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EVALUATION REPORT ON
WATER SUPPLY SYSTEM ALTERNATIVES
AND
GROUNDWATER TREATMENT SYSTEM ALTERNATIVES
FOR
BERKS SAND PIT REMEDIAL DESIGN
LONGSWAMP TOWNSHIP, PENNSYLVANIA

MARCH 6, 1989

PREPARED FOR:

USEPA ARCs REGION III
WORK ASSIGNMENT NO. 85-03-3N64

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1. EVALUATION OF WATER SUPPLY ALTERNATIVES

In October 1988, Baker/TSA Inc. submitted a final Feasibility Study (FS) Report which included the design and costing of three alternate water supply systems. These were the Benfield Road water supply system, the Topton Borough water supply system, and The Mountain Village Mobile Home Park water supply system, all in Longswamp Township, Berks County. This was for potable supply only, without fire flow demand.

The estimated costs (1988 dollars) for these three alternatives in the October 1988 Report are given in Table 1 below:

- TABLE 1 -

Alternative	Description	Capital Cost	1st yr. O & M Cost	Present Worth O & M	Total Present Worth Cost
A	Benfield Rd. Well Field	$1,151,272	$55,100	$519,427	$1,670,699
B	Expand Topton System	$1,217,000	0	0	$1,217,000
C	Expand Mt. Village System	$ 699,000	0	0	$ 699,000

In order to provide for a better comparison between the three water supply alternatives, Ecology & Environment, Inc. (E & E) re-evaluated the above alternatives, including significant cost factors not presented in the original FS cost data. In addition, two other existing municipal supplies at Alburtis Borough and Macungie Borough were identified as potentially feasible and were costed. Although these two boroughs are in Lehigh County, this does not preclude Longswamp Township from contracting with either borough for water service, if found to be feasible.

The technical and economic criteria used in re-evaluating the water supply options included the following:

1. In general the unit cost data has been utilized as provided in the October 1988 FS. Data has been rounded off to the nearest whole dollar integer.

2. The basic flow data of 181 GPCD, 4 capita/home, and two maximum days potable water storage has been used as it is in the October 1988 FS.

3. The use of pipe types has been generally accepted as presented in the FS for price comparison purposes.

4. A 100,000 gallon storage tank has been provided for all five alternative. This will supply 2 maximum demand days storage volume. Pennsylvania normally requires 1 day's storage however due to the large transmission distances, this additional volume is warranted as a safety consideration.

5. The straightest possible route has been selected for each pipeline to reduce length of transmission and thus reduce energy costs for pipe function costs. A few blowoffs and air valves are thus required and are costed.

6. The cost of temporary access gravel roads to parts of the pipeline and facilities is included.

7. The cost of aerial topography has been included, as it varies according to the length of the route and type of relief.

8. The cost of acquiring site property and pipeline easements has been included, since it is a significant cost and time item.

9. Water rates for existing borough systems have been obtained and included as O & M costs. Present worth was calculated for these costs. The Mt. Village Trailer Park owner indicated he would charge the going rate.

10. The three Borough systems' water managers indicated that the systems have adequate capacity to service 34 more homes without requiring an increase in facilities' capacity.

11. The trailer park owner stated that his one-well system has reached capacity and he is planning an expansion and capacity increase for his park.

12. The assumption has been made that none of the water systems will require iron removal. The Benfield Road alternative is the only one which requires a new chlorination system.

13. From the RI/FS data, it appears that well yield in the immediate vicinity of the Berks Study area varies from 10 GPM to 40 GPM, therefore it is possible that for Alternative A the number of wells that may be required could range from 1 to 4. This would result in an increase in the total present worth cost.

14. The cost of construction inspection services and construction surveying has been included at 10 percent of the total field cost.

Findings and Conclusions

The costs for the five alternatives evaluated are summarized in Table 2 below.

