) Modified Cap	45 days
6) Demobilization	<u>10 days</u>
	339 days ÷ 5 days = 68 weeks

	<i>2000 Means</i>			
Office Trailer Means	015-904-0500	17 months x \$315/mo.	=	\$5,355
Telephone	010-034-0140	17 months x \$235/mo.	=	\$3,995
Light & Heat	010-034-0160	17 months x \$88/mo.	=	\$1,496
Office Supplies	010-034-0120	17 months x \$85/mo.	=	\$1,445
Office Equipment	010-034-010	17 months x \$133/mo.	=	\$2,261
Port-a-John	016-420-6450	17 months x 4 ea. x \$165/mo.	=	\$11,220
Superintendent	010-036-0260	68 weeks x \$1,245/wk. x 135%	=	\$114,291
Project Manager	010-036-0200	68 weeks x \$1,320/wk. x 135%	=	<u>\$121,176</u>
		Subtotal		\$261,239

AR324956

GENERAL CONDITIONS (cont'd.)

Master Mechanic-Crane Rate	\$38.24 + 10% = \$42.06 x 110% x 48 hrs. x 68 weeks	=	\$151,012
Survey	013-306-120	20 days x \$575/day x 135%	= \$15,525
Equipment Mobilization and Setup	Geo-Con	Lump Sum	= \$150,000
Small Tools	010-082-0100	\$11,745,800 x 0.5%	= \$58,729
Equipment & Mobilization	Geo-Con	Lump Sum	= \$50,000
Handtools & Mat'l. Deliveries	022-274-1150	78 ea. x \$100/ea.	= \$7,800
Assume 3/wk.	010-040-0450	\$11,745,800 x 0.5%	= \$58,729
Insurance	013-803-0200	17 mo. x \$190/mo.	= <u>\$3,323</u>
Construction Photos 10/mo.			
		Subtotal	\$495,118
		Subtotal, previous page	<u>\$261,239</u>
		Total	\$756,357
		SAY	\$760,000

AR324957

URS Greiner Woodward Clyde

Page ____ of ____

Job Dupont

Project No. _____

Sheet 1 of ____

Description Alternate Exc East Side

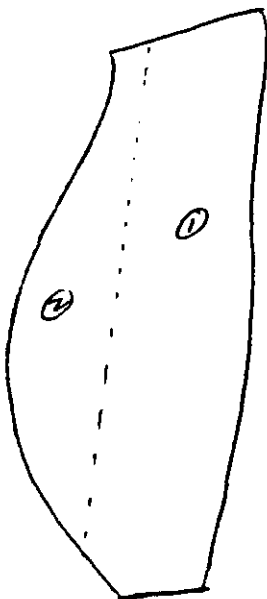
Computed by RD

Date 01/21/00

Checked by VEN

Date 01/29/00

Reference



	L	W	CP
AREA 1	90	90	85500 ✓
2	1/2 x 90	110	52250 ✓
			137750 ✓

$$\text{Vol } 137750 \times 15 = 2066250 \div 27 = 76500 \text{ CY} \quad \text{day 7}$$

Equipment Rental

BACKHUE 2 1/2 CY MEANS	016.408.0320	18300/mo ÷ 176 = 104 ⁰⁰ + 59 ⁰⁰ = 163 ⁰⁰
OFF HIGHWAY 35 TON	016.408.5600	11700/mo ÷ 176 = 66 ⁰⁰ + 32 ⁰⁰ = 98 ⁰⁰
Vib Roller Sheepsfoot	016.408.3320	6900/mo ÷ 176 = 39 ⁰⁰ + 26 ⁰⁰ = 65 ⁰⁰

HUE will load 10 TRKS / HC OR 200 CY / HC

Three trucks will each make 3 1/3 TRIP / HC

CROSS ROAD - SHORT HAUL

48 DAY REQUIRED TO EXC & MOVE

This mat would require SOIL TREATMENT ON WEST SIDE OF ROAD. Assume treatment at 50% cost as AUGER would be in place. Cement would still be required

Therefore $18^{75} \text{ / CY} - (50\% \text{ TREATMENT CREDIT}) = 11^{45} \text{ ADDED / CY TO EXC EAST SIDE}$

EXC add $76500 \text{ CY} \times 11^{45} \text{ / CY} = 8759250$

AR324958

GENERAL CONDITIONS

Project Schedule

1) Mobilization	15 days
2) Clear and Grub	6 days
3) Soil Cement (968 days ÷ 4 rigs)	242 days
4) Site Grading	33 days
5) Modified Cap	45 days
6) Demobilization	<u>10 days</u>
	339 days ÷ 5 days = 68 weeks

2000 Means

Office Trailer Means	015-904-0500	17 months x \$315/mo.	=	\$ 5,355
Telephone	010-034-0140	17 months x \$235/mo.	=	\$ 3,995
Light & Heat	010-034-0160	17 months x \$88/mo.	=	\$ 1,496
Office Supplies	010-034-0120	17 months x \$85/mo.	=	\$ 1,445
Office Equipment	010-034-010	17 months x \$133/mo.	=	\$ 2,261
Port-a-John	016-420-6450	17 months x 4 ea. x \$165/mo.	=	\$ 11,220
Superintendent	010-036-0260	68 weeks x \$1,245/wk. x 135%	=	\$114,291
Project Manager	010-036-0200	68 weeks x \$1,320/wk. x 135%	=	\$121,176
Master Mechanic-Crane Rate	\$38.24 + 10% = \$42.06 x 110% x 48 hrs. x 68 weeks	=		\$151,012

AR324959

GENERAL CONDITIONS (cont'd.)

Survey	013-306-120	20 days x \$575/day x 135%	=	\$15,525
Equipment Mobilization and Setup	Geo-Con	Lump Sum	=	\$150,000
Small Tools	010-082-0100	\$10,916,000 x 0.5%	=	\$ 54,580
Equipment & Mobilization	Geo-Con	Lump Sum	=	\$ 50,000
Handtools & Mat'l. Deliveries Assume 3/wk.	022-274-1150	78 ea. x \$100/ea.	=	\$ 7,800
Insurance	010-040-0450	\$10,916,000 x 0.5%	=	\$ 54,580
Construction Photos 10/mo.	013-803-0200	17 mo. x \$190/mo.	=	\$ 3,323
				<u>\$747,969</u>
				SAY \$750,000

AR324960

URS
CONSULTANTS, INC.

Name and Address of Firm Submitting Bid: ST MARYS CEMENT CO DELAWARE OFFICE		Description of Project Being Bid On: DUPONT	
Vendor's Representative: Chuck Green	Vendor's Phone No.: 1-800-365-0851		
Terms:	Delivery Date: Del in 2001	FOB: ☐ Prepaid ☐ Collect Subject to Inspection	
Quantity	Description	Unit Price	Total
125000	TON PORTLAND CEMENT	85¢/ton	
Note A Large quantity as this open A 10 MONTH TIME FRAME MAY REQUIRE 2 SUPPLIERS AS I MAY NOT HAVE TOTAL AMOUNT OF MATERIAL REQUIRED THIS IS ANTICIPATED COST FOR WORK IN 2001			
Freight Costs	Sales/Use Tax	Total Cost for Labor	Total Cost for Material
\$	\$	\$	\$
Freight costs are sales tax exempt - Always separate		☐ Tax Exempt	
All Work and Material as per Plans and Specifications		☐ Yes ☐ No	
Bid Inclusions:		Bid Exclusions	
Date This Bid Phoned In: 02/11/00 10:30		Time This Bid Phoned In: AM am pm X	
Signature of Representative Accepting This Bid:		AR324961	

MEMO OF TELECON

JOB NO.: 050035729.00 DATE: 01/21/00
JOB TITLE: Dupont FILE UNDER: _____
PERSON CALLING: Dick Davison PERSON CALLED: Mike Caly
REPRESENTING: U.K.S. REPRESENTING: Geo Con
TELEPHONE #: 1-412-856-7700
SUBJECT: SAL MIXING AT Dupont

SUMMARY OF CONVERSATION:

SOIL MIXING 100 TO 150 TON CRANE mounted
w/8' ϕ CASSION RIG, Backhoe, Labor Foreman - 31.00
2 MIX PLANTS (500^{cu}/hr) 25KVA GENERATOR - 2 PUMPS (500^{cu}/hr)
Silo & Storage Area

For production allow 2 CASSIONS / HOUR
USE 80% of Volume to Allow for OVERLAP
\$150,000⁺ mobilization is required to move Equipment
& Set up.

Cost should be 30' to 40' / CY or Less due to
Size of site 10 M DAY DRILL 17 to 18 HOLES / DAY.

CEMENT should be 20% mix by Volume
COST 80^{cu} / ton $\div$ 2000^{cu} = .04 / yard

AR324962

AR324963

APPENDIX D
HELP CALCULATIONS

AR324964

Cap and Barrier Flux Calculations Based on HELP Model Infiltration Rates

Cap Composite Infiltration Rate - Current Proposed Cap Design

Surface	Area (ft ²)	HELP Recharge (in/yr)	% Total Area	Fraction Rchg (in/yr)	Wall Flux (cm ³ /cm ² /day)	Wall Life (yrs)	x4
Asphalt Road	41064	0.04700	0.062	0.00290			
7% Grade Cap	436323	0.00017	0.656	0.00011			
1-3% Grade Cap	187864	0.00036	0.282	0.00010			
Totals	665251			0.00311	0.00064	2890	11559

HELP Model Wall Flux and Life Calculations

Assumes that we cannot segregate flow from above and in the waste, so just look at infiltration rates.

wall length = 2200 ft
 wall depth = 10 ft
 wall thickness = 1.5 ft
 porosity = 0.3
 Flow = Area * infiltration rate

Designed Cap:

Area =	15 acres	residence time in wall =	21,313 days
Inf rate =	0.00311 in/year	vel =	0.0021 cm/day
Flow =	0.0024 gpm	flux =	0.00064 cm ³ /cm ² /day

Current Conditions:

Area =	15 acres	residence time in wall =	11 days
Inf rate =	6.0 in/year	vel =	4.13 cm/day
Flow =	4.65 gpm	flux =	1.24 cm ³ /cm ² /day

EXHIBIT 5.3-1
URS Greiner
CALCULATION COVER SHEET

File 35849.08

DC-1

Client: DUPONT URS - DIA Project Name: SOUTH LANDFILL

Project/Calculation Number: 05- 35489- 35849

Title: HELP MODEL ANALYSIS OF CAP AND ROADWAY INFILTRATION

Total number of pages (including cover sheet): 57 (incl. Addendum #1 - SEE BELOW)

Total number of computer runs: 5

Prepared by: KEVIN FARRINGTON Date: 12/18/2000 1/11/01 ^{ADDENDUM #1}

Checked by: Marek Ostrowski Date: 12/18/2000 1/11/01

Description and Purpose:

EVALUATE POTENTIAL INFILTRATION THROUGH THE PROPOSED CAP, THE PROPOSED CAP PLUS A LATERAL DRAINAGE LAYER AND THE EXISTING ROADWAY.

Design bases/references/assumptions:

SEE NEXT PAGE

Remarks/conclusions:

SEE NEXT PAGE

Calculation Approved by:

[Signature] 12/19/00
Project Manager/Date

Revision No.:

Description of Revision:

Approved by:

ADDENDUM #1

EVALUATE CAP W/ A GEL LINER (GCL)

[Signature] 1/12/01

Project Manager/Date

AR324966

URSG PROJECT: Dupont South Landfill
 URSG PROJ. No.: 05_35849.00

TITLE: HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP)

Prepared by: Kevin Farrington 12/18/00
 Checked by: Marek Ostrowski 12/18/00

1. OBJECTIVE

The objective of this analysis is to estimate the average annual infiltration for the proposed capping system and for the existing asphalt road at the South Landfill facility.

2. DESIGN BASES

The proposed cap is described below:

Case 1: 6" of topsoil
 12" of barrier protection soil
 40 mil Geomembrane Liner
 12" of grading fill
 SLOPE=3%

Case 2: same as Case 1 except;
 SLOPE=7%

Case 3: 6" of topsoil
 12" of barrier protection soil
 0.5 cm lateral drainage layer
 40 mil geomembrane liner
 12" of grading fill
 SLOPE=3%

Case 4: same as Case 3 except;
 SLOPE=7%

The existing roadway is described below:

Case 1: 4" of asphalt
 2" of gravel
 12" of grading fill

Climatological Data

Climatological data was synthetically generated from the HELP database for the location of Wilmington, Delaware for a time period of 50 years.

The evapotranspiration zone depth is the maximum depth from which water may be removed by evapotranspiration. Where surface vegetation is present, such as at the South Landfill, the evaporative zone depth should at least equal the expected average depth of root penetration. In humid areas, such as Wilmington, DE, grasses may have rooting depth of 6 to 24 inches. The evaporative zone depth should be somewhat greater than the rooting depth, but may not exceed the depth to the top of the topmost barrier soil layer or in this case the top of the geomembrane. The evaporative zone depth is, therefore, set at 15 inches for the proposed cover system and 0.2 inches for asphalt.

The maximum leaf area index (LAI) is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. The maximum LAI was selected to be 2.0, based on the typical value for a fair stand of grass. For the asphalt road, the maximum LAI is 0.

AR324967

URSG PROJECT: Dupont South Landfill
URSG PROJ. No.: 05_35849.00

TITLE: HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP)

Runoff Parameters

According the proposed grading plan, landfill slopes will vary from 3% to 7%. Surface water collection swells will typically be constructed every 200 feet, with a *longest* flow length equal to 350 feet. The surface type for the calculation of the CN curve number was based on a poor stand of grass.

For the asphalt cap, the CN number was user-specified at the value of 90 (Reference 1, Erie and Niagara Counties Storm Drainage Design Manual).

Soil Data

Soil and material types were selected from the HELP database. The following soil types were used:

Topsoil:	#9, Silty Loam
Barrier Soil:	#22, Compacted Silt
Grading Fill:	#22, Compacted Silt
Drainage Net:	#20
Geomembrane:	#35, High Density Polyethylene (HDPE)
Asphalt:	#16, Barrier Soil
Gravel:	#2, Sand

Asphalt was modeled as a barrier protection layer with a lateral drainage layer above it. This model best simulates the drainage from a road surface, which is primarily in the lateral direction.

3. RESULTS

Detailed results are contained the attached Worksheet Data Files as follows:

<u>CASE</u>	<u>NAME OF RESULTS FILE</u>
Case 1 (Proposed cap @ 3% slope):	A_3%
Case 2 (Proposed cap @ 7% slope):	B_7%
Case 3 (Proposed cap plus lateral drainage layer, 3% slope):	D_3%
Case 4 (Proposed cap plus lateral drainage layer, 7% slope):	E_7%
Case 5 (Road):	ROAD1

4. CONCLUSIONS

The average annual percolation through the proposed cover system is:

<u>CASE</u>	<u>AVG. ANNUAL PERCOLATION RATE</u>
Case 1 (Proposed cap @ 3% slope):	0.389 in/yr
Case 2 (Proposed cap @ 7% slope):	0.389 in/yr
Case 3 (Proposed cap plus lateral drainage layer, 3% slope):	0.00036 in/yr
Case 4 (Proposed cap plus lateral drainage layer, 7% slope):	0.00017 in/yr
Case 5 (Road):	0.047 in/yr

AR324968

p. dH

URSG PROJECT: Dupont South Landfill
URSG PROJ. No.: 05_35849.00

**TITLE: HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP)
ADDENDUM #1**

Prepared by: Kevin Farrington 1/11/01
Checked by: Marek Ostrowski 1/11/01 M.O.

