TECHNICAL REPORT DATA
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4. TITLE AND SUBTITLE	5. REPORT DATE
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9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS U. S. Environmental Protection Agency 401 "M" Street, S. W. Washington, D. C. 20460	13. TYPE OF REPORT AND PERIOD COVERED Final ROD Report 14. SPONSORING AGENCY CODE 800/00

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Enterprise Avenue site is located within the City of Philadelphia. It encompasses approximately 57 acres and is situated within the 100-year flood plain of the Delaware River. It has been determined that the site is contaminated with industrial and chemical wastes from the unauthorized disposal of approximately 5,000 to 15,000 drums containing paint sludges, solvents, oils, resins, metal finishing wastes, and solid inorganic wastes.

The off-site disposal alternative was selected as the most cost-effective remedial action. This alternative includes: resampling and analyzing the stockpiled soils in 100-cubic-yard lots for key indicator parameters; on-site containment of soils which do not exceed key indicator limits; off-site disposal at a RCRA approved facility of soils which exceed parameter limits; grading, completion of clay cap and cover, and site vegetation. The capital cost for the selected alternative is estimated to be $4,324,000 and annual O&M costs are $4,200.

Key Words: Municipally-Owned Site, Potential Responsible Party (PRP), Key Indicator Analysis, Soil Contamination, RCRA Closure Regulations, Off-Site Disposal, On-Site Disposal

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Record of Decision Site Name: Enterprise Avenue Site, PA Contaminated media: sw, soil Key contaminants: paint sludges, solvents oils, resins, metals		

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
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	None	

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ROD BRIEFING ISSUES

Site: Enterprise Avenue, Pennsylvania

Region: III

AA, OSWER
Briefing Date: May 4, 1984

SITE DESCRIPTION

The Enterprise Avenue site is located within the City of Philadelphia. It encompasses approximately 57 acres and is situated within the 100-year flood plain of the Delaware River. It has been determined that the site is contaminated with industrial and chemical wastes from the unauthorized disposal of approximately 5,000 to 15,000 drums containing paint sludges, solvents, oils, resins, metal finishing wastes, and solid inorganic wastes.

SELECTED ALTERNATIVE

The off-site disposal alternative was selected as the most cost-effective remedial action. This alternative includes: resampling and analyzing the stockpiled soils in 100-cubic-yard lots for key indicator parameters; on-site containment of soils which do not exceed key indicator limits; off-site disposal at a RCRA approved facility of soils which exceed parameter limits; grading, completion of clay cap and cover, and site vegetation. The capital cost for the selected alternative is estimated to be $4,324,000 and annual O&M costs are $4,200.

ISSUES AND RESOLUTIONS

1. The Enterprise Avenue site is a city-owned landfill contaminated with illegally dumped industrial waste materials. The City has undertaken response actions at the site and would like to continue to oversee the remaining cleanup activities. However, the City has been identified as a Potential Responsible Party (PRP). Therefore, specific criteria were developed for the Cooperative Agreement to define the rationale for enforcement where Fund monies will be used by a PRP for cleanup. These criteria included:

    - EPA's reserved right to sue
    - Reimbursement agreement between the City and EPA

KEY WORDS

- Municipally-Owned Site
- Potential Responsible Party (PRP)

ISSUES AND RESOLUTIONS	KEY WORDS
• The City's responsibility to continue to pursue its pending lawsuits against Enterprise Avenue generators.	
2. A Key Indicator Analysis (KIA) was developed and used to determine whether or not excavated soil was contaminated. The objective of the KIA was to identify those contaminants which were most likely to be found on-site and of greatest concern with respect to potential environmental impacts. Technical Report #5 "Hot Spot Soil Handling Protocol" discusses the rationale employed in the KIA development and is included as an attachment to the ROD.	• Key Indicator Analysis • Soil Contamination
3. The recommended alternative complies with the Part 265 RCRA closure regulations. This includes ground water monitoring, a 2-foot clay cover and site vegetation.	• RCRA Closure Regulations
4. The justification for off-site disposal was based on the elimination of on-site disposal options for the following technical reasons:	• Off-Site Disposal • On-Site Disposal
1. The high ground water table and subsurface soils are not suitable for construction of a land disposal facility.	
2. There is a high possibility for differential settlement due to the presence of organic matter in the subsurface soils (incinerator residue), that could adversely affect the integrity of a land disposal cell.	
3. Migration to the shallow ground water table (2-5 ft.) could be expected in the event of a release of contaminants from a disposal cell.	