- TABLE 2 -

	Water System Alternative	Capital Cost	1st yr. O & M Cost (a)	Present Worth O & M	Total Present Worth Cost
A	Berkes Sand Pit	$1,216,900	$53,200	$486,600	$1,703,500
B	Topton Borough	1,523,100	20,084	189,400	1,712,500
C	Mtn. Village Mobile Home Park	1,169,600	20,084	189,400	1,359,000
D	Alburtis Borough	1,186,600	15,708	148,100	1,334,700
E	Macungie Borough	1,479,300	13,160	124,100	1,603,400

a) Based on rates same as charged to existing users.

It appears that Alternative D, connection to the Alburtis Borough system, is the most cost-effective based on present worth analysis. The Mtn. Village Mobile Home Park alternative appears to be the next most cost-effective system.

There are several factors, however which could have a significant impact on the cost comparison analysis given above. One factor is that water usage rates charged by the boroughs for service to customers outside the borough corporate limits could be increased by 50% to 100% above existing in-borough rates. Thus the O & M present worth would increase at a similar rate. A second factor concerns right-of-way requirements. Some ROW may be more difficult to obtain (i.e., eminent domain could be required). The length of time to acquire ROW may preclude a selected alternative from being feasible if excessive time is required to secure them. With respect to the mobile home park system, cost savings might be realized if the owner's expansion plans would allow for the second supply well to be placed closer to the Berks study area.

Alternatives C and D were explored in more detail in order to provide additional information on those variables significantly affecting system costs. Based on discussions with responsible personnel from the Alburtis Borough and the Mt. Village Trailer Park, the following information was acquired, with resulting cost modifications (see Table 3).

- TABLE 3 -

	Water System Alternative	Capital Cost	1st yr. O & M Cost	Present Worth O & M	Total Present Worth Cost
C-1	Mtn. Village Park	$ 868,200	$20,400	$192,400	$1,060,600
C-2	Mtn. Village Park	1,169,600	15,708	148,100	1,317,700

The Alburtis Borough has fixed its rates such that outside customers will pay the same costs as borough residents. Therefore, O&M costs for Alternative D in Table 2 are accurate at this time. Mtn. Village has plans to provide a second supply well and required pipeline to serve a mobile home park expansion area closer to the Berks study area. In Alternative C-1, the capital costs could be reduced assuming some type of cost sharing with the owner on common facilities such as the well, pipeline and storage tank. Alternative C-2 assumes O&M costs based on Alburtis Borough user rates.

The final evaluation to select and implement the most feasible alternative will be based on the ability to negotiate terms for connecting the Berks water supply system to the Alburtis or Mtn. Village systems, and on potential constraints to acquiring right of ways.

In order to facilitate final selection and implementation of the water supply system design, it is recommended that the following technical and administrative work be performed:

- Commence negotiations with the owners of the two water supply systems to work out basic facilities' design parameters, cost sharing, and easments/ROW as required, and select preferred system.
- Authorize detailed work plan preparation of proposed work.
- Authorize aerial topography of selected route (or routes if needed to finalize pipeline location). March/April is a good time for aerial fly-overs because vegetation is not fully out.
- Commence discussion with Town of Longswamp officials on formation of a water district for the 34 study area homes.
- Prepare preliminary location, design and route drawings for use in previous items of work.
- Authorize final design of selected water system.
- Assist either Mtn. Villiage or Alburtis in preparing necessary support materials for public hearings, board meetings, etc.

2. EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES

An engineering evaluation was done on the two groundwater remediation alternatives, air stripping with vapor phase carbon absorption and liquid phase carbon adsorption in order to more accurately determine the most cost-effective solution. As part of this evaluation, a review of site hydrogeologic and contaminant information found in the remedial investigation report (Baker, 1988) was also done to identify data gaps which will effect the final design of the groundwater remediation system.

2.1 SITE HYDROGEOLOGY AND CONTAMINATION

A summary of known information important to the design of the groundwater extraction/treatment/injection system is given below:

Hydrogeology

(1) There are basically two groundwater zones beneath the Berks site, a shallow aquifer in the overburden and weathered bedrock (approximately 0-60 feet), and the bedrock aquifer (from approximately 60 feet to over 300 feet). These two zones are not geologically or hydrologically distinct but rather are gradational. The bedrock aquifer hydraulic characteristics also vary with depth, the deeper zones having less fractures and appearing to be less transmissive than the shallower zones.