1. OBJECTIVE

The objective of this addendum is to provide a comparative analysis between the average annual infiltration for the proposed capping system, including drainage layer, (previously calculated) and the same capping system when a Geosynthetic Clay Liner (GCL), such as bentonite mat, is placed directly beneath the geomembrane liner. This case will be run for both the 3% and 7% slopes.

2. DESIGN BASES

The proposed cap is described below:

ADD. Case 1:

6" of topsoil
12" of barrier protection soil
0.2" drainage layer
40 mil Geomembrane Liner
0.6 cm Bentonite Mat
12" of grading fill
SLOPE=3%

ADD. Case 2:

same as Case 1 except;
SLOPE=7%

Climatological Data / Runoff Parameters

Same as in original calculation

Soil Data

Additional Soil and material types selected from the HELP database:

Geosynthetic Clay Liner (GCL): #17, Bentonite Mat

3. RESULTS

Detailed results are contained in the attached Worksheet Data Files as follows:

CASE

ADD. Case 1 (Proposed cap w/ GCL @ 3% slope)

ADD. Case 2 (Proposed cap w/ GCL @ 7% slope)

NAME OF RESULTS FILE

A_3%_GCL

B_7%_GCL

4. CONCLUSIONS

The average annual percolation through the proposed cover system was previously calculated (see original calculation) as:

CASE

Case 1 (Proposed cap @ 3% slope)

Case 2 (Proposed cap @ 7% slope)

AVG. ANNUAL PERCOLATION RATE

0.00036 in/yr

0.00017 in/yr

By comparison, the average annual percolation through the cap with the addition of a GCL is:

CASE

ADD. Case 1 (Proposed cap w/ GCL @ 3% slope)

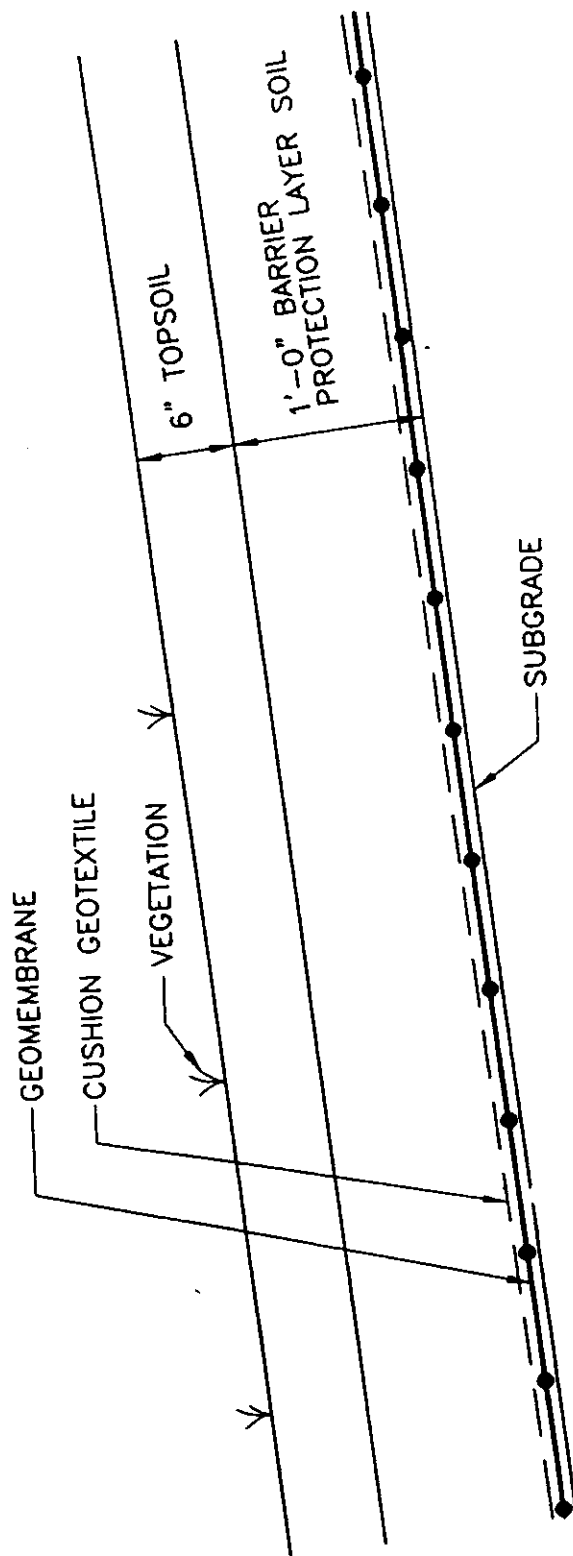
ADD. Case 2 (Proposed cap w/ GCL @ 7% slope)

AVG. ANNUAL PERCOLATION RATE

0.0000 in/yr

0.0000 in/yr

AR324969



CAP SYSTEM DETAIL (TYP.)



4
8

AR324970

(4)

11

```

**
**
**      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
**
**

```

TIME: 14:44 DATE: 12/14/2000

AR324971

A_3%

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	=	0.4569	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 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4231	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	CM/SEC

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 -	GOOD

LAYER 4

6

A_3%

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	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 3.8
AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.562	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.777	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.430	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	12.847	INCHES
TOTAL INITIAL WATER	=	12.847	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	107	
END OF GROWING SEASON (JULIAN DATE)	=	298	
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES

AR324973

A_3%

AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----

2

A_3%

PRECIPITATION

TOTALS	3.18	2.59	4.31	3.26	3.47	3.69
	3.71	4.02	3.55	2.64	3.06	3.26
STD. DEVIATIONS	1.58	1.22	1.75	1.15	1.56	1.88
	1.82	2.13	2.16	1.40	1.63	1.79

RUNOFF

TOTALS	2.070	1.690	2.600	0.471	0.216	0.244
	0.125	0.127	0.298	0.356	0.834	1.612
STD. DEVIATIONS	1.545	1.106	1.975	0.579	0.428	0.569
	0.441	0.261	0.724	0.885	1.417	1.701

EVAPOTRANSPIRATION

TOTALS	0.825	0.831	2.310	3.438	3.521	5.188
	3.928	3.810	2.295	1.415	1.232	0.907
STD. DEVIATIONS	0.294	0.444	0.495	0.655	1.103	0.987
	1.560	1.550	0.968	0.326	0.196	0.191

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0379	0.0265	0.0482	0.0469	0.0427	0.0305
	0.0140	0.0135	0.0162	0.0261	0.0385	0.0484
STD. DEVIATIONS	0.0174	0.0163	0.0098	0.0038	0.0039	0.0067
	0.0055	0.0071	0.0106	0.0175	0.0169	0.0149

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	11.0511	8.4076	14.1346	14.2626	12.5566	9.1767
	3.9200	3.7521	4.7483	7.5303	11.6233	14.2109
STD. DEVIATIONS	5.2008	5.3479	2.9290	1.1640	1.1586	2.0622
	1.6624	2.1372	3.2827	5.2429	5.2351	4.4518

A_3%

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.74 (5.925)	147883.3	100.00
RUNOFF	10.642 (4.1098)	38630.28	26.122
EVAPOTRANSPIRATION	29.699 (3.5446)	107807.45	72.900
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.38939 (0.05598)	1413.503	0.95582
AVERAGE HEAD ON TOP OF LAYER 3	9.615 (1.425)		
CHANGE IN WATER STORAGE	0.009 (0.8691)	32.06	0.022

□

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	5.26	19093.801
RUNOFF	3.630	13178.4365
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001974	7.16719
AVERAGE HEAD ON TOP OF LAYER 3	18.000	
SNOW WATER	4.03	14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4518
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1620

10

A_3%

□

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	2.8967	0.4828
2	5.0771	0.4231
3	0.0000	0.0000
4	5.0280	0.4190
SNOW WATER	0.287	

AR324977

CASE 2

B_7%

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\DATA4.D4
TEMPERATURE DATA FILE: C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE: C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\DATA10B.D10
OUTPUT DATA FILE: C:\HELP3\b_7%.OUT

TIME: 14:46 DATE: 12/14/2000

TITLE: Dupont South Landfill

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

Page 1

AR324978

B 7%

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	=	0.4569	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 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4231	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	CM/SEC

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3	- GOOD

LAYER 4

B_7%

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	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 7.%
AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	82.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.562	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.777	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.430	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	12.847	INCHES
TOTAL INITIAL WATER	=	12.847	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	107	
END OF GROWING SEASON (JULIAN DATE)	=	298	
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES

B_7%

AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT) *

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----

B_7%

PRECIPITATION

TOTALS	3.18 3.71	2.59 4.02	4.31 3.55	3.26 2.64	3.47 3.06	3.69 3.26
STD. DEVIATIONS	1.58 1.82	1.22 2.13	1.75 2.16	1.15 1.40	1.56 1.63	1.88 1.79

RUNOFF

TOTALS	2.069 0.131	1.689 0.136	2.603 0.303	0.472 0.355	0.219 0.832	0.251 1.609
STD. DEVIATIONS	1.544 0.447	1.105 0.272	1.974 0.724	0.578 0.880	0.426 1.412	0.578 1.700

EVAPOTRANSPIRATION

TOTALS	0.825 3.920	0.830 3.804	2.309 2.292	3.439 1.415	3.514 1.231	5.187 0.906
STD. DEVIATIONS	0.294 1.561	0.444 1.547	0.495 0.970	0.653 0.326	1.102 0.195	0.992 0.189

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0379 0.0140	0.0265 0.0134	0.0482 0.0161	0.0469 0.0259	0.0427 0.0384	0.0304 0.0484
STD. DEVIATIONS	0.0174 0.0055	0.0163 0.0070	0.0098 0.0105	0.0038 0.0175	0.0039 0.0170	0.0067 0.0149

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	11.0592 3.9109	8.4083 3.7330	14.1326 4.7102	14.2553 7.4921	12.5435 11.5894	9.1549 14.2021
STD. DEVIATIONS	5.1871 1.6563	5.3467 2.1016	2.9284 3.2494	1.1654 5.2336	1.1482 5.2380	2.0836 4.4463

B_7%

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50				
	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.74	(5.925)	147883.3	100.00
RUNOFF	10.668	(4.1129)	38726.55	26.187
EVAPOTRANSPIRATION	29.673	(3.5313)	107713.36	72.837
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.38879	(0.05608)	1411.323	0.95435
AVERAGE HEAD ON TOP OF LAYER 3	9.599	(1.428)		
CHANGE IN WATER STORAGE	0.009	(0.8661)	32.06	0.022

□

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50		
	(INCHES)	(CU. FT.)
PRECIPITATION	5.26	19093.801
RUNOFF	3.630	13176.5449
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001974	7.16719
AVERAGE HEAD ON TOP OF LAYER 3	18.000	
SNOW WATER	4.03	14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4518
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1620

B 7%

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	2.8966	0.4828
2	5.0771	0.4231
3	0.0000	0.0000
4	5.0280	0.4190
SNOW WATER	0.287	

CASE 3
D_3%

□

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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\DATA4.D4
TEMPERATURE DATA FILE: C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE: C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\DATA10d.D10
OUTPUT DATA FILE: C:\HELP3\d_3%.OUT

TIME: 14:50 DATE: 12/14/2000

TITLE: Dupont South Landfill

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

13

D 38
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	=	0.2687	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 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3443	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	CM/SEC

LAYER 3

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	=	0.0993	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	350.0	FEET

LAYER 4

60

D 3%

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3	- GOOD

LAYER 5

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	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 350. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.641	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.777	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.430	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.791	INCHES

(51)

	D_3%	=	10.791	INCHES
TOTAL INITIAL WATER		=	0.00	INCHES/YEAR
TOTAL SUBSURFACE INFLOW				

EVAPOTRANSPIRATION AND WEATHER DATA -----

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	107
END OF GROWING SEASON (JULIAN DATE)	=	298
EVAPORATIVE ZONE DEPTH	=	15.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

D_3%

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
	-----	-----	-----	-----	-----	-----
PRECIPITATION						

TOTALS	3.18 3.71	2.59 4.02	4.31 3.55	3.26 2.64	3.47 3.06	3.69 3.26
STD. DEVIATIONS	1.58 1.82	1.22 2.13	1.75 2.16	1.15 1.40	1.56 1.63	1.88 1.79
RUNOFF						

TOTALS	0.753 0.111	0.934 0.123	0.747 0.181	0.023 0.104	0.022 0.068	0.066 0.237
STD. DEVIATIONS	0.906 0.363	0.900 0.245	1.198 0.403	0.059 0.274	0.046 0.131	0.152 0.658
EVAPOTRANSPIRATION						

TOTALS	0.825 3.331	0.833 3.684	2.312 2.316	3.459 1.525	3.515 1.265	3.831 0.914
STD. DEVIATIONS	0.296 1.322	0.448 1.468	0.497 0.998	0.654 0.404	1.101 0.218	1.461 0.200
LATERAL DRAINAGE COLLECTED FROM LAYER 3						

TOTALS	1.2857 0.0840	0.7105 0.1872	2.2601 0.4144	0.6044 0.7145	0.1898 1.2391	0.2315 1.6360
STD. DEVIATIONS	1.2664 0.1958	0.9489 0.4511	1.5039 0.8766	0.5799 1.1647	0.3525 1.4371	0.5226 1.4178

23

D_3%

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0085	0.0052	0.0150	0.0041	0.0013	0.0016
	0.0006	0.0012	0.0028	0.0047	0.0085	0.0109
STD. DEVIATIONS	0.0084	0.0069	0.0100	0.0040	0.0023	0.0036
	0.0013	0.0030	0.0060	0.0077	0.0099	0.0094

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.74	(5.925)	147883.3	100.00
RUNOFF	3.369	(2.1914)	12228.96	8.269
EVAPOTRANSPIRATION	27.811	(3.4662)	100953.67	68.266
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.55710	(3.60619)	34692.281	23.45923
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00036	(0.00013)	1.301	0.00088
AVERAGE HEAD ON TOP OF LAYER 4	0.005	(0.002)		

AR324990

		D 3%		
CHANGE IN WATER STORAGE	0.002	(0.7305)	7.08	0.005

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	5.26	19093.801
RUNOFF	2.410	8749.3164
DRAINAGE COLLECTED FROM LAYER 3	0.64627	2345.95239
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000021	0.07585
AVERAGE HEAD ON TOP OF LAYER 4	0.133	
MAXIMUM HEAD ON TOP OF LAYER 4	0.263	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	3.5 FEET	
SNOW WATER	4.03	14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4480
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1620

*** 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.

AR324991

25

D_38

□

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.7220	0.2870
2	3.8457	0.3205
3	0.0062	0.0311
4	0.0000	0.0000
5	5.0280	0.4190
SNOW WATER	0.287	

AR324992

CASE 4
E-7%

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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\DATA4.D4
TEMPERATURE DATA FILE: C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE: C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\DATA10e.D10
OUTPUT DATA FILE: C:\HELP3\e-7%.OUT

TIME: 14:58 DATE: 12/14/2000

```
*****
TITLE: Dupont South Landfill
*****
```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

AR324993

E-7%

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	=	0.2713	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 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3460	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.50	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0259	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	7.00	PERCENT
DRAINAGE LENGTH	=	350.0	FEET

LAYER 4

E-7%

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	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 7.8
AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	82.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.672	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.777	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.430	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.821	INCHES

E-7%

TOTAL INITIAL WATER	=	10.821	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	107	
END OF GROWING SEASON (JULIAN DATE)	=	298	
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

E-7%

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
	-----	-----	-----	-----	-----	-----
PRECIPITATION						

TOTALS	3.18 3.71	2.59 4.02	4.31 3.55	3.26 2.64	3.47 3.06	3.69 3.26
STD. DEVIATIONS	1.58 1.82	1.22 2.13	1.75 2.16	1.15 1.40	1.56 1.63	1.88 1.79
RUNOFF						