Record of Decision
Remedial Alternative Selection

SITE: Enterprise Avenue Site, Philadelphia, Pennsylvania

DOCUMENTS REVIEWED

I have reviewed the following documents describing the analysis of cost-effectiveness of remedial alternatives for the Enterprise Avenue site:

- Enterprise Avenue Remedial Action Feasibility Study titled "Remedial Action Program, Excavation and Disposal of Hot-Spot Soil From, and Closure of, the Enterprise Avenue Site, Philadelphia, Pennsylvania, dated April 1984.

- Summary of Remedial Alternatives Selection

- Technical reports prepared by Roy F. Weston, Inc. in September of 1981 for the City of Philadelphia #5, "Hot Spot Soil Handling Protocol" and #3, "Groundwater and Surface Water Monitoring".

- Responsiveness summary dated February 23, 1984.

DESCRIPTION OF SELECTED REMEDY

- Sampling and analysis of all soil stockpiled on-site in 100-cubic-yard lots to determine disposal requirement.

- Off-site disposal at a RCRA approved facility of all soils which fail the Key Indicator Parameter Test.

- Backfilling, grading and vegetating of the site as a final cover.

DECLARATIONS

Consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and the National Contingency Plan (40 CFR Part 300), I have determined that the off-site disposal of contaminated soil at the Enterprise Avenue site is a cost-effective remedy and provides adequate protection of public health, welfare, and the environment. The State of Pennsylvania has been consulted and agrees with the approved remedy.

I have also determined that the action being taken is appropriate when balanced against the availability of Trust Fund monies for use at other sites. In addition, the off-site transport and secure disposition in an approved facility is more cost-effective than other remedial actions and is necessary to protect public health, welfare, and the environment.

5/10/84
Date

Lee M. Thomas
Assistant Administrator
Office of Solid Waste and Emergency Response

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION
ENTERPRISE AVENUE SITE

SITE LOCATION AND DESCRIPTION

The Enterprise Avenue site is located within the City of Philadelphia adjacent to the Southwest Water Pollution Control Plant and near the eastern end of Philadelphia International Airport (See Figure 1). The city-owned site encompasses a total of approximately 57 acres, and is located within the 100-year flood plain of the Delaware River. The immediately adjacent land use is primarily industrial, and the closest residential population is located slightly more than two miles northwest of the site.

Natural marsh conditions are found at the site in isolated areas. A low-permeability, silty clay layer underlies the site. The thickness of this layer ranges from 5 feet to 25 feet. Multiple culverts, canals, and drainage ways introduce variability to the surface water system by concentrating runoff. All surface drainage from the site is channeled into Eagle Creek, which flows to Mingo Creek, then to the Schuylkill River, and ultimately the Delaware River.

There are two ground water-bearing zones at the site. The first zone is above a silty clay layer. It is under perched water table conditions. The second ground water-bearing zone is found in the sands and gravel that lie beneath the silty clay. The ground water in this zone is under confined conditions. There are no known users of the ground water in the general area; however, the deeper ground water-bearing zone may recharge sources of ground water for portions of southern New Jersey. The observed flow in the deep aquifer is east toward the Delaware River.

SITE HISTORY

The Enterprise Avenue site historically was part of the extensive tidal marshland along the Delaware River. The back channel of the Delaware River had naturally silted-in because of extensive farming and mining on the upper reaches of the Schuylkill and Delaware Rivers. The low-lying land in the area has been extensively filled-in for facilities such as the airport, tanker terminals, roadways, and industrial sites. Until mid-1976, the City of Philadelphia Streets Department used 40 acres of the low-lying land to landfill primarily incinerator residue and lesser quantities of fly ash and construction/demolition debris.