(2) The groundwater in both water zones flows from the center of the site to the north, east and west. The Liebensburger and Van Elsywyck properties are approximately on the groundwater divide. However, approximately 98% of the contamination is on the east side of the divide and is flowing towards the east. Only 2% flows towards the north and a trace to the west.

(3) The transmissivity of the upper 150 feet of the bedrock aquifer in the vicinity of MW1 and MW2 is on the order of 5×10^4 gpd/ft (or 0.2 cm/sec). The bedrock in the vicinity of MW7 appears to be much tighter, on the order of 200 gpd/ft (or .009 cm/sec). The transmissivity of the bedrock below 150 feet is unknown but appears to also be lower (tighter) than the shallower bedrock based on fracture frequency in the cores.

(4) The groundwater flow velocity in the bedrock aquifer is on the order of 0.25 ft/day. This is based on the bedrock aquifer having a porosity of 20% and responding more like a porous medium than a fractured aquifer. The porosity value of 20% was derived from borehole geophysical logs, and verified qualitatively by the delay in response to pumping and the relatively high fracture frequency in the cores.

(5) It is anticipated that the rate of contaminant migration will be close to the rate of groundwater flow (0.25 ft/day) in the bedrock

aquifer because there is minimal organic carbon to retard the contaminants.

(6) If the center o the plume has only migrated from the source (assumed to be in the vicinity of the Liebensburger/Van Elswyck property line) to MW4 (the furthest downgradient well and the most highly contaminated), then the contaminant migration velocity is 0.25 ft/day. This agrees with the calculations made using a 20% porosity as noted above.

(7) There is an upward hydraulic gradient between the competent bedrock aquifer and the shallow weathered bedrock aquifer. This indicates that the deep bedrock aquifer is a least semi-confined and that the site is approaching a surface discharge zone. It is anticipated that this surface discharge is Perkiomen Creek.

(8) There is a thickening of the layered sapprolite sequence (weathered bedrock of the shallow aquifer) towards the east, downgradient from the suspected source area. This may tend to funnel the shallow contaminant migration towards the southeast.

(9) MW7 can be pumped at a maximum rate of 20 gpm. Any higher pump rate would create the risk of pumping the well dry.

(10) MW1 should sustain pump rates as high as 250 gpm. However, a 100 gpm pump rate should capture the majority of the TCA and DCE plumes (out to the 1 ppm isopleth), if a newly installed pumping well near MW4 can be pumped as effectively as MW1. MW4 is a 4 inch well completed with a 90 foot screen whereas all the other bedrock wells are 6 inch wells with open hole completions. This will effect the maximum rate at which we can pump MW4 because of pump size limitations. Therefore, a replacement extraction well should be installed in the vicinity of MW4 since the groundwater is the most contaminated in this area.

Contamination

(1) The highest TCA and DCE concentrations detected to date were recorded in 1982 when the first Emergency Response action was taken. TCA was found at 124,600 ppb in RW3 (Van Elswyck's well) at this time. A year later the concentrations had decreased 50% to 53,000 ppb, indicating the plume is migrating and dispersing quite rapidly. By the time of the Remedial Investigation (1987) these concentrations had decreased another order of magnitude. Currently the highest TCA concentration is 5500 ppb and the highest DCE concentration is 660 ppb. Both maximums were found in monitoring well MW4 in the bedrock aquifer.

(2) Sampling from the monitoring wells installed in 1987 indicates that the probable source area is in the vicinity of the Leibensburger/Van Elswyck backyards. The sand pit is no longer the suspected source area. When it was excavated, no contamination was found there. In addition, some of the highest contaminant

concentrations have since been detected in well MW7, upgradient and about a hundred feet away from the sand pit. The highest soil gas samples were also found close to MW7.

(3) The contamination plume is narrow and elongated in the east-west direction, trending downgradient towards Perkiomen Creek. TCA concentrations as high as 2600 ppb and DCE contamination as high as 990 ppb were found in seep samples associated with this creek.