TOTALS	0.760 0.118	0.937 0.133	0.757 0.192	0.025 0.109	0.026 0.075	0.072 0.246
STD. DEVIATIONS	0.907 0.371	0.900 0.259	1.201 0.412	0.062 0.280	0.051 0.142	0.161 0.659
EVAPOTRANSPIRATION						

TOTALS	0.826 3.335	0.834 3.688	2.312 2.311	3.462 1.521	3.516 1.266	3.836 0.915
STD. DEVIATIONS	0.296 1.320	0.449 1.473	0.497 1.000	0.656 0.406	1.100 0.217	1.464 0.200
LATERAL DRAINAGE COLLECTED FROM LAYER 3						

TOTALS	1.2806 0.0760	0.7061 0.1747	2.2463 0.4056	0.6016 0.7063	0.1874 1.2278	0.2221 1.6310
STD. DEVIATIONS	1.2508 0.1845	0.9409 0.4273	1.4944 0.8517	0.5742 1.1499	0.3476 1.4305	0.5096 1.4095

E-7%

PERCOLATION/LEAKAGE THROUGH LAYER 5

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 4

AVERAGES	0.0037	0.0022	0.0065	0.0018	0.0005	0.0007
	0.0002	0.0005	0.0012	0.0020	0.0037	0.0047
STD. DEVIATIONS	0.0036	0.0030	0.0044	0.0017	0.0010	0.0015
	0.0005	0.0012	0.0025	0.0033	0.0043	0.0041

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.74	(5.925)	147883.3	100.00
RUNOFF	3.451	(2.2060)	12525.81	8.470
EVAPOTRANSPIRATION	27.821	(3.4735)	100991.76	68.292
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.46547	(3.56873)	34359.664	23.23431
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00017	(0.00006)	0.602	0.00041
AVERAGE HEAD ON TOP OF LAYER 4	0.002	(0.001)		

(32)

CHANGE IN WATER STORAGE E-7% 0.002 (0.7344) 5.46 0.004

□

PEAK DAILY VALUES FOR YEARS		1 THROUGH	50
		(INCHES)	(CU. FT.)
PRECIPITATION		5.26	19093.801
RUNOFF		2.442	8863.3369
DRAINAGE COLLECTED FROM LAYER	3	0.67747	2459.22949
PERCOLATION/LEAKAGE THROUGH LAYER	5	0.000010	0.03686
AVERAGE HEAD ON TOP OF LAYER	4	0.060	
MAXIMUM HEAD ON TOP OF LAYER	4	0.118	
LOCATION OF MAXIMUM HEAD IN LAYER	3		
(DISTANCE FROM DRAIN)		3.6 FEET	
SNOW WATER		4.03	14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL)			0.4470
MINIMUM VEG. SOIL WATER (VOL/VOL)			0.1620

*** 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.

E-7%

□

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.7296	0.2883
2	3.8451	0.3204
3	0.0069	0.0139
4	0.0000	0.0000
5	5.0280	0.4190
SNOW WATER	0.287	

CASE 5

Road1

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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
**
**
*****
*****
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```
PRECIPITATION DATA FILE: C:\HELP3\DATA4RD.D4
TEMPERATURE DATA FILE: C:\HELP3\DATA7RD.D7
SOLAR RADIATION DATA FILE: C:\HELP3\DATA13RD.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\DATA11RD.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\ROAD1.D10
OUTPUT DATA FILE: C:\HELP3\ROAD1.OUT
```

TIME: 8:53 DATE: 12/15/2000

TITLE: Dupont South Landfill

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 2 - LATERAL DRAINAGE LAYER

Road1
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 = 0.0058 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC
SLOPE = 2.00 PERCENT
DRAINAGE LENGTH = 30.0 FEET

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16
THICKNESS = 4.00 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 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 2.00 INCHES
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0803 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.579999993000E-02 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-

Road1
SPECIFIED CURVE NUMBER OF 90.0, A SURFACE SLOPE
OF 2.% AND A SLOPE LENGTH OF 30. FEET.

SCS RUNOFF CURVE NUMBER	=	91.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	0.2	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.001	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	0.170	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.001	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1.870	INCHES
TOTAL INITIAL WATER	=	1.870	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	107
END OF GROWING SEASON (JULIAN DATE)	=	298
EVAPORATIVE ZONE DEPTH	=	0.2 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

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Road1

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----	-----
PRECIPITATION						

TOTALS	3.18 3.71	2.59 4.02	4.31 3.55	3.26 2.64	3.47 3.06	3.69 3.26
STD. DEVIATIONS	1.58 1.82	1.22 2.13	1.75 2.16	1.15 1.40	1.56 1.63	1.88 1.79
RUNOFF						

TOTALS	1.327 0.642	1.410 0.771	1.414 0.723	0.313 0.412	0.389 0.426	0.568 0.625
STD. DEVIATIONS	1.330 0.747	1.089 0.794	1.383 0.841	0.324 0.504	0.427 0.530	0.577 0.834
EVAPOTRANSPIRATION						

TOTALS	0.506	0.451	0.786	0.806	0.779	0.610

AR325004

	0.556	Road1 0.622	0.445	0.337	0.432	0.415
STD. DEVIATIONS	0.185	0.161	0.278	0.362	0.394	0.364
	0.358	0.319	0.289	0.219	0.190	0.148
LATERAL DRAINAGE COLLECTED FROM LAYER 1						

TOTALS	1.2330	0.6940	2.4677	2.1307	2.3078	2.5053
	2.5025	2.6251	2.3837	1.8950	2.1509	2.0259
STD. DEVIATIONS	1.0807	0.8398	1.2210	0.7378	0.9308	1.1812
	1.0328	1.3168	1.2243	0.8923	1.1075	1.0815
PERCOLATION/LEAKAGE THROUGH LAYER 2						

TOTALS	0.0049	0.0028	0.0051	0.0041	0.0045	0.0038
	0.0034	0.0035	0.0028	0.0027	0.0038	0.0059
STD. DEVIATIONS	0.0029	0.0018	0.0024	0.0017	0.0014	0.0018
	0.0015	0.0015	0.0012	0.0015	0.0016	0.0029
PERCOLATION/LEAKAGE THROUGH LAYER 3						

TOTALS	0.0041	0.0040	0.0037	0.0041	0.0042	0.0043
	0.0043	0.0041	0.0040	0.0039	0.0033	0.0033
STD. DEVIATIONS	0.0012	0.0010	0.0009	0.0011	0.0010	0.0009
	0.0008	0.0007	0.0006	0.0006	0.0006	0.0007

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0069	0.0045	0.0123	0.0113	0.0113	0.0116
	0.0114	0.0112	0.0102	0.0082	0.0107	0.0099
STD. DEVIATIONS	0.0049	0.0047	0.0052	0.0037	0.0042	0.0052
	0.0042	0.0045	0.0046	0.0032	0.0050	0.0046

39

Road1

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.74	(5.925)	147883.3	100.00
RUNOFF	9.019	(3.2335)	32738.21	22.138
EVAPOTRANSPIRATION	6.745	(1.0502)	24484.69	16.557
LATERAL DRAINAGE COLLECTED FROM LAYER 1	24.92171	(3.80153)	90465.828	61.17379
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.04729	(0.00654)	171.645	0.1160
AVERAGE HEAD ON TOP OF LAYER 2	0.010	(0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.04729	(0.00610)	171.653	0.1160
CHANGE IN WATER STORAGE	0.006	(0.5005)	22.93	0.016

□

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	5.26	19093.801
RUNOFF	3.338	12118.7061
DRAINAGE COLLECTED FROM LAYER 1	1.86382	6765.67236
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.002999	10.88669
AVERAGE HEAD ON TOP OF LAYER 2	0.104	
MAXIMUM HEAD ON TOP OF LAYER 2	0.094	

AR325006

Road1
LOCATION OF MAXIMUM HEAD IN LAYER 1
(DISTANCE FROM DRAIN) 1.4 FEET
PERCOLATION/LEAKAGE THROUGH LAYER 3 0.000414 1.50356
SNOW WATER 4.03 14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.8500
MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0050

*** 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 50

LAYER	(INCHES)	(VOL/VOL)
1	0.0305	0.1523
2	1.7080	0.4270
3	0.1605	0.0803
SNOW WATER	0.287	

IME: 11:42 DATE: 1/11/2001

TITLE: Dupont South Landfill

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

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	=	0.2687	VOL/VOL

A_3%_gcl

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 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3443	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	CM/SEC

LAYER 3

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	=	0.0993	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	350.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 -	GOOD

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

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	=	0.7470	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 6

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	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 3.8
 AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.641	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.777	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.430	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.970	INCHES
TOTAL INITIAL WATER	=	10.970	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA -----

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	107
END OF GROWING SEASON (JULIAN DATE)	=	298
EVAPORATIVE ZONE DEPTH	=	15.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.18 3.71	2.59 4.02	4.31 3.55	3.26 2.64	3.47 3.06	3.69 3.26
STD. DEVIATIONS	1.58 1.82	1.22 2.13	1.75 2.16	1.15 1.40	1.56 1.63	1.88 1.79
RUNOFF						
TOTALS	0.753 0.111	0.934 0.123	0.747 0.181	0.023 0.104	0.022 0.068	0.066 0.237
STD. DEVIATIONS	0.906 0.363	0.900 0.245	1.198 0.403	0.059 0.274	0.046 0.131	0.152 0.658
EVAPOTRANSPIRATION						
TOTALS	0.825 3.331	0.833 3.684	2.312 2.316	3.459 1.525	3.515 1.265	3.831 0.914
STD. DEVIATIONS	0.296 1.322	0.448 1.468	0.497 0.998	0.654 0.404	1.101 0.218	1.461 0.200
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	1.2858 0.0840	0.7105 0.1872	2.2602 0.4144	0.6044 0.7145	0.1898 1.2391	0.2315 1.6361
STD. DEVIATIONS	1.2665 0.1958	0.9489 0.4511	1.5040 0.8767	0.5799 1.1647	0.3525 1.4371	0.5226 1.4179
PERCOLATION/LEAKAGE THROUGH LAYER 4						
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 6						
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

1.76

A 3_{gcl}

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 4

AVERAGES	0.0085	0.0052	0.0150	0.0041	0.0013	0.0016
	0.0006	0.0012	0.0028	0.0047	0.0085	0.0109
STD. DEVIATIONS	0.0084	0.0069	0.0100	0.0040	0.0023	0.0036
	0.0013	0.0030	0.0060	0.0077	0.0099	0.0094

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
	-----		-----	-----
PRECIPITATION	40.74	(5.925)	147883.3	100.00
RUNOFF	3.369	(2.1914)	12228.96	8.269
EVAPOTRANSPIRATION	27.811	(3.4662)	100953.67	68.266
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.55746	(3.60632)	34693.570	23.46010
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.006	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.005	(0.002)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.006	0.00000
AVERAGE HEAD ON TOP OF LAYER 6	0.000	(0.000)		

CHANGE IN WATER STORAGE 0.002 (0.7305) 7.08 0.005

□

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	5.26	19093.801
RUNOFF	2.410	8749.3164
DRAINAGE COLLECTED FROM LAYER 3	0.64629	2346.02808
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00021
AVERAGE HEAD ON TOP OF LAYER 4	0.133	
MAXIMUM HEAD ON TOP OF LAYER 4	0.263	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	3.9 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00021
AVERAGE HEAD ON TOP OF LAYER 6	0.000	
SNOW WATER	4.03	14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4480
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1620

*** 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 50

LAYER	(INCHES)	(VOL/VOL)
-----	-----	-----
1	1.7220	0.2870
2	3.8457	0.3205
3	0.0062	0.0311
4	0.0000	0.0000
5	0.1793	0.7470
6	5.0280	0.4190
SNOW WATER	0.287	