In response to reports of unauthorized dumping of industrial waste, the Philadelphia Water Department (PWD) in late 1978 developed a work scope to perform an initial investigation of the site conditions in consultation with EPA. Exploratory excavations during January of 1979 uncovered approximately 1,700 55-gallon drums containing industrial waste materials. The

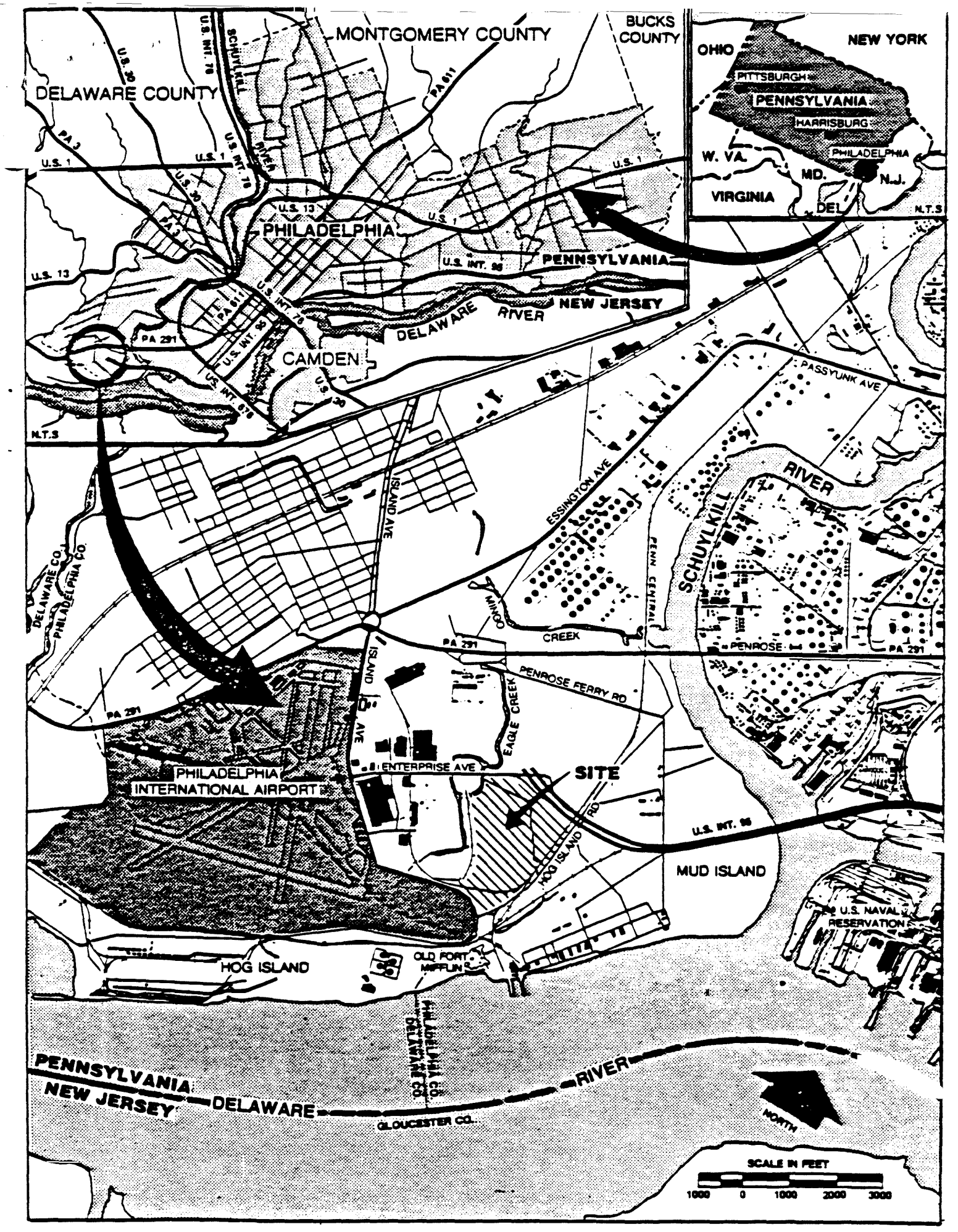


FIGURE 1 LOCATION OF THE ENTERPRISE AVENUE SITE

great majority of these drums were broken and fragmented. Generally, it was determined that the drums contained such industrial and chemical wastes as paint sludges, solvents, oils, resins, metal finishing wastes, and solid inorganic wastes. The total number of drums disposed of at the site was estimated by the PWD to be between 5,000 and 15,000.

The PWD undertook a response action at the site which included: A detailed site investigation to determine the degree and extent of contamination; the development of plans and specifications to accomplish site cleanup; and procurement of a cleanup contractor to excavate and properly dispose of contaminated soil and drummed waste at an approved off-site facility. Contaminated water was also taken off-site for disposal.

A Key Indicator Analysis (KIA) was used to determine whether or not excavated soil was to be considered contaminated. The objective of the KIA was to identify those contaminants which were most likely to be found on-site and of greatest concern with respect to potential environmental impacts. The list of key indicator contaminants was developed by reviewing the records in existence which pertained