(4) The bedrock aquifer is more contaminated than the shallow aquifer, indicating that the contamination is sinking. Currently, approximately twice as much TCA contamination occurs in the bedrock aquifer as in the shallow aquifer; approximately three times as much DCE contamination occurs in the deep bedrock aquifer as in the shallow aquifer.

(5) The majority of the plume is moving east away from the residences on Benfield and Walker Roads. However, concentration levels at the residences could continue to increase by lateral dispersion of the plume. Recent analytical results show that concentrations in the residential wells close to Walker Road are approaching Drinking Water Standards for both TCA and DCE.

There are several significant data gaps in the hydrogeologic and contamination data collected during the RI which make it difficult to perform a quality Remedial Design. The most important unknowns include:

Hydrogeology

(1) The transmissivity of the aquifer in the vicinity of MW4 and MW6 to the east in the direction of plume movement is poorly defined. No significant drawdown was observed in any of the easterly wells during the pump testing of MW1 and MW7. Since the bedrock appears to be quite nonhomogeneous (the transmissivity at MW1 is two orders of magnitude above the transissivity at MW7) it may be erroneous to assume MW4 and MW6 have the same transmissivity as MW1 and MW2.

(2) The actual discharge area of the bedrock aquifer is unknown. However, it appears that Perkiomen Creek is the primary regional discharge basin for this area. Perkiomen Creek flows to the south and eventually intercepts the Schuylkill River.

(3) The transmissivity of the shallow aquifer is poorly estimated. The fact that it drewdown when the deeper zone was pumped primarily indicates that the two water zones are interconnected. It may be possible to extract the contamination from the shallow aquifer by pumping the bedrock aquifer, however, a better estimate of the shallow zone's transmissivity is required.

Contamination

(1) The downgradient extent of contamination is unknown and cannot be predicted from the available data. The well furthest downgradient (MW4) had the highest levels of contamination found on the site.

(2) The vertical extent of contamination is not well defined. The packer test data, wherein isolated depths were sampled, indicated that contaminant concentrations well above Drinking Water Standards were observed in all wells down to 125 feet (the deepest sample taken) as well as in MW2 down to 250 feet. However, Baker indicated that the packer test data failed QA/QC requirements. Had we been able to rely on these data, we would still be unable to define the "bottom" of the contaminant plume. We could only say that the concentrations at 250 feet were lower than the concentrations at 100 feet.

(3) Present contaminant concentration levels are unknown. Based on historical data, levels are decreasing fairly rapidly due to dispersion and migration.