```
*****  
*****  
**  
**  
**      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\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\B_7%_GCL.D10
OUTPUT DATA FILE:            C:\HELP3\B_7%_GCL.OUT
```

TIME: 11:44 DATE: 1/11/2001

TITLE: Dupont South Landfill

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

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	=	0.2719	VOL/VOL

p.50

B_7%_gcl

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 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3490	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	CM/SEC

LAYER 3

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	=	0.0528	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	7.00	PERCENT
DRAINAGE LENGTH	=	350.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

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	=	0.7470	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 6

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 22

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.189999992000E-04	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 7.8
AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	82.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	15.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.703	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.777	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.430	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	11.037	INCHES
TOTAL INITIAL WATER	=	11.037	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA -----

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WILMINGTON DELAWARE

STATION LATITUDE	=	39.80 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	107
END OF GROWING SEASON (JULIAN DATE)	=	298
EVAPORATIVE ZONE DEPTH	=	15.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	71.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION

TOTALS	3.18	2.59	4.31	3.26	3.47	3.69
	3.71	4.02	3.55	2.64	3.06	3.26

STD. DEVIATIONS	1.58	1.22	1.75	1.15	1.56	1.88
	1.82	2.13	2.16	1.40	1.63	1.79

RUNOFF

TOTALS	0.767	0.939	0.763	0.027	0.027	0.074
	0.120	0.134	0.197	0.114	0.078	0.254

STD. DEVIATIONS	0.910	0.901	1.203	0.064	0.052	0.164
	0.368	0.261	0.423	0.288	0.146	0.675

EVAPOTRANSPIRATION

TOTALS	0.825	0.834	2.312	3.464	3.509	3.849
	3.332	3.693	2.308	1.518	1.265	0.914

STD. DEVIATIONS	0.296	0.449	0.497	0.655	1.100	1.464
	1.319	1.472	0.997	0.405	0.217	0.200

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	1.2741	0.7077	2.2290	0.6103	0.1895	0.2195
	0.0731	0.1708	0.3979	0.7042	1.2230	1.6228

STD. DEVIATIONS	1.2368	0.9423	1.4823	0.5823	0.3459	0.5065
	0.1776	0.4223	0.8381	1.1509	1.4253	1.4008

PERCOLATION/LEAKAGE THROUGH LAYER 4

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 6

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

p. 34

0.0000 B 7% gcl 0.0000 0.0000 0.0000 0.0000

 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0036	0.0022	0.0064	0.0018	0.0005	0.0006
	0.0002	0.0005	0.0012	0.0020	0.0036	0.0046
STD. DEVIATIONS	0.0035	0.0029	0.0042	0.0017	0.0010	0.0015
	0.0005	0.0012	0.0025	0.0033	0.0042	0.0040

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
	-----		-----	-----
PRECIPITATION	40.74	(5.925)	147883.3	100.00
RUNOFF	3.493	(2.2182)	12679.29	8.574
EVAPOTRANSPIRATION	27.823	(3.4711)	100999.26	68.297
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.42189	(3.55429)	34201.457	23.12733
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.004	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.002	(0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.004	0.00000
AVERAGE HEAD ON TOP OF LAYER 6	0.000	(0.000)		

B_7%_gcl

CHANGE IN WATER STORAGE 0.001 (0.7333) 3.29 0.002

□

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	5.26	19093.801
RUNOFF	2.392	8683.6396
DRAINAGE COLLECTED FROM LAYER 3	0.64629	2346.02808
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00009
AVERAGE HEAD ON TOP OF LAYER 4	0.057	
MAXIMUM HEAD ON TOP OF LAYER 4	0.117	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00009
AVERAGE HEAD ON TOP OF LAYER 6	0.000	
SNOW WATER	4.03	14622.6279
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4488
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1620

*** 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 50

LAYER	(INCHES)	(VOL/VOL)
1	1.7391	0.2899
2	3.8457	0.3205
3	0.0040	0.0199
4	0.0000	0.0000
5	0.1793	0.7470
6	5.0280	0.4190

SNOW WATER 0.287

AR325024

APPENDIX E

PROPOSED CHANGES TO PERFORMANCE STANDARDS

AR325025

APPENDIX E

PROPOSED MODIFICATIONS to the PERFORMANCE STANDARDS

The PRB remedy is consistent with the criteria set forth in 40 CFR Part 300, Section 430(e)(9)(iii)—the National Contingency Plan—and was developed to ensure that this technology for the South Landfill is at least as protective of human health and the environment as the South Landfill remedy mandated in the 1993 ROD and 1995 ESD. The proposed performance standards are consistent with the proposed PRB remedy changes and would either add to or replace/delete (as indicated) the standards contained in Section 3 of the 1993 ROD and in the 1995 ESD.

3.2. In-Situ Stabilization --- (Delete, including Performance Standards 3.2.1. to 3.2.4.)

3.3. South Landfill Cap

DESCRIPTION: (Replaces existing Description) Once the groundwater barrier and permeable reactive barriers are installed, the entire South Landfill shall be capped. The cap shall include a synthetic geomembrane. South James Street/Basin Road will be left in place, and the cap will be sufficiently tied into the existing road structure so as to eliminate, to the extent practicable, infiltration of precipitation along the roadway.

PERFORMANCE STANDARDS:

3.3.12. (Replaces 3.3.8.) A landfill cap shall be installed that completely covers (to the maximum extent practicable) the South Landfill, including the portion owned by DuPont and the portion owned by the State of Delaware. The cap, at a minimum, shall extend to the vertical barrier wall/permeable reactive barrier wall system and shall be constructed in such a way as to prevent infiltration of water between the edges of the cap and the barrier/permeable walls.

3.3.13. (Replaces 3.3.10.) South James Street/Basin Road will be left in place. The cap will be tied into the existing road structure in such a way as to eliminate, to the extent practicable, infiltration of water between the edges of the cap and the roadway.

3.3.14. The cap for the intertidal riverbank area will consist of a geosynthetic membrane and armor stone to control erosion and isolate the river from the landfill materials.

3.3.15. An inspection and maintenance plan for South James Street/Basin Road will be prepared to ensure infiltration is minimized. The plan will provide for an annual inspection and repair of potholes and cracks. In addition, the annual inspection will include an assessment of roadway integrity and specifically address the need for more extensive repairs, such as resurfacing.

3.5. South Landfill Institutional Controls

DESCRIPTION: (Replaces existing Description) Institutional controls shall be placed on the DuPont property south of the Christina River and on the State of Delaware's contaminated property to restrict future land use, to notify the public of past land use, and/or to ensure the protectiveness of the remedy. A health and safety shall be developed to protect future maintenance workers who may be required to come into contact with landfill waste (such as sewer main workers or highway workers).

3.5.8. (Replaces 3.5.7.) A health and safety plan shall be developed to protect future maintenance workers who may be required to come into contact with landfill waste (such as sewer main workers or highway workers).

3.6. Ground-water Barrier Wall

DESCRIPTION: (Replaces existing Description) A vertical barrier wall shall be installed from the ground surface to a low-permeable clay layer that lies below the waste material in the South Landfill. The wall shall be constructed parallel to the riverbank and be located along the south side of the New Castle County sewer main. The slurry wall will join the permeable reactive wall section at each end in order to form a continuous barrier.

PERFORMANCE STANDARDS:

3.6.6. (Replaces 3.6.1.) A vertical groundwater barrier wall designed to limit, to the maximum extent practicable, the migration of groundwater from the Christina River into the landfill (or vice-versa) shall be installed. The permeability of the wall shall at least be equivalent to the permeability of a 3-foot-thick, 10^{-7} cm/s barrier.

3.6.7. (Replaces 3.6.3.) The wall shall be placed parallel to the riverbank along the south side of the New Castle County sewer main. The impermeable barrier wall will be keyed into the permeable reactive barrier wall sections to create a continuous barrier circumscribing the South Landfill wastes.

3.6.8. (Replaces 3.6.5.) The wall shall be installed prior to the capping and riverbank stabilization activities.

3.7. Ground-water Pump & Treat System -- (Delete, including Performance Standards 3.7.1 to 3.7.5.)

3.8. Sulfate/Sulfide Treatment -- (Delete, including Performance Standards 3.8.1 to 3.8.10.)

3.9. Permeable Reactive Barrier Wall

DESCRIPTION: A vertical, permeable reactive barrier (PRB) wall, consisting of gypsum, zero-valent iron, magnesite, and sand will be installed to immobilize all constituents of interest migrating from the site. The PRB wall shall be installed from the ground surface to a low-permeable clay layer that lies below the waste material in the South Landfill. The wall shall be placed along the remainder of the landfill perimeter not bounded by the vertical ground-water barrier wall. The PRB wall will be keyed into the vertical groundwater barrier wall at each end in order to form a continuous barrier circumscribing the South Landfill.

3.9.1. A vertical PRB wall designed to immobilize all constituents of interest migrating from the site to levels below the treatment standards established in 3.8.5 shall be installed. The wall shall be 18-inches thick and shall be placed along the remainder of the landfill perimeter not bounded by the vertical groundwater barrier wall.

3.9.2. The PRB shall extend from the ground surface to an intermediate clay lens in the Columbia aquifer that is below the waste material. The PRB wall should extend three feet into the clay lens.

3.9.3. The PRB wall will be keyed into the impermeable barrier wall section at each end to create a continuous barrier circumscribing the South Landfill wastes.

3.9.4. The PRB will be composed of reactive agents and sand in a 100:20:5:5 weight ratio of soil: gypsum: iron: magnesite (as $Mg_5(CO_3)_4(OH_2) \cdot 4H_2O$).

3.9.5. Approximately ten monitoring wells will be installed, on 200-foot centers, in the outer 6 to 12 inches of the reactive barrier. The wells will be screened across the entire reactive zone.

3.9.6. Monitoring wells will be installed downgradient of the PRB. The wells will be screened across the entire reactive zone.

3.9.7. The monitoring wells (both within the PRB and outside the landfill) will be sampled for the constituents of concern (barium, lead, zinc, cadmium, manganese, copper and nickel) and iron on a quarterly frequency for one year and on a semi-annual frequency thereafter upon approval by EPA. Field measurements of pH, eH, and dissolved oxygen will also be performed.

3.9.8. The PRB wall shall be installed prior to the landfill and riverbank capping activities.

APPENDIX F

**SOUTH LANDFILL EXPLANATION OF SIGNIFICANT
DIFFERENCES**

AR325030

APPENDIX F
SOUTH LANDFILL
EXPLANATION OF SIGNIFICANT DIFFERENCES
E.I. DuPONT, NEWPORT SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

EPA ANNOUNCES A REMEDY CHANGE

This Explanation of Significant Differences (ESD) describes EPA's revised remedy to address contamination in the South Landfill area of the E.I. DuPont, Newport Superfund Site which is located in Newport, New Castle County, Delaware. Also known as the DuPont-Newport Site, it is referred to throughout this document as the "Site."

On August 26, 1993, the Environmental Protection Agency (EPA) issued a Record of Decision (ROD) for this Site formally outlining how EPA will address the Site contamination. The ROD discussed seven areas of the Site: a ballpark, the north landfill and wetlands, the south landfill, the south wetlands, the Christina River, the Ciba-Geigy and DuPont Holly Run chemical plants, and the ground water.

In October 1993, new information was presented to EPA regarding the volume of waste in the south landfill. At that time, EPA was presented with several new alternatives that addressed the risks from the contamination in the south landfill. On August 17, 1995 EPA issued an ESD revising the original remedy from in-situ soil mixing to in-situ chemical stabilization with hydraulic containment of the waste materials.