to the type and quantity of waste materials buried at the site. In general, the waste materials were organic in nature. The key indicators and their associated limits are listed below. If any one limit were exceeded in an analysis, the entire batch of soil was considered contaminated and was taken off-site for disposal at an approved landfill. If none of the limits were exceeded, the soil was classified as noncontaminated and remained on-site to be used as backfill material.

Key Indicator Analysis

Indicator	Limit
1. TOX (Total Organic Halogen)	25 ppm
2. Volatile Organics	
- Benzene	12 ppm
- Toluene	15 ppm
- Ethylbenzene	15 ppm
3. EP Toxicity (Metals)	
- Arsenic	5 ppm
- Barium	100 ppm
- Cadmium	1 ppm
- Chromium	5 ppm
- Lead	5 ppm
- Mercury	0.2 ppm
- Selenium	1 ppm
- Silver	5 ppm

In developing the limits for the key indicators, the maximum background levels present for the various parameters were identified. The upper limits for the key organic indicators were established at 75 times the maximum background levels. As the limits were set they were compared to the maximum fresh water criteria for reasonableness and found to be comparable. The EP toxicity test was applied for analysis of metals only, due to the fact that the TOX indicator will detect the presence of pesticides/herbicides. The approach taken for establishing the organic limits (i.e., 75x) is consistent with EPA's methodology which uses 100 times drinking water standards for establishing the limits for EP toxicity under RCRA. Technical Report #5 entitled "Hot Spot Soil Handling Protocol" discusses the rationale employed in the KIA development.