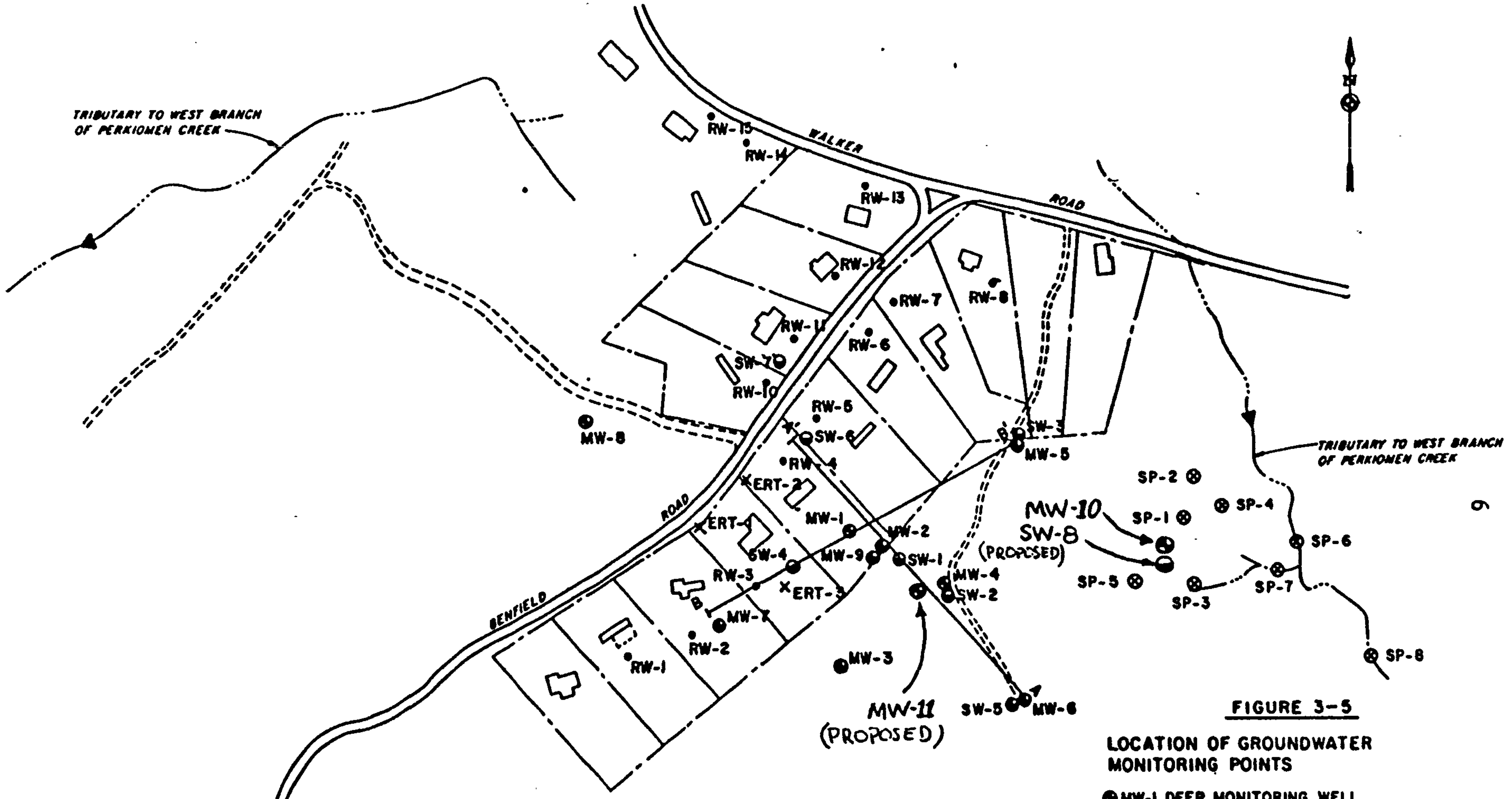
Based on the above summary of known and unknown hydrogeologic and contamination data, several field tasks have been identified in order to fill data gaps and provide required information for final remedial design. The following five tasks are designed to more accurately determine aerial and vertical extent of contamination, and provide data on aquifer characteristics:

- Task 1 - Additional Monitoring/Extraction Well Installation
- Task 2 - Groundwater Sampling
- Task 3 - Measurement of Groundwater Levels
- Task 4 - Pumping Test
- Task 5 - Packer Test

Detailed explanations of each task are as follows:

Task 1: Well Installation. Two deep bedrock monitoring/extraction wells (MW10, MW11) and one shallow overburden well (SW8) are recommended to assess the extent of and to extract contaminated groundwater (see Figure 3-5). Wells (MW10 and SW8) will be installed as nested pairs to determine contaminant concentrations in both the shallow and deep aquifers. The rationale for the placement of the monitoring wells is as follows:

- MW10 and SW8: will be drilled downgradient of the site in the vicinity of the seeps near Perkiomen Creek. The purpose of the wells is to characterize the VOC groundwater plume in this area. One high reading of 3590 ppb total VOCs was collected from a surface seep located downgradient, directly in line with the plume axis. SW8 will be a 2-inch diameter well drilled into competent bedrock which is expected to be about 60 feet. It is recommended that MW10 be a 6-inch diameter well drilled to a depth of 150 to 200 feet. The large diameter for MW10 is necessary because this well may ultimately be used to extract contaminated groundwater.



BERKS SAND PIT.

N.T.S.