Subsequent to the issuance of the 1995 ESD, new information was presented to the EPA regarding the required volume of treatment materials and corresponding increase in net waste volume generated by 1995 ESD remedy. EPA was later presented with new alternatives that addressed the risks from the contamination in the south landfill.

Based on its review, EPA believes that changes are warranted in the way the south landfill will be cleaned up. The current clean-up plan for the south landfill was outlined in the August 17, 1995 ESD. This January 2001 ESD describes a new revised remedy for the south landfill and explains why EPA is changing the remedy. The changes do not fundamentally alter the previously selected remedy for the south landfill with respect to scope or performance.. Therefore, a ROD amendment is not required.

The Administrative Record file, which contains the information upon which EPA based this remedy change, is available at the following information repositories:

U.S. EPA Region III, Docket Room
Mrs. Anna Butch (3HW14)
841 Chestnut Building, 9th floor
Philadelphia, PA 19107
(215) 597-3037

The Kirkwood Library
6000 Kirkwood Highway
Wilmington, DE 19808
(302) 995-7663

Town Hall of Newport
15 N. Augustine St.
Newport, DE 19804
(302) 994-6403

SITE DESCRIPTION AND BACKGROUND

The DuPont-Newport Superfund Site occupies approximately 120 acres on the banks of the Christina River at James and Water Streets in Newport, Delaware. It is near the I-95, I-495, and Delaware State 141 interchange (see Figure 1). The Site includes land currently occupied by a paint pigment production facility (the Ciba-Geigy plant), a former chromium dioxide production facility (the DuPont Holly Run plant), two industrial landfills separated by the Christina River (known locally by some as the Christiana River), and a baseball diamond (owned by DuPont and referred to as the ballpark) located just northwest of the Ciba-Geigy plant across the Amtrak railroad (see Figure 2). Part of the Site is in the town of Newport and part of the Site is in unincorporated New Castle County.

Originally built during the period from 1900 to 1902, the pigment plant was owned and operated by Henrik J. Krebs. The plant produced Lithopone, a white inorganic paint pigment. E.I. du Pont de Nemours & Company (DuPont) purchased the plant in 1929 and continued to produce Lithopone, but slowly changed and added processes to produce other organic and inorganic pigments. DuPont sold the pigment manufacturing operations to Ciba-Geigy Corporation in 1984.

As part of the Ciba-Geigy pigment plant operations (although prior to Ciba-Geigy's ownership), waste and off-specification products were disposed of in the north and south landfills. The south landfill, which operated from approximately 1902 to 1953, was used for the disposal of large quantities of Lithopone wastes. Waste sludges from the purification of zinc and barium ores were pumped from the plant and discharged into the south wetlands, creating a landfill. The waste sludges contained numerous heavy metal contaminants. In the 1970's, the south landfill was covered with soils from excavations for the construction of the Delaware Highway 141 Christina River bridge.

Results of ground water samples collected in the late 1970's and early 1980's, indicated elevated levels of heavy metals (especially barium, cadmium, and zinc) and volatile organic compounds (mainly tetrachloroethene and trichloroethene) in the ground water. The Site was proposed to be included on the National Priorities List (NPL) in January 1987. It was added to the NPL in February 1990.

On August 22, 1988, DuPont entered into an Administrative Order by Consent with EPA. This meant that DuPont agreed to perform a Remedial Investigation and Feasibility Study (RI/FS) for the Site, which led to the August 26, 1993 ROD.

Attached are Figures 3, 4, and 5 from the ROD. Figure 3 contains data from soil samples from across the Site including sample TP-6, located in the south landfill, which shows high levels of contamination. Figures 4 and 5 show that the landfill extends to the east of where James Street/Basin Road is located today. James Street/Basin Road, which once formed the border of the landfill, was relocated to accommodate construction of the Delaware State Highway 141 bridge.

In 1993, the Delaware Department of Transportation (DelDOT) collected a number of soil samples from the portion of the south landfill owned by the State of Delaware (currently underneath and to the east of James Street/Basin Road). DelDOT did this to more accurately determine the amount and extent of soil contamination. Data collected by DelDOT indicated that 85,000 cubic yards (instead of the 37,000 cubic yards estimated in the ROD) would require excavation, because the contamination was deeper than originally anticipated, representing a 230% increase in cost.

In 1994 DelDOT and DuPont independently submitted alternate remedy proposals to the EPA in an effort to address the contamination in a less costly manner. In 1995, EPA selected an alternate remedy for the south landfill and issued an Explanation of Significant Differences (1995 ESD) to modify the 1993 ROD. The revised remedy changed the treatment technology from in-situ stabilization to chemical precipitation with sodium sulfide and sodium sulfate. The 1995 ESD also upgraded the containment system from a soil cover to a low permeability cap, a circumscribing groundwater barrier wall, and a groundwater pump and treat system.

Subsequent to the issuance of the 1995 ESD, new information was presented to the EPA regarding the required volume of treatment materials and corresponding increase in net waste volume generated by 1995 ESD remedy. EPA was later presented with new alternatives that addressed the risks from the contamination in the south landfill.

REMEDY CHANGE

The 1995 ESD remedy called for the in-situ stabilization of the south landfill wastes by precipitation with sodium sulfate and sodium sulfide treatment agents. EPA originally estimated that the amount of reagents required for treatment was 82 tons. Data collected by DuPont indicates that 34,000 tons of reagents are actually necessary and would incur a 5 percent increase in the total volume of waste materials. EPA originally estimated the cost of the south landfill portion of the selected 1995 ESD remedy to be \$11,600,000. Based on the new estimate of the

materials required for treatment, EPA's revised cost estimate for the south landfill portion of the selected remedy is \$23,110,000.

In January 2001, DuPont presented an alternative remedy to address the south landfill in a less costly manner. This alternative would involve installing an impermeable groundwater barrier wall along the south bank of the Christina River coupled with a permeable reactive barrier (PRB) wall along the east and west sides of the south landfill and along the portion of the landfill owned by the state. The treatment matrix in the PRB would immobilize contaminants present in the groundwater migrating from the landfill. An engineered cap would be placed over the entire landfill area, preventing rainwater from contacting the waste material. This technology is a passive treatment system and would not require operation of a groundwater extraction and treatment system.

After careful review by EPA and Delaware Department of Natural Resources of Environmental Control (DNREC), EPA is selecting this new proposal as the remedy at the south landfill. The revised remedy involves changing the treatment technology from chemical precipitation with sodium sulfate and sodium sulfide to the PRB treatment technology and eliminating the pump-and-treat containment requirement.

DESCRIPTION OF REVISED REMEDY

The revised remedy for the south landfill includes a complete barrier system to physically separate the waste material from the environment. The barrier system will consist of a low-permeability (1×10^{-7} cm/s or less) slurry wall coupled with a permeable reactive barrier wall, as shown in Figure 10. The slurry wall will be placed parallel to the Christina River along the south side of the New Castle County sewer main, and the PRB wall will surround the remainder of the landfill. Both barriers will be tied into the relatively impermeable marsh deposit below the landfill (see Figures 11 and 12). The slurry wall and reactive barrier will contain, to the extent practical, all of the waste material within the south landfill, including the portion on the State's property, as shown in Figure 10.

The riverbank will be capped by clearing existing vegetation, extending the synthetic cap to the low mean tide (-1.6 ft MSL) elevation, and covering the riverbank with armor stone. The landward slurry wall, engineered cap, and riverbank cap will prevent further migration through the waste material not contained within the circumscribing slurry/reactive wall structures. The riverbank stabilization measures will prevent further erosion and complete the containment of the waste.

The slurry wall will be 36-inches wide with a 3-foot key into the clayey-silt marsh deposit. The permeable reactive barrier (18-inches wide) will be a mixture of treatment agents and clean sand in the weight ratio of 100:20:5:5 (DelDOT mortar sand: gypsum: iron: magnesite). The gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and magnesite ($\text{Mg}_3(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{H}_2\text{O}$) reactive materials are slightly soluble, and the (zero-valent, metallic) iron is insoluble in comparison to the highly soluble reactive materials used in the 1995 ESD remedy. Therefore, these materials will not be readily flushed from the wall should infiltration rates increase. Results from field and laboratory investigations calculate the PRB wall life to be hundreds of years.

All groundwater originating in the waste material will pass through the permeable barrier for treatment. The PRB is designed to reduce soluble metals concentrations to below the following levels.

Barium	7,800 ppb*
Cadmium	4 ppb
Copper	18 ppb
Lead	15 ppb
Manganese	1,000 ppb
Nickel	730 ppb
Zinc	120 ppb

* ppb = parts per billion

Within the reactive wall, the iron will immobilize soluble zinc via surface adsorption reactions. The gypsum and magnesite will immobilize soluble barium and manganese as barium sulfate and manganese carbonate precipitates, respectively. The treatment will not specifically target cadmium, copper, lead, and nickel; however, the concentrations for these metals already meet the above criteria.

Two additional contaminants of concern, arsenic and chromium, are also not expected to be impacted by the PRB treatment. Chromium concentrations are already below levels considered protective and do not warrant further treatment. Recent sampling results indicated that arsenic is also below levels considered protective of the environment and human health.

Monitoring wells placed inside the permeable reactive barrier (see Figure 12) will confirm ground-water treatment and provide an early warning against premature wall breakthrough to ensure protection of human health and the environment. Approximately 10 monitoring wells (on 200 foot centers) will be installed in the outside six inches of the barrier. In addition, downgradient wells will be installed to observe metals attenuation.

A single-layer engineered cap will cover all of the waste material and extend beyond the limits of the slurry wall and reactive barrier to the riverbank and wetlands areas, respectively. The cap will have a maximum permeability of 10^{-7} cm/sec and will be designed as shown in Figure 11. The design includes a single barrier synthetic geomembrane layer, a drainage layer, protective soil, and topsoil. The cap design is a change from the 1995 ESD requirement for a dual-barrier cap containing at least a synthetic geomembrane liner. The dual layer cap in the 1995 ESD remedy was essential for reducing ground-water to the maximum extent practical because the treatment agents were extremely soluble and could be flushed from the waste by infiltrating rainwater. Maximum reduction of infiltration is not as critical to the current proposed PRB remedy because the treatment agents are either sparingly soluble or insoluble and also because any infiltrated water will be treated as it flows through the PRB.

As in the 1995 ESD remedy, additional fencing and a vegetative barrier will be installed (as needed) around the entire South Landfill area to control trespassing. The institutional controls have already been established, including a notification attached to the deed regarding past land use, restrictions on future land use, and health and safety requirements for maintenance workers of the sewer main that runs through the South Landfill. These steps will protect maintenance workers during future subsurface work.