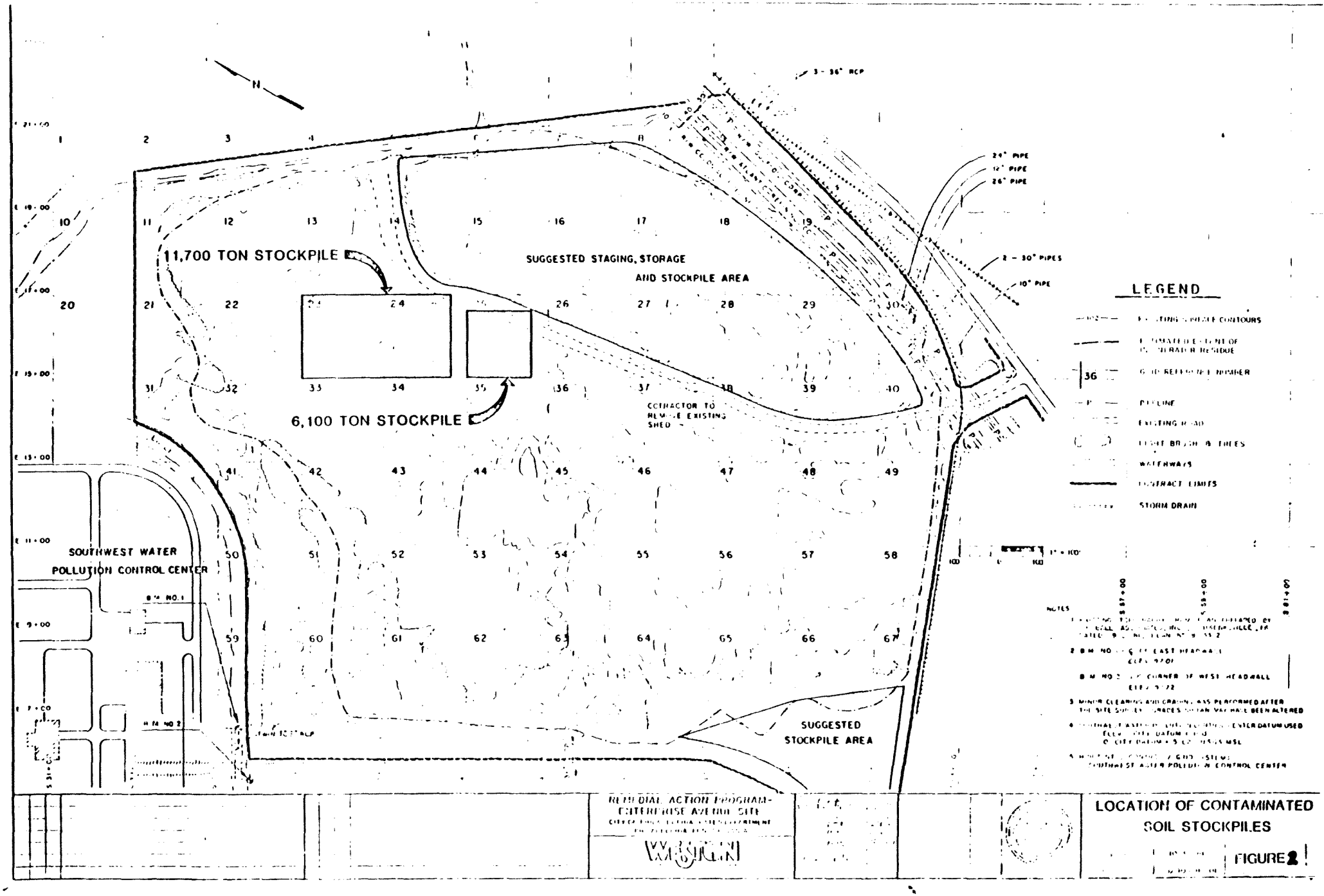
Unfortunately, in the Fall of 1982 the PWD had to halt cleanup work at the site due to a lack of funds available for the completion of the project. The remedial project contract cost had reached $7.2M at that time. The initial bid price was $4.95M. The work accomplished during 1982 included: excavation of all contaminated soil and buried drums; off-site disposal of all drummed waste material (11,600 drums uncovered); off-site disposal of approximately 226,000 gallons of contaminated water; and off-site disposal of 21,350 tons of the approximately 39,150 tons of contaminated soil present on-site. When the PWD realized that the funds available were inadequate to complete the project, they directed the contractor to stockpile the remaining 17,800 tons of excavated contaminated soil on-site (see Figure 2 for location of piles). The City of Philadelphia spent more than $8.35M for site cleanup and related investigative and engineering activities.

All cleanup actions taken to date at the site by the PWD were done with the concurrence of EPA. The Agency was intimately involved, both technically and legally, in the development and implementation phases of the cleanup. All proposed actions were reviewed to assure that they complied with Federal environmental regulations which existed at the time. The City was most cooperative in modifying it's plans in response to the Agency's comments.