FIGURE 3-5

LOCATION OF GROUNDWATER MONITORING POINTS

⊗ MW-1 DEEP MONITORING WELL
⊖ SW-1 SHALLOW MONITORING WELL
• RW-1 RESIDENTIAL WELL
× ERT-1 OTHER MONITORING WELLS
A ⊢⊣ A' CROSS-SECTION LINE (SEE FIGURES 3-13 AND 3-14)
⊗ SP-1 LOCATION OF SURFACE WATER AND SEDIMENT SAMPLING POINT

- MW11 will be a 6-inch diameter bedrock well drilled to approximately 150 - 200 feet and placed immediately adjacent to MW4. This well, which is located in the most contaminated portion of the plume, will be pump tested and used in the future as a groundwater extraction well. MW4 is not a suitable extraction well because it cannot be pumped at rates of greater than 40 gpm due to its 4-inch diameter. Pumping rates greater than 40 gpm are necessary to extend the capture zone of the well.

Since MW's 10 and 11, would be used as extraction wells, it is recommended that they be designed in a durable manner. Thus, it is recommended that stainless-steel construction be used for these wells. While the initial capital costs of stainless-steel construction are higher than other techniques, the long-term stability of this well design should prove cost-effective over the duration of site remediation. SW8 will be constructed with PVC.

Task 2: <u>Groundwater Sampling</u>. A limited number of monitoring wells, including wells which are planned and wells which are pre-existing, should be sampled following implementation of Task 1. Groundwater sampling is necessary to define the correct groundwater plume configuration and provide concentration values for treatment system design. Only wells which define the highest contaminant concentrations (greater than 0.1 ppm total VOCs) will be sampled. This will include about 18 wells. It is recommended that groundwater be analyzed using EPA Method 601 which is a GC method and thus has lower detection limits than comparable GS/MS techniques. Method 601 is also more cost-effective.

Task 3: <u>Measurement of Groundwater Levels</u>. Groundwater elevations of all residential wells, monitoring wells and ERT wells should be taken prior to the pump test. The purpose of this task will be to determine the potentiometric surfaces of both the shallow and deep aquifers. This information will be synthesized with contaminant concentration maps to refine the location of extraction wells and will also be used to specifically define the orientation of the previously discussed groundwater divide and the groundwater flow pattern to the north.

Task 4: <u>Completion of a Pumping Test</u>. A 24 hour pump test should be performed on MW11 to determine the optimum pumping rate for groundwater extraction and the effective radius of influence. This test is necessary because the initial pumping test conducted in MW1 did not result in estimates of the transmissivity of MW4 and areas to the east which are now the most contaminated. Although the exact specifications for the test are yet to be developed, it is expected that between 8 to 12 wells will be monitored; that MW11 will be pumped at a rate of 100 gpm and that groundwater will be sampled every 3 hours to determine if VOC levels become constant after several hours of pumping. Additionally, a temporary storage system should be implemented prior to the test since up to 144,000 gallons of contaminated groundwater will be extracted from the aquifer. This water would later be treated by the groundwater treatment system.

Task 5: Packer Tests in MW2. E & E recommends performing depth specific packer tests in MW2, between 100 to 300 feet, to estimated the vertical extent of groundwater contamination. This data will be used to determine if extraction wells are needed beneath depths of 200 feet. One of the major data gaps in the RI was that the depth of the VOC groundwater plume had not been adequately defined. Depth specific packer tests and groundwater sampling were performed in 6 of 9 deep monitoring wells. However, the analytical data from groundwater sampling was reported as invalid. Currently, E & E is attempting to determine why the groundwater data was invalidated, however, Baker/TSA has not yet provided E & E with a specific explanation for the invalidation.

A summary of estimated costs for the above 5 tasks is given below:

o Task 1:	Installation of Wells (1.5 weeks)	- $49,000
o Task 2:	Collect Groundwater Samples (1 week)	- $ 8,300
o Task 3:	Water Level Measurements (1 day)	- $ 760
o Task 4:	Pump Test, MW11 (1 week)	- $18,000
o Task 5:	Packer Test, MW2 (2 days)	- $ 3,700
	TOTAL:	$ 79,760

2.2 AIR STRIPPING/CARBON ADSORPTION ALTERNATIVE EVALUATION

The estimated costs, as reported in the Feasibility Study (Baker, 1988), for alternatives employing air stripping and carbon adsorption are given in Table 4 below:

- TABLE 4 -

Alternative	Description	Capital Cost	1st yr. O & M Cost	Present Worth O & M	Total Present Worth Cost
A	Air Stripping (AS)	$902,336	$104,390	$984,079	$1,886,415
B	AS with Vapor Phase Carbon Ads.	$1,161,984	$424,934	$4,005,815	$5,167,799
C	AS with Vapor and Liquid Carbon Ads.	$1,761,884	$519,394	$4,896,315	$6,658,199
D	Liquid Phase Carbon Adsorption	$920,386	$508,297	$4,791,671	$5,712,057

Alternatives B and D were considered to be relatively cost-effective in meeting the required clean-up criteria. In order to more accurately determine the best option, E & E re-evaluated the technical and economic basis of these two alternatives. Based on a review of pilot scale and field applications of air stripping and carbon adsorption for removal of chlorinated volatile organics from groundwater, both technologies were shown to be effective. Therefore, evaluation of the two alternatives focused on the design criteria and resulting cost estimates, as presented in the FS report.

The technical and economic criteria used in evaluating the groundwater treatment alternatives included the following:

1. Generally, unit cost data was utilized as provided in the FS report. Costs were rounded off to the nearest whole dollar interger.

2. Design criteria (flow rates, contaminant concentrations) were reviewed as they applied to all alternatives to insure a reasonable basis for comparison between the alternatives.

3. Major equipment and operating expenses, including air strippers, activated carbon units, off-gas control equipment, carbon regeneration options, energy requirements and carbon usage rates, were re-evaluated since these items represented the largest portion of total capital and O & M costs.

4. An on-site carbon regeneration system option was reviewed as a potentially cost-effective method of regenerating carbon from the vapor phase adsorber system.

5. Since the project duration was given in the F.S. report as 10 to 30 years, a present worth analysis was also done for the shorter time period in order to compare costs.

The revised costs for Alternatives B - Air Stripping/Vapor Phase Carbon Adsorption and D - Liquid Phase Carbon Adsorption are given in Table 5. A third alternative, Alternative E - Air Stripping/Vapor Phase Carbon Adsorption with on-site carbon regeneration was also included.

- TABLE 5 -

Alternative	Description	Capital Cost	1st yr. O & M Cost	Present Worth O & M	Total Present Worth Cost
B	Air Strip/V.P. Carbon Ads.	$1,128,067	$276,403	$2,605,636	$3,733,703
D	Liquid Carbon Adsorption	$941,970	$390,235	$3,678,707	$4,620,677
E	A.S/V.P. Carbon Ads. w/On-Site Regeneration	$1,774,273	$145,507	$1,371,685	$3,145,958

Over a 30-year project life, Alternative E appears to be the most cost-effective option followed by Alternative B. Total present worth of the three alternatives using a 10 year project life indicates Alternative E is marginally less expensive then Alternative B, as shown below:

Alternative B:	$2,826,453
Alternative D:	$3,339,808
Alternative E:	$2,668,355

On-site carbon regeneration using a thermal destruction system integrated with vapor phase carbon adsorbers is available in a modular, automated form from at least one manufacturer. The process uses high temperature gas to first desorb organics from the carbon and then destroy the concentrated VOCs in an after-burner type operation. A wet scrubber system to control HCl and particulate emissions from the after burner would most likely be required. Since the thermal destruction system is used for a dual purpose, i.e., reclaiming spent carbon and destroying VOCs in a gas stream, its classification under RCRA as a recycling unit versus incineration unit is subject to regulatory interpretation. Discussions with Federal RCRA personnel and past experience from two applications of this system indicated that classification as a recycling unit was accepted by regulatory agencies.

On-site carbon regeneration with emission controls requires a capital equipment investment of approximately $400,000, and operation and maintenance costs of approximately $30,000 per year. Savings are realized by lower carbon regeneration costs. However, from the above comparison of costs over different project durations, it is apparent that a shorter time period favors use of off-site regeneration (Alternative B). At a project life of approximately 10 years, the costs of the two approaches (on-site versus off-site regeneration) are comparable.