The present worth cost of this remedy is \$5,050,000, adjusting the overall cost of the remedy in the 1993 ROD from \$47,700,000 to \$38,450,000 (see Table 16B [replaces Table 16A in the 1995 ESD]). For a complete listing of the applicable or relevant and appropriate requirements (ARARs) for the new remedy, see the attached Table 12A. Also attached are the modified Performance Standards that, by this ESD are incorporated into the ROD.

RATIONALE FOR SELECTION

The above alternative was evaluated in detail and compared to the previously selected 1993 ROD and 1995 ESD remedies in order to determine which would be the most effective in achieving the goals of CERCLA and in achieving the remedial action objectives for the Site. EPA uses nine criteria, which are summarized in Table 1, to guide remedy selection. The first two criteria (overall protection of human health and the environment; compliance with applicable or relevant appropriate requirements [ARARs]) are threshold criteria and must be met by the chosen site remedy (except when an ARAR waiver is invoked). The next five criteria (long-term effectiveness and performance; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are the primary balancing criteria. The remaining two criteria (state acceptance and community acceptance) are referred to as modifying criteria.

Below is a comparison of the revised remedy for the South Landfill to the previously selected remedy using the nine EPA criteria.

Overall Protection of Human Health and the Environment

The ROD stated:

In summary, based on the potential impacts to human health and the environment, EPA has determined that the following areas of the Site warrant remediation:

South landfill: This area continually releases contaminants to the ground water in the fill zone and/or Columbia aquifers which affects shallow ground water in the direction of migration and ground water discharge areas. The two discharge points are the river and the south wetlands which have AWQC (*ambient water quality criteria*) or SWQS (*State water quality standards*) exceedances and some sediments which exhibit unacceptable environmental impacts. Future subsurface maintenance or construction activities would result in unacceptable risks to humans.

This newly revised remedy offers a greater degree of overall protection to human health and the environment than either the original 1993 ROD remedy or the 1995 ESD remedy. In the original ROD remedy, the stabilized waste would continue to leach small amounts of contaminants to the river and wetlands because the waste would not be isolated from the surrounding environment.

Both the 1995 ESD remedy and this revised include complete containment systems that will isolate the waste materials from the surrounding environment. The difference between these two containment systems is that the PRB remedy incorporates a reactive barrier as part of the circumscribing wall. Contaminated water from inside the landfill will be treated as it flows through the reactive barrier component of the wall. In the unlikely event that the soil cover and

cap fail, the PRB would continue to treat fluids exiting the landfill, safeguarding against releases to the surrounding environment. Furthermore, the revised remedy is a passive treatment system, relying upon the natural flow of groundwater and in-situ processes to treat the landfill fluids. Unlike the 1995 ESD remedy, the revised remedy is not dependent upon the continuous operation of a mechanical extraction and treatment system for optimal performance.

Sewer line workers and highway workers will continue to be protected by special health and safety measures. Institutional controls preventing new utilities in the landfill will protect other utility workers.

Compliance with ARARS

Both the 1995 ESD and the revised remedies meet all ARARs associated with the South Landfill. Most of the major ARARs for the South Landfill are related to the protection of wetlands, with the exception of Resource Conservation and Recovery Act (RCRA) Subtitle D closure requirements and Delaware Regulations Governing Solid Waste (see Table 12A). Care will be taken during the design and construction of the revised remedy to prevent any adverse effects in the South Wetlands and the Christina River. The riverbank cap ensures long-term containment of landfill material outside of the slurry wall and sewer line. Any wetlands that will be destroyed during the remedial action will be replaced on a one-to-one basis.

Long-term Effectiveness and Performance

The revised remedy offers a greater degree of long-term effectiveness when compared to the 1995 ESD remedy. The revised remedy is designed for long-term (hundreds of years) immobilization of metals by treatment materials that are either sparingly soluble (gypsum and magnesite) or insoluble (iron). The 1995 ESD treatment agents are extremely soluble, hence susceptible to flushing from the waste by infiltration. Due to the differences in solubility of the reactive materials in the two remedies, the revised remedy performance is not as dependent upon the cap integrity as the 1995 ESD remedy. Should the revised remedy cap fail, infiltrated water would merely flow through the reactive barrier and be treated. Placing monitoring wells within the barrier provides decades of advance warning to ensure contaminants are treated and contained. Conversely, cap failure for the 1995 ESD remedy could result in flushing of the reactive agents and potential releases of waste materials to the surrounding environment.

The 1995 ESD remedy also requires the continuous operation and maintenance of a groundwater extraction and treatment system to ensure waste containment and remedy success. Any downtime experienced by this pump-and-treat system could impact the performance and effectiveness of the 1995 ESD remedy. The effectiveness of the revised remedy is not dependent upon external mechanical systems.

Reduction of Toxicity, Mobility, or Volume through Treatment

Both the revised remedy and the 1995 ESD remedy would significantly reduce the mobility of the metals through treatment. The 1995 ESD remedy is estimated to increase the total waste volume by five percent (DuPont, 1999). The revised remedy will immobilize migrating metals via precipitation and adsorption reactions within the treatment matrix, with no net increase in waste volume. This will aid the design and construction of the treatment remedy and will minimize any decrease in floodplain volume. Another disadvantage of the 1995 ESD remedy is that the ground-water treatment system will generate additional waste materials that would require off-site disposal. The revised remedy will not generate any additional waste materials.

Short-term Effectiveness

The revised remedy ranks better than the original remedy in short-term effectiveness. The revised remedy is expected to take less than one year to construct rather than the two to three years for the 1995 ESD and 1993 ROD remedies. The revised remedy will not disturb the existing soil cover until the cap is installed, reducing potential risks for environmental releases and exposure to the waste materials. Impacts to traffic along South James Street/Basin Road would be reduced under the revised remedy.

The ESD required installation of a dual-barrier cap under South James Street. This would have required an extended road closure (~ one month), diversion of traffic, and relocation of equipment by businesses requiring access to Route 141. The revised remedy will allow uninterrupted travel, except during a few hours when the vertical barrier crossings are made.

Implementability

Both the revised remedy and the 1995 ESD remedy are implementable with the revised remedy being easier to implement due to its shorter construction period, use of proven construction methods, and inherent protection of the sewer line by less-intrusive equipment. Both the 1993 ROD soil mixing and the 1995 ESD remedies must cover the entire landfill area, ensuring that all waste volume is treated in place. Conversely, the revised remedy will be emplaced along the circumference of the landfill, and will treat only the volume of waste material leaching from the landfill. Furthermore, the revised remedy is a passive treatment remedy. Treatment success is not contingent upon continuous operation and maintenance of a containment and treatment system.

Cost

The revised remedy is less expensive than the 1995 ESD remedy. Utilizing the current estimates of the volume of contaminated soil, the revised remedy has a present worth cost of \$5,050,000 compared to \$17,370,000 for the original 1993 ROD remedy and \$23,110,000 for the 1995 ESD remedy, (estimated to be \$33,500,000 and \$11,600,000 respectively in the August 17, 1995 ESD).

State Acceptance

It is expected that the state will support the PRB remedy because it is cost-effective and reduces impact on the Basin Road traffic.

Community Acceptance

Although no public comment period has been held (because no fundamental changes to the ROD are being made), community acceptance of this remedy change is judged to be high. Some of the main concerns previously expressed by the public include the high cost of the remedy and the impacts to traffic along South James Street/Basin Road. The revised remedy is less costly and will incur fewer impacts to local traffic.

SUMMARY

In summary, EPA is changing the remedy for the South Landfill component of the August 17, 1995 ESD and August 23, 1993 ROD. The revised remedy includes a circumscribing barrier/PRB wall system and single barrier cap that would isolate the waste materials from the surrounding environment. The revised remedy changes the waste treatment from sodium sulfide/sulfate injection to the in-situ permeable reactive barrier treatment technology using zero-valent iron, gypsum, and magnesite. The net present worth cost of the revised remedy for the South Landfill is \$5,050,000.

It is believed that this revised remedy ranks significantly better than the original 1993 ROD and 1995 ESD remedies with respect to the nine criteria used to evaluate remedies. It is also believed that this revised remedy would protect human health and the environment, would comply with ARARs, would be cost-effective, and would utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. The revised remedy will satisfy the preference for treatment as a principal element.

TABLE 1

EPA CRITERIA FOR EVALUATING ALTERNATIVES

Threshold Criteria

- **Overall Protection of Human Health and the Environment:** Describes how the alternative achieves and maintains protection of human health and the environment, and how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
- **Compliance with ARARs:** Addresses whether an alternative will meet all of the applicable or relevant and appropriate requirements (ARARs) of Federal and State environmental laws and/or justifies invoking a waiver.

Primary Balancing Criteria

- **Long-Term Effectiveness and Permanence:** Considers the ability of the remedy to maintain reliable protection of human health and the environment over time once clean-up goals have been met.
- **Reduction of Toxicity, Mobility, or Volume Through Treatment:** Describes the anticipated performance of the treatment technologies that may be employed in an alternative.
- **Short-Term Effectiveness:** Examines the effectiveness of an alternative in protecting human health and the environment during the construction and implementation of the remedy, until the clean-up levels are achieved.
- **Implementability:** Evaluates the technical and administrative feasibility of an alternative and the availability of required materials and services.
- **Cost:** Considers the capital, as well as operation and maintenance (O&M) costs of the alternatives.

Modifying Criteria

- **State Acceptance:** Indicates whether the state agency, based on its review of the proposed remedy change, concurs with, opposes, or has no comment regarding the new remedy.
- **Community Acceptance:** A measure of the community's general acceptance of the new remedy.

TABLE 16B
REMEDIAL COSTS FOR THE SOUTH LANDFILL

Direct Costs	
Cap/Pavement/Riverbank	\$ 1,968,000
Site Preparation	\$ 248,000
Treatment	\$ 977,000
Slurry Wall	\$ 152,000
Total Direct Costs	\$ 3,345,000
Indirect Costs	
General Condition, Profit, Overhead, Engineering, Support	\$ 1,076,000
O&M (30yrs, 5%) (Monitoring, Maintenance)	\$ 385,000
Total Cost	\$ 4,806,000
Contingency (5%)	\$ 240,000
Total Present Worth Costs	\$ 5,046,000

E.I. DuPont, Newport Site
South Landfill

TABLE 12A (8/95)
(Changes to Table 12 [8/26/93] are in italics or "strikeout")
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
AND TO BE CONSIDERED MATERIAL (TBCs)