CURRENT SITE STATUS

The two stockpiles of soil remaining on the site are the subjects of the proposed remedial action. The larger of the two piles (11,700 tons) was determined to be contaminated primarily with Total Organic Halogens (TOX). The median TOX concentration of the soil in this pile is 65 ppm, the average is 350 ppm, and the range is 29 ppm to 5,350 ppm. The smaller pile (6,100 tons) is primarily contaminated with Volatile Organics (i.e. Benzene, Ethylbenzene, Toluene). A summary of the concentration values of the soils in the smaller pile is as follows:

	Median (ppm)	Average (ppm)	Range (ppm)
Toluene	36	172	19 to 1,000
Benzene	24	34	17 to 86
Ethylbenzene	41	94	18 to 427


11,700 TON STOCKPILE
6,100 TON STOCKPILE
SUGGESTED STAGING, STORAGE AND STOCKPILE AREA
CONTRACTOR TO REMOVE EXISTING SHED
SOUTHWEST WATER POLLUTION CONTROL CENTER
SUGGESTED STOCKPILE AREA
3 - 36" RCP
24" PIPE
12" PIPE
24" PIPE
2 - 30" PIPES
10" PIPE
LEGEND
EXISTING CONTOUR
PROPERTY LINE
GRID REFERENCE NUMBER
PIPELINE
EXISTING ROAD
WATERWAYS
CONTRACT LIMITS
STORM DRAIN
NOTES
REMEDIAL ACTION PROGRAM
ENTERPRISE AVENUE SITE
LOCATION OF CONTAMINATED SOIL STOCKPILES
FIGURE 2

Each stockpile has been graded and covered with 9 to 12 inches of clay. The determination as to which soil would be stockpiled was based upon analytical results produced by the cleanup contractor in the Fall of 1982. (See Appendix A for results.)

Subsequent sampling and analysis of soil from the stockpiles performed by Roy F. Weston, Inc. in March of 1983 and March of 1984 yield results which, when compared to the original analytical results of the cleanup contractor, raise questions as to the level of contamination in the piles. The Weston results are generally lower than the contractor's. (See Appendix B for Weston's analytical results.) This could be due to volatilization/biodegradation of some contaminants. Also, it could be the result of non-representative sampling of the piles. In any event, re-verification of the degree of contamination in the soil must be done prior to final disposition.

Contamination at the site is limited to the confines of the two stockpiles. Ground water and surface water samples taken each month at the site continue to indicate no measurable impact from the site on the surrounding environment.

A silty clay layer from 5 to 25 feet in thickness, which underlies the site, generally restricts movement of the surface water and shallow ground water into the deep water-bearing zone. As a result, most precipitation infiltrating the ground at the site drains to adjacent surface streams via discharge of the shallow (perched) water-bearing zone rather than moving downward into the deep water-bearing zone. However, the potential exists for contamination from the stockpiled soil to leach into the deep water aquifer, and for volatile compounds to find their way into the various surface streams in the area.

ENFORCEMENT

EPA has sent the City a letter stating that the agency does not plan to initiate any court actions concerning Enterprise Avenue so long as the City continues to pursue it's pending lawsuit against Enterprise Avenue generators, and returns half of the recovered monies to the Superfund until the Superfund expenses are fully repaid. EPA is not involved in any litigation or negotiations concerning generators or transporters linked to the Enterprise site. The City's Philadelphia v. Stepan case was filed against more than 80 generators in 1980. The City has also brought suit against transporters linked to the site.

ALTERNATIVES EVALUATION

The remaining cleanup action to be undertaken at the site will address the stockpiled soil. The objective of the cleanup is to provide adequate protection of public health, welfare, and the environment. The alternatives for cleanup action considered include:

- Soil Aeration
- Land Treatment
- Composting

- On-Site Encapsulation
- Off-Site Disposal
- No Action

Since the origins of the hazardous substances discovered at the site could not be determined conclusively, it was assumed that the stockpiled soil is regulated by RCRA for handling and disposal purposes. All alternatives evaluated (except No Action) were designed to comply with RCRA technical and administrative requirements.

The Remedial Action strategy may be an individual alternative, or a combination of the alternatives evaluated. Each of the alternatives has been evaluated with respect to: technical advantages, disadvantages, and limitations; cost; environmental factors; implementability; and institutional and regulatory considerations.