DU PONT-NEWPORT SITE

AR325042

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
1. CHEMICAL SPECIFIC					
A. Water					
1. Safe Drinking Water Act	42 U.S.C. § 300f et seq.				
a. Maximum Contaminant Level Goals (MCLGs)	40 C.F.R. § 141.50-51	Relevant and Appropriate	Non-enforceable health goals for public water supplies. The NCP requires that non-zero MCLGs shall be attained by remedial actions for ground water that is a current or potential source of drinking water, where the MCLGs are relevant and appropriate under the circumstances of the release.	The "greater harm to human health and the environment" ARAR waiver has been invoked for both the Potomac and Columbia aquifers.	GW
b. Maximum Contaminant Levels (MCLs)	40 C.F.R. § 141.11-12	Relevant and Appropriate	Enforceable standards for public drinking water supply systems (with at least fifteen service connections or used by at least 25 persons). The NCP requires that MCLs, for those contaminants whose MCLG is zero, shall be attained by remedial actions for ground water that is a current or potential source of drinking water, where the MCLs are relevant and appropriate under the circumstances of the release.	The "greater harm to human health and the environment" ARAR waiver has been invoked for both the Potomac and Columbia aquifers.	GW
c. Maximum Contaminant Levels (MCLs)	40 C.F.R. § 141.11-12	Applicable	Enforceable standards for public drinking water supply systems (with at least fifteen service connections or used by at least 25 persons). MCLs apply to public water systems that provide piped water for human consumption.	Installation of public water supply line shall be done in such a way as to provide drinking water in compliance with these standards.	GW
2. Health Effects Assessment		To be Considered	Non-enforceable toxicity data for specific chemicals for use in public health assessments. Also "to be considered" are Carcinogenic Potency Factors and Reference Doses provided in the Superfund Public Health Evaluation Manual.	To be considered where remedial action addresses risk-based criteria or when setting clean-up standards for the protection of human health.	NLSL, CG/RP, GW

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
3. Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites	EPA OSWER Directive #9355.4-02, dated 12/8/89	To Be Considered	To be considered when remedial action addresses soils that cause a threat to human health through direct contact, ingestion, or inhalation of lead.	To be considered when lead is present and remedial action addresses soils that cause a threat to human health through direct contact, ingestion, or inhalation.	BP, NL, SL, CC/HR
4. State of Delaware Regulations Governing Public Drinking Water Revised March 11, 1991	Sections 22.2, 22.3, 22.4, 22.6, 22.10	Relevant and Appropriate	Sets criteria for public drinking water supplies. These requirements are not directly applicable since ground water at the Site is used as a private drinking water supply. However, under the circumstances of this Site, these requirements are relevant and appropriate.	The "greater harm to human health and the environment" ARAR waiver has been invoked for both the Potomac and Columbia aquifers.	GW
6. State of Delaware Regulations Governing Public Drinking Water Revised March 11, 1991	Sections 22.2, 22.3, 22.4, 22.6, 22.10	Applicable	Sets criteria for public drinking water supplies.	Installation of public water supply line shall be done in such a way as to provide drinking water in compliance with these standards.	GW
7. Delaware Comprehensive Water Resources Management Committee Report, December 13, 1983		To Be Considered	The reports were adopted as policy by the DNREC Secretary. Among these reports is the Groundwater Quality Management Report, July 1983, which provided Delaware with a number of tools for dealing with ground-water contamination.	To be considered for ground-water monitoring.	GW
8. Clean Water Act	Clean Water Act, Section 303	Relevant and Appropriate	Water quality criteria set at levels to protect human health for water and fish ingestion and protection of aquatic life in streams, lakes, and rivers.	These standards have been waived for the surface water in the Christina River by invoking the "technical impracticability" ARAR waiver due to non-Site related upstream sources of contamination.	CR
9. Delaware Surface Water Quality Standards as amended, Feb. 26, 1993	Sections 3, 4, 5, 6, 8, 9, 10, 11.1, 11.2, 11.3, 11.4, 11.6, 12	Applicable	Criteria are provided to maintain surface water for streams, lakes, rivers, and standing water in wetlands of satisfactory quality consistent with public health and recreational purposes, the propagation and protection of fish and aquatic life, and other beneficial uses of water.	1. Any surface water discharge must meet these levels if more stringent than federal regulations. 2. These standards have been waived for the surface water in the north wetlands and the Christina River by invoking the "technical impracticability" ARAR waiver due to non-Site related upstream sources of contamination. These standards have been waived for the surface water in the south wetlands by invoking the "greater harm to human health and the environment" ARAR waiver.	NL, SW, CR, CC/HR, SL

AR325043

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
B. Air					
1. Clean Air Act	42 U.S.C § 7401				
a. National Emissions Standards for Hazardous Air Pollutants	40 C.F.R. Part 61	Relevant and Appropriate	Standards promulgated for air emissions from specific source categories. Not applicable but may be relevant and appropriate for emissions from air strippers at Superfund sites.	Relevant and appropriate for potential releases of vinyl chloride and radionuclides resulting from ground-water treatment.	NL, CG/HR SL
2. Delaware Ambient Air Quality Standards	Title 7, Delaware Code, Ch 60, Regulation 3, Section 6003	Applicable	Establishes ambient air quality standards.	Applicable for potential releases from air stripping of ground water, excavation work, or other remedial actions.	ALL
C. Miscellaneous					
1. Standards for Protection Against Radiation	10 C.F.R. Part 20	Relevant and Appropriate	These standards are designed to limit radiation hazards caused by Nuclear Regulatory Commission-licensed activities. The general requirement is that every reasonable effort to maintain radiation exposures "as low as is reasonably achievable" be made. This regulation also describes specific radiation dose limits for the protection of workers and members of the public, radioactivity concentration limits for effluents, precautionary procedures, and waste disposal requirements.	Remediation must take place in such a way as to prevent over-exposure of radiation to workers or public. Discharges to air or water must meet specific concentration limits for radionuclides. Waste disposal must also meet any pertinent requirements.	NL, CG/HR
2. Delaware Radiation Control Regulations	Title 16, Delaware Code, 7405	Applicable	Establishes regulations for registration of facilities, licensing of materials, standards of protection, safety requirements, and notification requirements.	May be applicable for work at the north landfill and the ground water pump and treat system at this area.	NL, CG/HR
II. LOCATION SPECIFIC					
1. Coastal Zone Management Act of 1972; Coastal Zone Act Reauthorization Amendments of 1990	16 U.S.C. 1451 et seq. 15 C.F.R. Part 930	Applicable	Requires that Federal agencies conducting or supporting activities directly affecting the coastal zone, conduct or support those activities in a manner that is consistent with the approved appropriate State coastal zone management program. (See Delaware's Comprehensive Update and Routine Program Implementation, March 1993)	On-site remedial actions are required to be consistent, to the maximum extent practicable, with Delaware's coastal zone management program. EPA must notify Delaware of its determination that the actions are consistent to the maximum extent practicable.	NL,SL, SW,CR, CG/HR

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
2. The Archaeological and Historical Preservation Act of 1974	16 U.S.C. § 469	Applicable	Requirements relating to potential loss or destruction of significant scientific, historical, or archaeological data	Archaeological and historical resources have not been identified to date. However, the installation of the physical barrier wall along the Christina River has the potential for disturbing archeological resources. Further action will be taken to identify resources and, if identified, action will be taken to mitigate any adverse effects on those resources that would result from construction. If resources happen to be identified in other areas (although no specific actions will be taken to find), action will be taken to mitigate any adverse effects on those resources that would result from implementation of the remedial action.	NL, CG/HR
3. Protection of Floodplains	40 C.F.R. Part 6, Appendix A	Applicable	Sets forth EPA policy for carrying out provisions of Executive Order 11988 (Floodplain Management) which requires actions to avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values.	Applicable since much of the remedial action will take place within the 500-year floodplain. Due to the volume increase of the south landfill, the berm in the south wetlands will be removed to mitigate the loss of volume inside a floodplain.	ALL
4. Protection of Wetlands	40 C.F.R. Part 6, Appendix A	Applicable	Sets forth EPA policy for carrying out provisions of Executive Order 11990 (Protection of Wetlands) which requires actions to avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values.	Applicable since the construction of the north and south landfill caps will affect wetlands.	NL, SL, SW
5. Delaware Coastal Zone Act, 7 Delaware Code Chapter 70; Coastal Zone Act Regulations, 6/9/93	7 Delaware Code Sections 7003, 7004	To Be Considered	Controls the location, extent, and type of industrial development in Delaware's coastal areas.	Will be considered for consistency since the remedial action involves substantial aquatic habitat and is located in Delaware's coastal area although not in the defined coastal zone of this statute.	ALL
6. Delaware Wetlands Regulations Revised June 29, 1984	Sections 1, 2, 7	Applicable	Requires activities that may adversely affect wetlands in Delaware to be permitted. Permits must be approved by the county or municipality having jurisdiction.	Any substantive requirements shall be met since wetlands will be destroyed and replaced in the north drainage way, and dredged (or excavated) and restored in the north and south wetlands. Since all of the wetland or remediation is considered "on-site", no permit will be obtained.	NL, SL, SW

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
7. Delaware Regulations Governing the Use of Subaqueous Lands, amended September 2, 1992	Sections 1, 3, 4	Applicable	Requires activities that affect public or private subaqueous lands in the State be permitted.	Any substantive requirements shall be met since the remediation involves dredging of the Christina River. However, no permit shall be obtained.	NL, SL, SW, CR
8. Delaware Executive Order 56 on Freshwater Wetlands (1988)		To Be Considered	General policy to minimize the adverse effects to freshwater wetlands.	To be considered for wetland remediation and restoration.	NL, SL, SW
9. Governor's Roundtable Report on Freshwater Wetlands (1989)		To Be Considered	General policy to minimize the adverse effects to freshwater wetlands.	To be considered for wetland remediation and restoration.	NL, SL, SW
10. Ground Water Protection Strategy of 1984	EPA 440/6-84-002	To be Considered	Identifies ground water quality to be achieved during remedial actions based on aquifer characteristics and use.	The EPA aquifer classification will be taken into consideration during design and implementation of the treatment remedy.	GW
III. ACTION SPECIFIC					
A. Miscellaneous					
1. Council on Environmental Quality	40 C.F.R. 1500.2(f)	Relevant and Appropriate	Requires use of all practicable means, consistent with the requirements of NEPA to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects upon the quality of the human environment.	Institutional controls shall be added to the north and south landfill properties to make sure they remain wildlife habitat.	NL, SL
2. Delaware Regulations Governing Hazardous Substance Cleanup, 1/93	Section 9	Relevant and Appropriate	Establishes clean-up criteria for hazardous waste sites. Only criteria considered relevant and appropriate are for ground water and soil (1×10^{-3} ; Hazard Index of 1; or natural background if higher).	1. Waived for ground water using the "greater harm to human health and the environment" waiver. 2. Applies to the determination of soil clean-up criteria at the Basin Road portion of the south landfill. (Deleted with ESD in August 1995.) 2. May apply in determining location of ground water barrier wall at South Landfill.	SL, GW

AR325046

AR325047

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
B. Water					
1. Clean Water Act (CWA); National Pollutant Discharge Elimination System Requirements	40 C.F.R. Part 122-125	Applicable	Enforceable standards for all discharges to waters of the United States.	Discharge limits shall be met for all on-site discharges to surface water including treated ground water and wastewater from dewatering dredge material. Only substantive requirements shall be met and no permit shall be obtained.	NL, CG/HR, CR SL
2. General Pretreatment Regulations	40 C.F.R. Part 403	Applicable	Standards for discharge to POTW.	Applicable should the extracted ground water, treated ground water, or wastewater from dredge material be discharged to a POTW.	NL SL CG/HR, CR
3. Section 10 of the River and Harbors Act	33 U.S.C. Section 403 33 C.F.R. Part 320-330	Applicable	Permitting requirements for dredging.	The river dredging will comply to any substantive requirements, but no permit will be obtained.	CR
4. State of Delaware Regulations Governing the Construction of Water Wells, January 20, 1987	Sections 3, 4, 5, 6, 7, 8, 9, 10	Applicable	Contain requirements governing the location, design, installation, use, disinfection, modification, repair, and abandonment of all wells and associated pumping equipment.	Installation of any monitoring and recovery wells and the abandonment of wells shall meet all substantive requirements.	NL,SL, SW, CG/HR, GW
5. Delaware Water Quality Standards, as amended, February 26, 1993	Sections 3-6, 8-10, 11.1, 11.2, 11.3, 11.4, 11.6, 12	Applicable	Standards are established in order to regulate the discharge into state waters in order to maintain the integrity of the water.	Applicable should the ground-water treatment system involve discharge to surface water.	NL, CG/HR SL
6. Delaware River Basin Commission (DRBC) Water Quality	DRBC Ground Water Protected Area Regulation, No. 4, 6(f), 9, 10; Water Code of the Basin, Sections 2.20.4, 2.50.2	Applicable	Regulate restoration, enhancement, and preservation of waters in the Delaware River basin.	Applicable if remedial action involves discharge of >50,000 gallons/day average over any month or a withdrawal of ground water of 100,000 gallons/day or more average over any month.	NL, CG/HR SL
7. Delaware Regulations Governing the Allocation of Water March 1, 1987	Sections 1, 3, 5.05	Applicable	Contain information pertaining to water allocation permits and criteria for their approval.	May be applicable for the ground-water recovery system or the public water supply line. No permit required.	NL SL CG/HR, GW
8. State of Delaware Groundwater Management Plan November 1, 1987		To Be Considered	Policy for ground-water management.	To be considered in setting the ground water management zone.	GW

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
9. Delaware Regulations Governing Control of Water Pollution, amended 6/23/83	Section 7, 8, 9, 10, 11, 12, 13	Applicable	Contain water quality regulations for the discharging into surface and ground water.	Applicable for potential discharge of treated ground water into surface water. Also applicable for stormwater runoff into the Christina River.	NL,SL,OG/HR
10. State of Delaware Regulations Governing Public Drinking Water March 31, 1991	Sections 22.2, 22.3, 22.4, 22.6, 22.10	Applicable	Establishes requirements for public drinking water supplies.	Applicable for the establishment of public drinking water service to residents along Old Airport Road.	GW
C. Air					
1. Control of Air Emissions from Air Strippers at Superfund Ground Water Sites, June 15, 1989	EPA OSWER Directive 9355.0-28	To be Considered	Policy to guide the selection of controls for air strippers at groundwater sites according to the air quality status of the site's location (i.e., ozone attainment or non-attainment area).	To be considered in determining if air emissions controls are necessary for an air stripper because New Castle is in an ozone non-attainment area. Sources most in need of controls are those with emissions rates in excess of 3 lbs./hour or 15 lbs./day or a potential rate of 10 tons/year of total VOCs.	NL,CG/HR,SL
2. Delaware Regulations Governing the Control of Air Pollution	Regulations Number 2, 19, 24	Applicable	Sets forth the requirement that a permit is necessary to operate an air stripper if emissions will exceed 2.5 lbs./day. Section 2 describes general conditions. Section 19 deals with odor. Section 24 deals with volatile organic compounds.	If emissions exceed 2.5 lbs./day then the substantive requirements of the regulation must be met. In addition, the emissions from the air stripper must meet the Ambient Air Quality Standards set forth in Regulation 3 of 7 Delaware Code, Chapter 60, Section 6003.	NL,CG/HR,SL
E. Sediments/Solids					
1. Delaware Sediment and Stormwater Regulations January 23, 1991	Section 3, 6, 9, 10, 11, 15	Applicable	Establishes a statewide sediment and stormwater management program.	A stormwater and sediment management plan consistent with Delaware requirements must be approved by EPA only before construction disturbing over 5,000 square feet of land can begin.	NL,SL,SW,CR,OG/HR
F. Waste Handling and Disposal					
1. RCRA Subtitle D Landfill Regulations	40 C.F.R. 258.60(+)	Relevant and Appropriate	Closure requirements for RCRA subtitle D landfill. (Deleted as part of ESD in August 1995.)	Provides some technical requirements for the cap at the south landfill.	SL

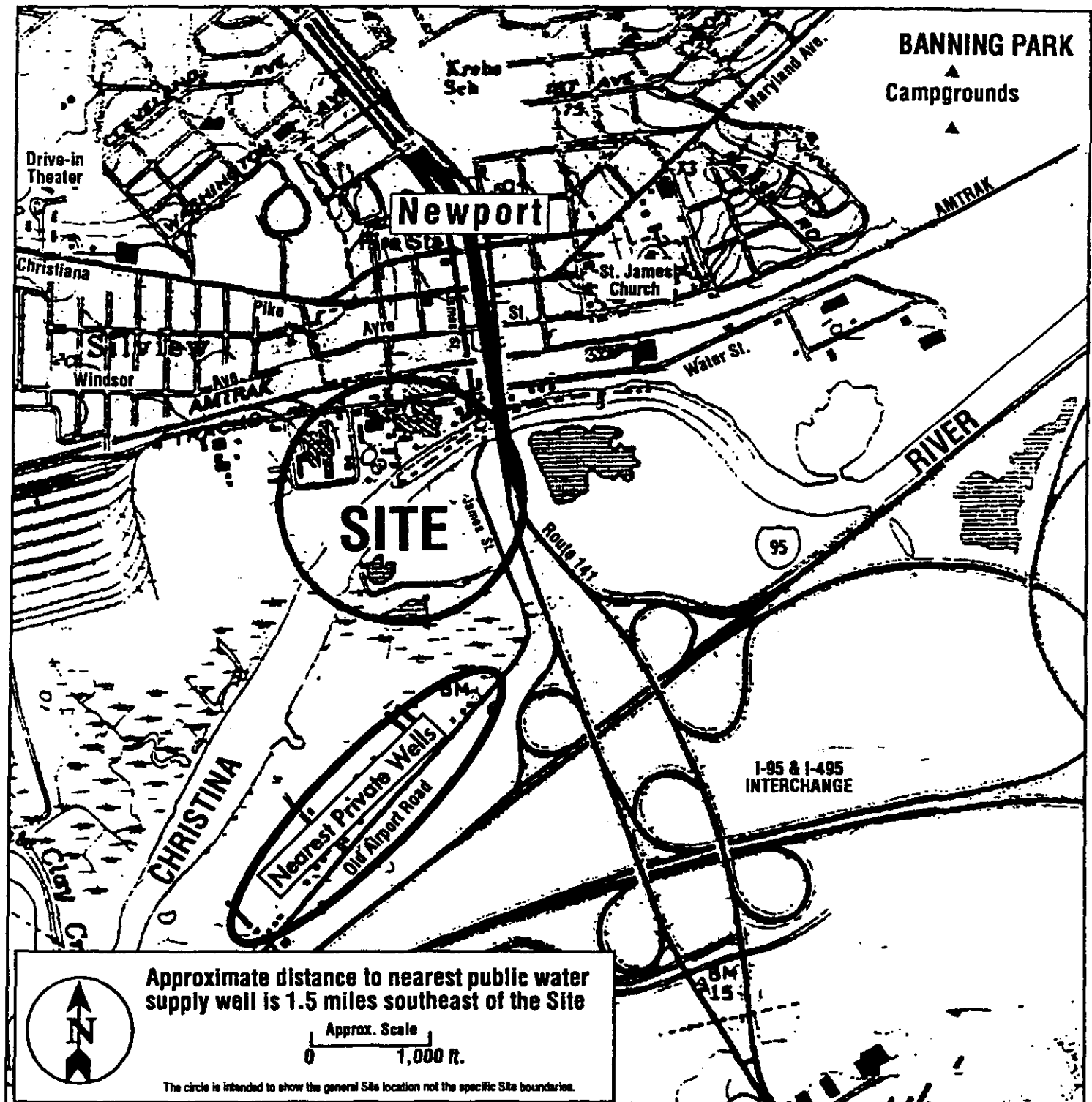
AR325049

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
2. Delaware Regulations Governing Solid Waste	Sections 2, 5-6 5f, 5k, 6f, 6k	Relevant and Appropriate	Establishes regulations to implement an improved solid waste management program, specifically relating to erosion control, water management, and post closure care.	Relevant and appropriate for the south landfill.	SL
3. Delaware Regulations Governing Hazardous Waste	SEE BELOW F.5, F.7, F.9, F.11, F.13, F.15, F.17	SEE BELOW	Delaware Regulations Governing Hazardous Waste Part 261 define "hazardous waste". The regulations listed below apply to the handling of such hazardous waste.	SEE BELOW	SEE BELOW
4. Resource Conservation and Recovery Act of 1976; Hazardous and Solid Waste Amendments of 1984	SEE BELOW F.6, F.8, F.10, F.12, F.14, F.16, F.18 Federal regulations would not apply for those regulations which Delaware has the authority from EPA to administer.	SEE BELOW	Regulates the management of hazardous waste, to ensure the safe disposal of wastes, and to provide for resource recovery from the environment by controlling hazardous wastes "from cradle to grave."	SEE BELOW	SEE BELOW
5. Standards Applicable to Generators of Hazardous Waste	Delaware Regulations Governing Hazardous Waste, Part 262.10-58	Applicable	Establishes standards for generators of hazardous wastes including waste determination manifests and pre-transport requirements.	Applicable to operator(s) of the wastewater treatment plant if the wastes generated by the groundwater treatment system is a RCRA-hazardous waste.	NL, CG/HR SL
6. Standards Applicable to Generators of Hazardous Waste	EPA Regulations, 40 C.F.R Part 262.10-58	Applicable	Establishes standards for generators of hazardous wastes including waste determination manifests and pre-transport requirements.	Applicable to operator(s) of the wastewater treatment plant if the wastes generated by the groundwater treatment system is a RCRA-hazardous waste.	NL, CG/HR SL
7. Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	Delaware Regulations Governing Hazardous Waste, Part 264 (40 C.F.R Part 264)	Applicable	Regulations for owners and operators of TSDFs which define acceptable management of hazardous wastes.	Applies to onsite recovery and treatment systems which handle hazardous waste	NL, CG/HR SL

ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
8. Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	EPA Regulations, 40 C.F.R. Part 264	Applicable	Regulations for owners and operators of TSDFs which define acceptable management of hazardous wastes.	Applies to onsite recovery and treatment systems which handle hazardous waste	NL, CG/HR, SL
9. RCRA Requirements for Use and Management of Containers	Delaware Regulations Governing Hazardous Waste, Part 264.170-178	Applicable	Requirements for storage of hazardous waste in storage containers.	Applicable for temporary storage containers and on-site treatment systems.	NL, SL, SW, CG/HR, CR
10. RCRA Requirements for Use and Management of Containers	EPA Regulations, 40 C.F.R. Part 264.170-178	Applicable	Requirements for storage of hazardous waste in storage containers.	Applicable for temporary storage containers and on-site treatment systems.	NL, SL, SW, CG/HR, CR
11. RCRA Requirements for Tanks Systems	Delaware Regulations Governing Hazardous Waste, Part 264.190-199	Applicable	Requirements for storage or treatment of hazardous waste in tank systems.	Only applicable for onsite treatment systems and temporary storage tanks containing hazardous wastes.	NL, SL, SW, CG/HR, CR
12. RCRA Requirements for Tanks Systems	EPA Regulations, 40 C.F.R. Part 264.190-199	Applicable	Requirements for storage or treatment of hazardous waste in tank systems.	Only applicable for onsite treatment systems and temporary storage tanks containing hazardous wastes.	NL, SL, SW, CG/HR, CR
13. The Hazardous Waste Permit Program	Delaware Regulations Governing Hazardous Waste, Part 122	Applicable	Requires a permit for the treatment, storage, or disposal of any hazardous waste as identified or listed in Part 261.	Any substantive requirements will be met. But no permit will be obtained	NL, SL, SW, CG/HR, CR
14. The Hazardous Waste Permit Program	EPA Regulations, 40 C.F.R. Part 122	Applicable	Requires a permit for the treatment, storage, or disposal of any hazardous waste as identified or listed in Part 261.	Any substantive requirements will be met. But no permit will be obtained	NL, SL, SW, CG/HR, CR
15. Identification and Listing of Hazardous Wastes	Delaware Regulations Governing Hazardous Wastes, Part 261	Applicable	Identifies solid wastes which are regulated as hazardous wastes.	Use to determine which materials to be disposed of are hazardous wastes.	ALL

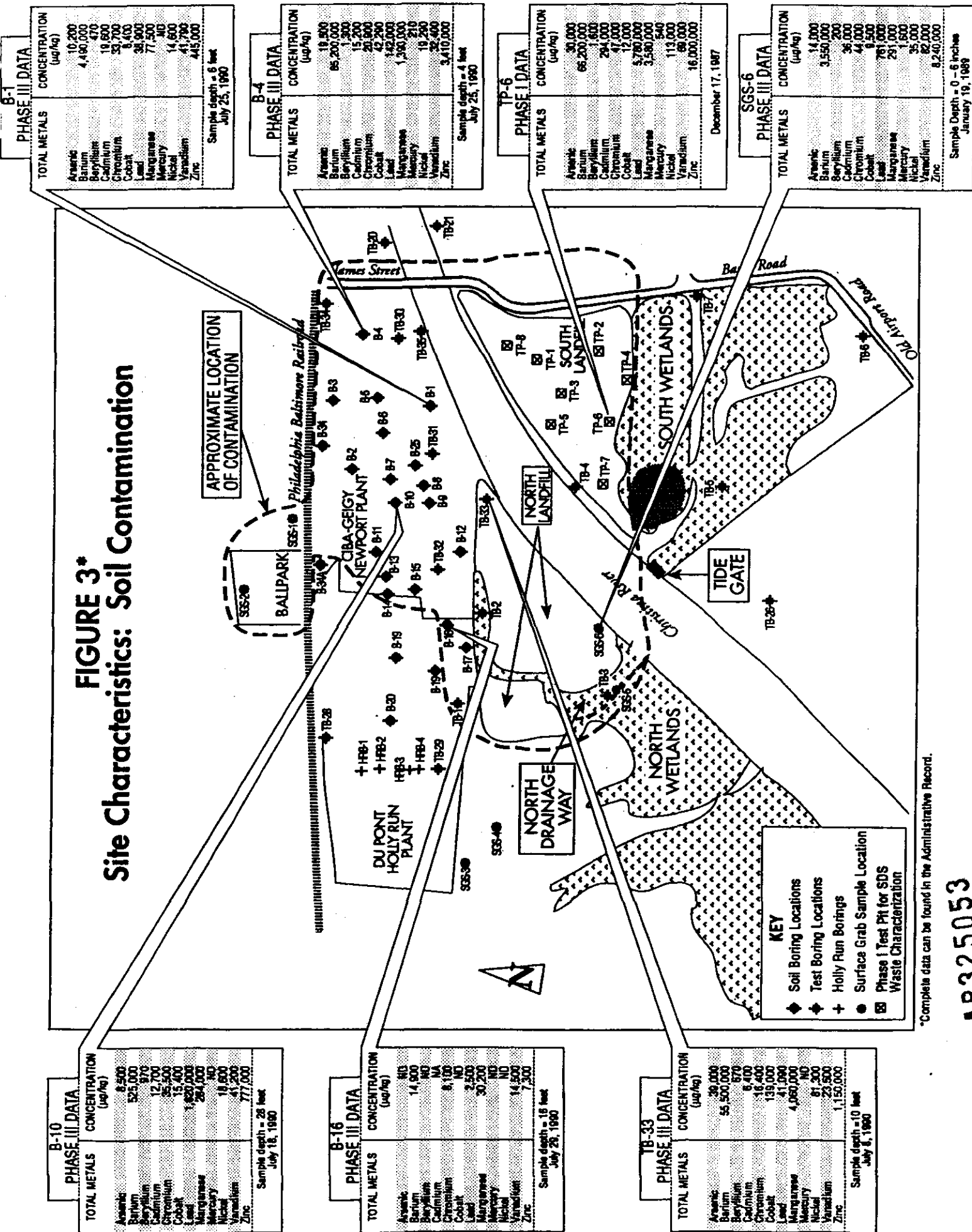
ARAR or TBC	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Selected Remedy	Area of Concern
16. Identification and Listing of Hazardous Wastes	EPA Regulations, 40 C.F.R. Part 261	Applicable	Identifies solid wastes which are regulated as hazardous wastes.	Use to determine which materials to be disposed of are hazardous wastes.	ALL
17. RCRA Land Disposal Restrictions	Delaware Regulation Governing Hazardous Waste, Part 268	Applicable	Restrictions on land disposal of hazardous wastes.	Applies to remedial actions in the south landfill, the south wetlands, and the Christina River only if any stabilization treatment is done ex-situ and waste is hazardous. Applies to dirt from the ballpark if it is hazardous.	BP,NL, SL,SW, CR
18. RCRA Land Disposal Restrictions	EPA Regulations, 40 C.F.R. Part 268	Applicable	Restrictions on land disposal of hazardous wastes.	Applies to remedial actions in the south landfill, the south wetlands, and the Christina River only if any stabilization treatment is done ex-situ and waste is hazardous. Applies to dirt from the ballpark if it is hazardous.	BP,NL, SL,SW, CR

FIGURE 1
Site Location Map
E.I. DuPont, Newport Superfund Site



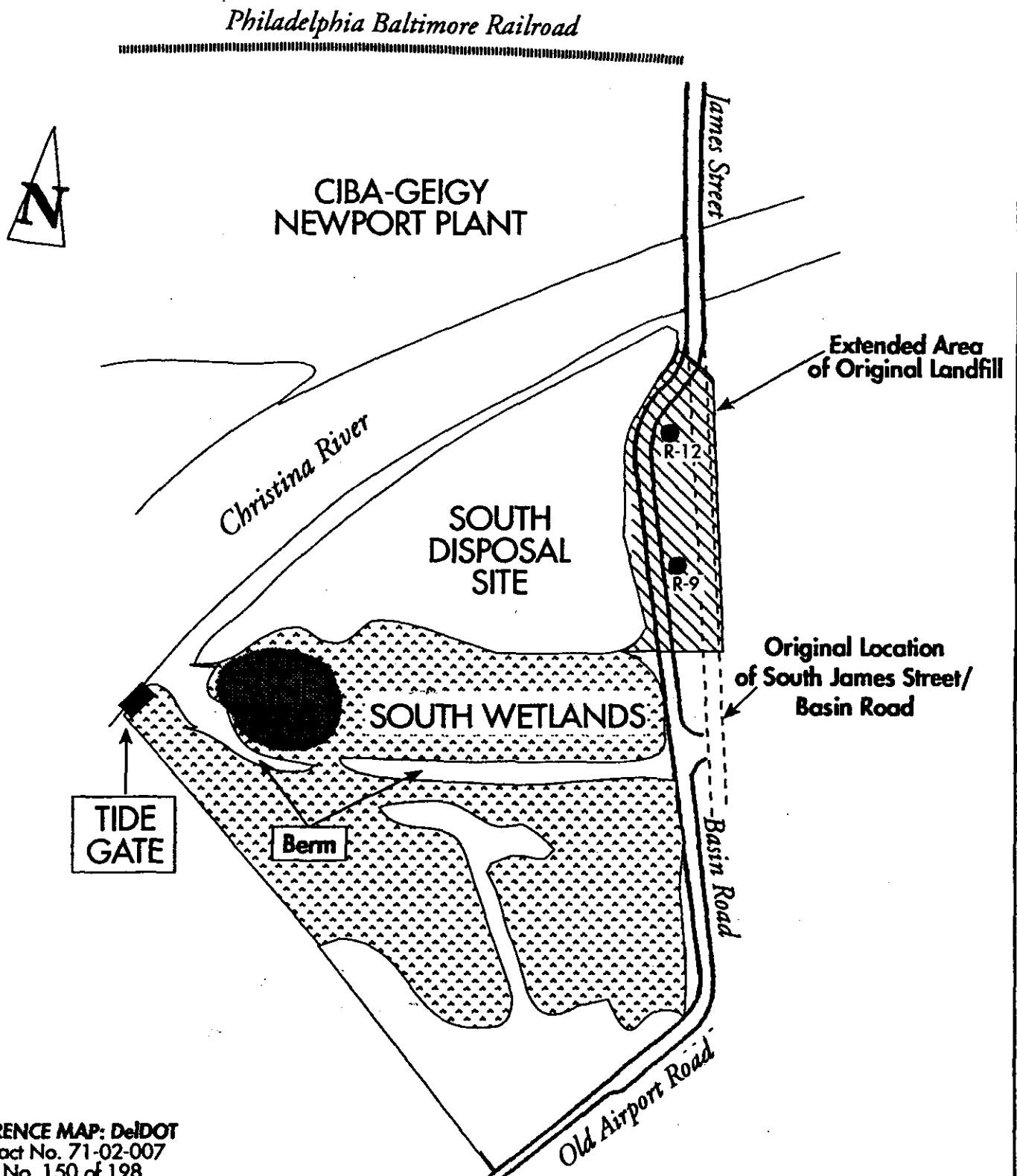
AR325052

FIGURE 3* **Site Characteristics: Soil Contamination**



AR325053

FIGURE 4 Relocated South James Street/Basin Road Through Newport



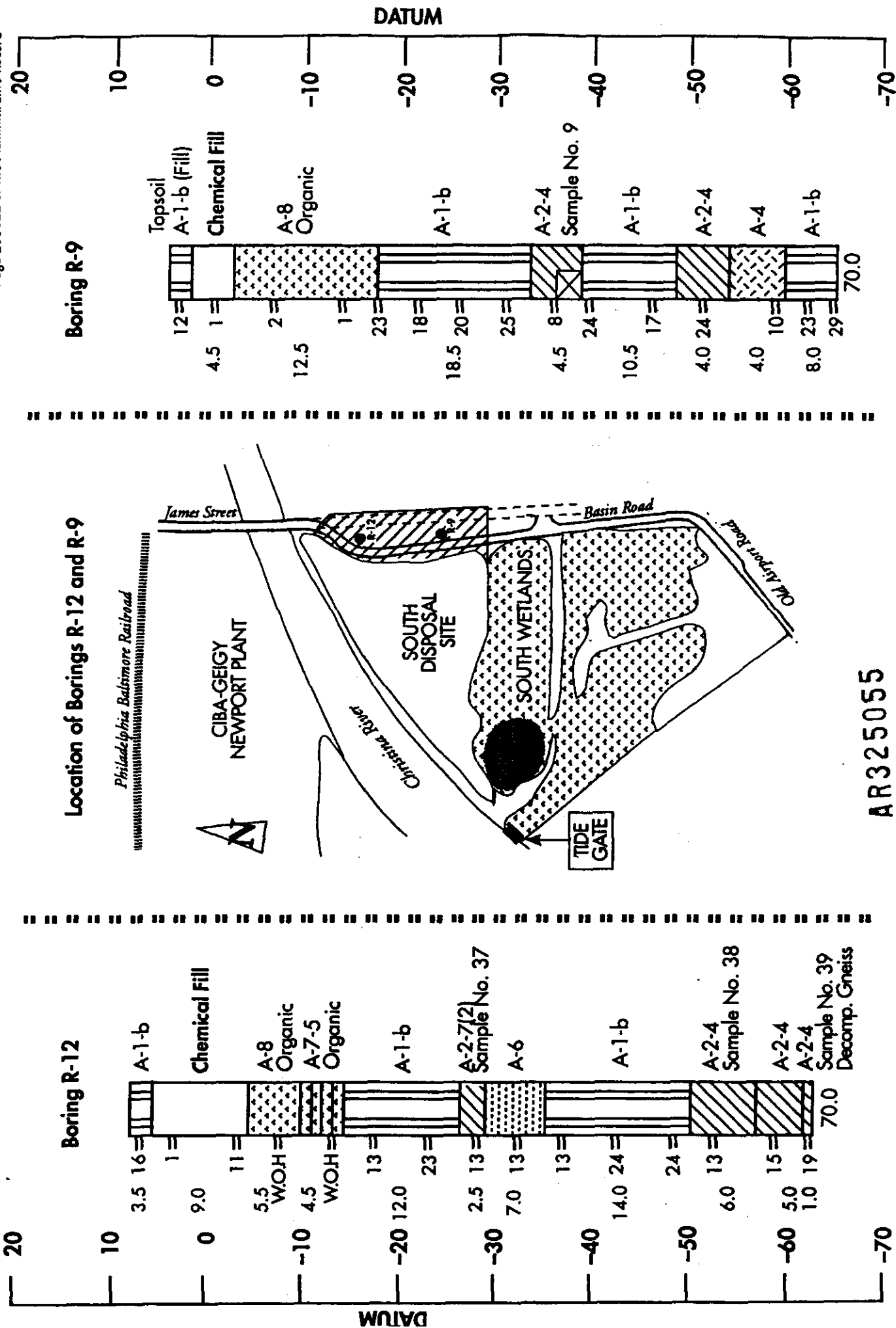
REFERENCE MAP: DelDOT
Contract No. 71-02-007
Sheet No. 150 of 198
Page 500047f of The Administrative Record.
NOTE: Boring locations are approximate.

AR325054

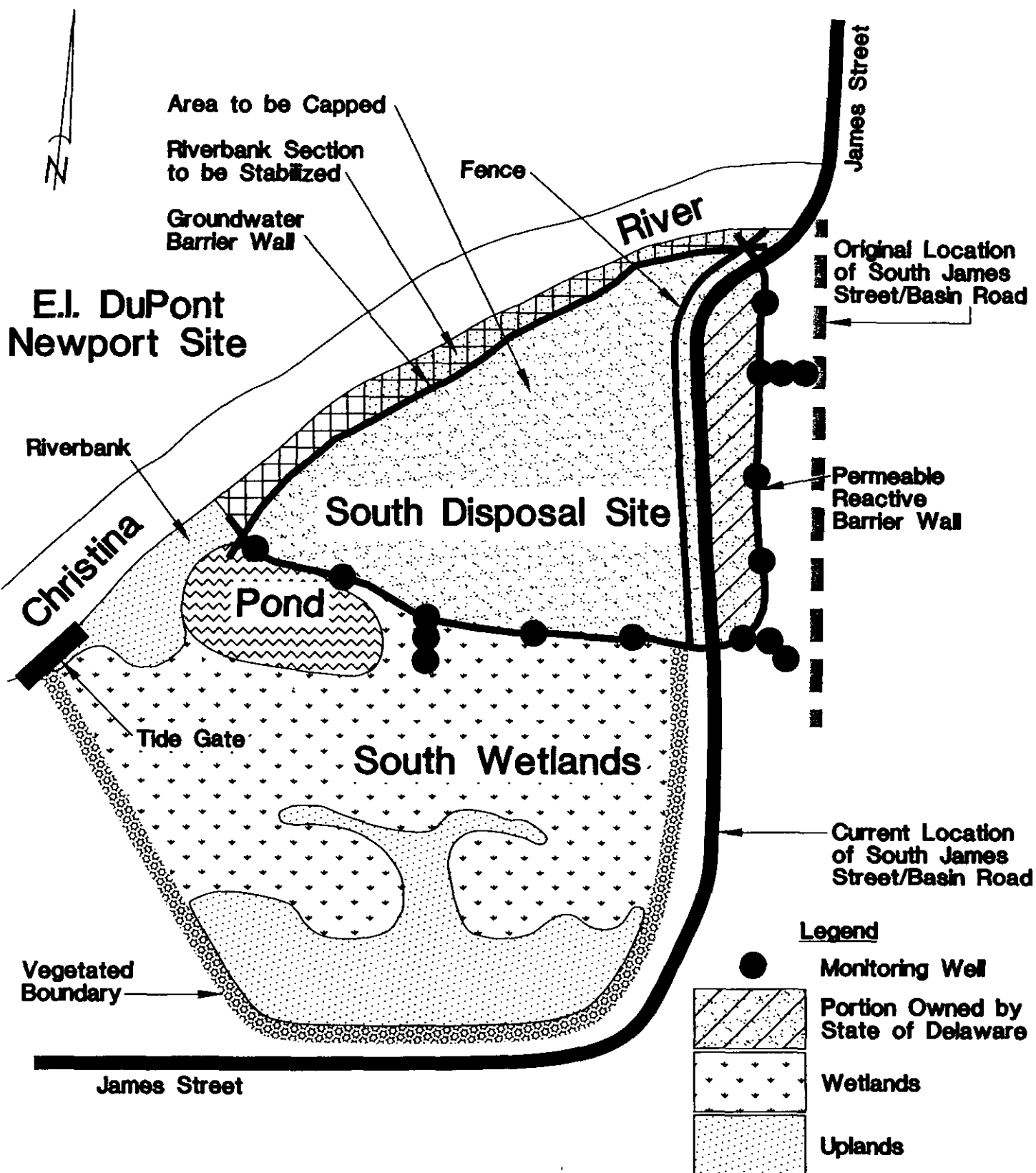
FIGURE 5

Configuration of Borings R-9 and R-12

REFERENCE MAP: D-1007
 Contract No. 71-02-007
 Sheet No. 153 of 198
 Page 203822 of The Administrative Record



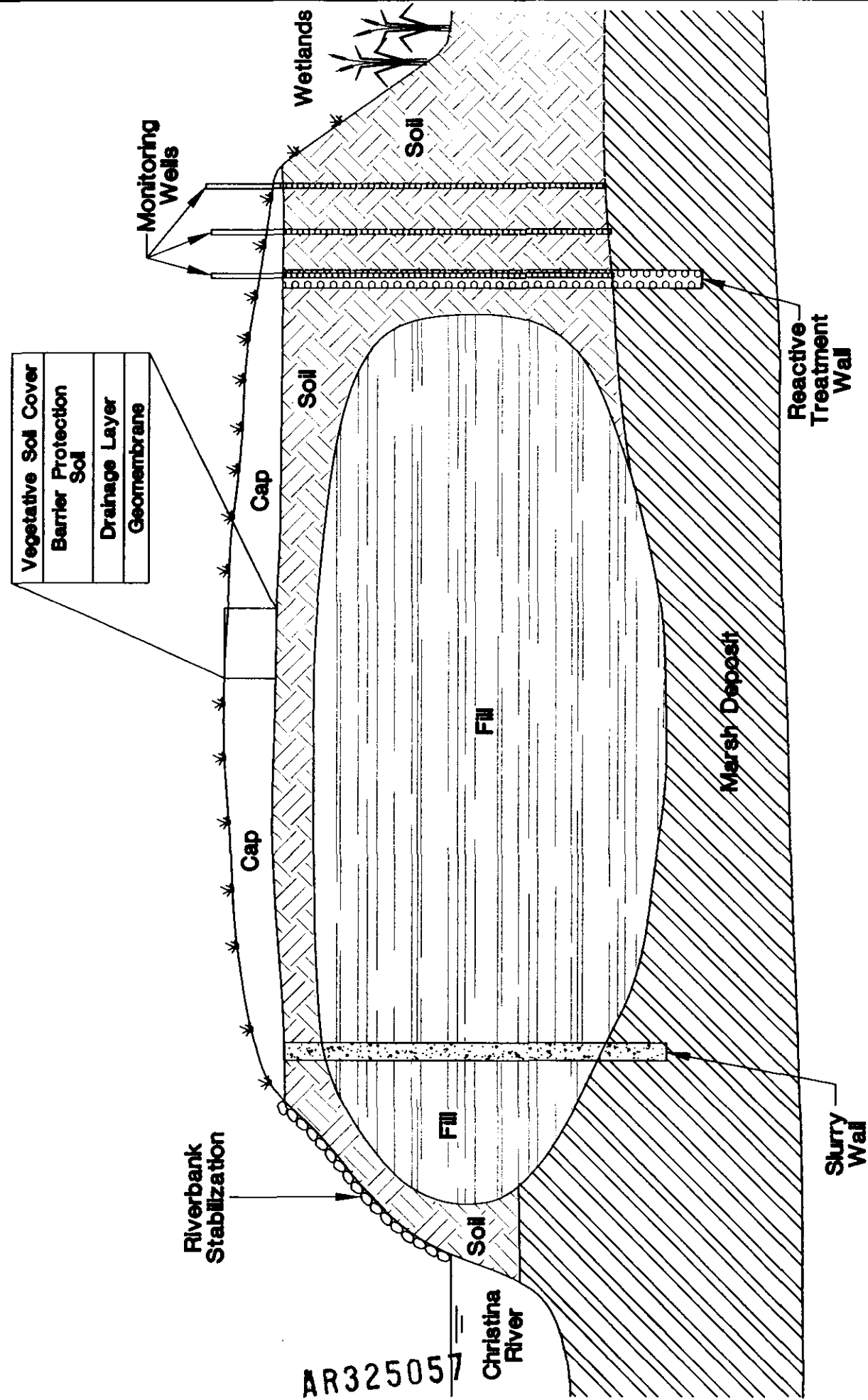
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PERMEABLE REACTIVE BARRIER REMEDY

AR325056

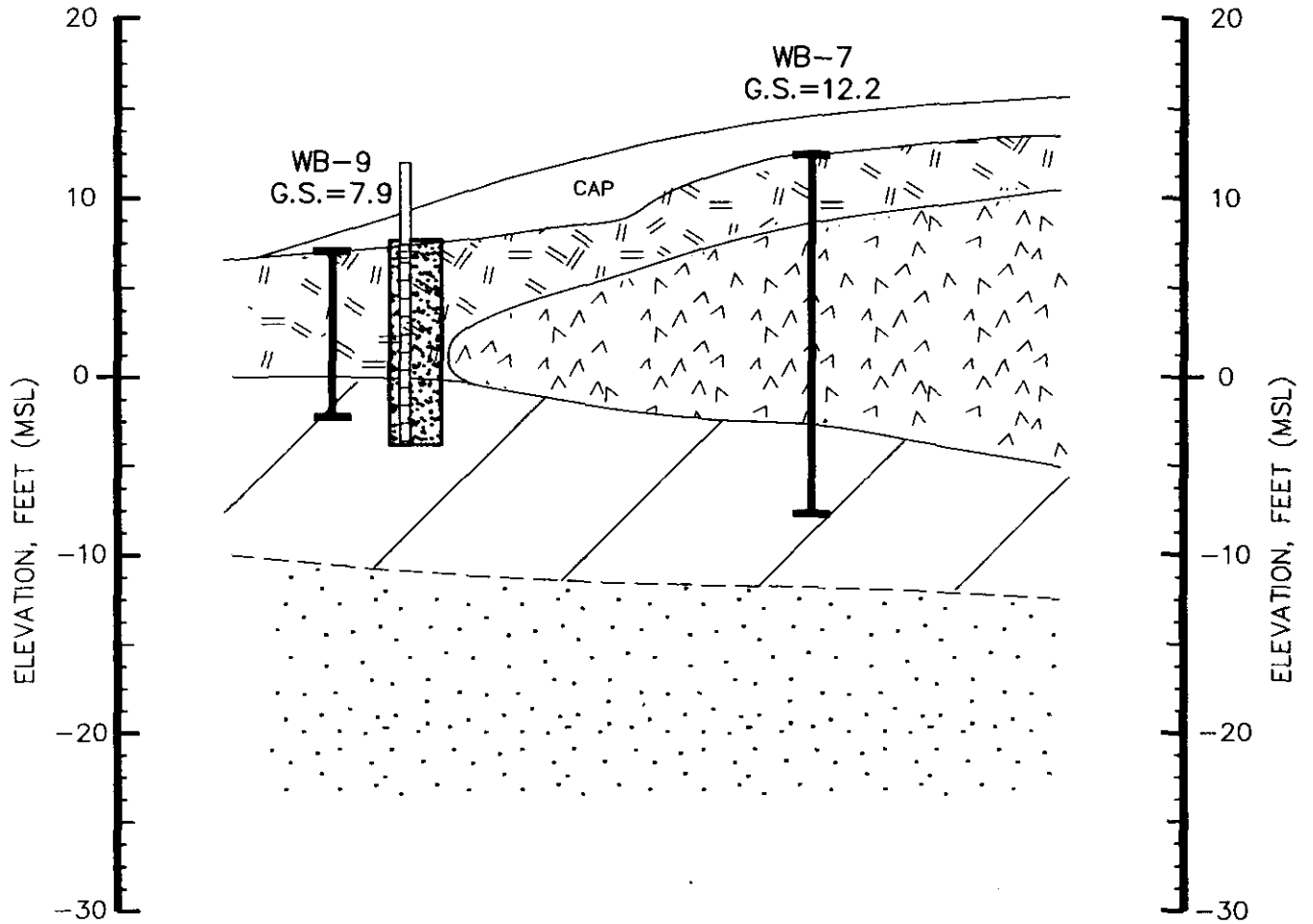
Figure 10



**SAMPLE CROSS-SECTION
OF SOUTH LANDFILL**

SOUTH

NORTH



LEGEND

	COVER SOIL, TYPICALLY GRAY TO BROWN, SILT TO SILTY CLAY		SAND, COLUMBIA FORMATION, TYPICALLY ORANGE TO ORANGE BROWN, FINE TO COURSE SAND, SOME GRAVEL
	FILL MATERIAL		CLAYEY SILT, MARSH DEPOSIT, TYPICALLY DARK TO OLIVE GREEN, CLAYEY SILT
	PRB WALL		

Detail of PRB Wall

Figure 12

AR325058

Barley Mill Plaza, Building 27

Lancaster Pike & Route 141

Wilmington, DE 19805

AR325059