The on-site encapsulation, on-site treatment, and off-site disposal options were analyzed in detail. The No Action alternative was eliminated from evaluation during the screening process. This was due to the fact that the existing piles were a means of temporary storage, and they do not comply with technical requirements of RCRA (i.e., no synthetic liner, no leachate collection system). This is in addition to the potential contamination to ground and surface waters from the stockpiles.

The On-Site Encapsulation alternative involves the construction of a cell on-site for the permanent containment of the stockpiled soil materials. The design of such a system would comply with the technical requirements of RCRA, which in this case would include protection from a 100-year flood occurrance, placement of monitoring wells around the cell, and a proper liner and capping system. Several technical disadvantages of this alternative are:

1. Although construction of an on-site disposal facility would be in compliance with appropriate RCRA regulations, the high ground water table and subsurface soils are generally not suitable for construction of a land disposal facility.

   This also is consistant with Pennsylvania regulations, which require that a separation of at least four feet be maintained between the seasonal high elevation of the shallow (perched) water table and the base of the encapsulation cell.

2. The on-site material (incinerator residue) upon which the cell will be placed contains organic matter and is difficult to compact. The possibility exists for differencial settlement to occur which may adversely affect the integrity of the cell and allow for the release of the contained material.

3. The depth to ground water at the site has been measured to be as little as 2 - 5 feet below the surface. In the event of a release of contaminated material from the cell, migration of contaminants to the shallow ground water table could be expected.

Besides these factors, the Pennsylvania Department of Environmental Resources prohibits the placement of encapsulation cells within the 100-year flood plain, regardless of the flood protection provisions made.

The other alternatives evaluated all require verification sampling and analysis of the stockpiled soil to determine whether or not it presently exceeds the key indicator parameters established for this project. The most recent analytical results indicate that approximately 25% of the samples taken from the piles fail the KIA. However, the samples were drawn from the upper layers of the piles. Degree of contamination of the soil at greater depths is unknown. For the purposes of developing cost estimates for the alternatives which include off-site disposal of soil, it was assumed that 50% of the soil in the stockpiles is currently contaminated (i.e., will fail the KIA test). This percentage was derived using the latest analytical results, and includes a 25% contingency due to the uncertainty associated with the degree of contamination of the soil in the inner portions of the piles. The remaining 50% of the soil was assumed to be noncontaminated and suitable for use as backfill on-site.

The on-site treatment alternatives (Land Treatment, Composting, and Soil Aeration) are all source control measures which call for treatment of the soil which exceeds the key indicator limits with the goal of reducing the degree of contamination through aeration and biodegradation. After a batch of soil receives treatment, it would be tested and, if it still exceeds the parameters, it would be taken off-site for disposal at an approved landfill.

In the Soil Aeration alternative, treatment of the soils would be accomplished by using mechanical equipment to agitate, mix, and aerate the soils. Some technical uncertainties are associated with this operation since mechanical aeration of soils has not been extensively used in the past. The moisture content and consistency of the soils would need to be controlled to insure that the soils can be physically mixed and will not jam or plug the equipment. In addition, the residence time and agitation required to achieve an acceptable level of devolatilization is not known.

In the Composting alternative, biological treatment of the soil would be employed to achieve contamination reduction. Even though composting has proved successful for municipal sewage sludge, its application to contaminated soils has not been proved. There are also technical uncertainties regarding the microorganisms and nutrient seed material to be used, and the degree of success which can be expected from the process.

The Land Treatment alternative involves spreading and cultivating of the contaminated soils. Cultivation would be performed using agricultural equipment such as disc harrows, rakes, or plows. Contamination reduction could be achieved by volatilization and biodegradation. Although land treatment has been used successfully for many years in the petroleum refining industry, the rate or levels of treatment that can be achieved for the waste contained in the stockpiled soil is unknown. As stated

earlier, the ground water level at this site has been measured to be as little as 2 - 5 feet below the surface. If the land treatment technique were implemented and reduction of the hazardous waste were not achieved, the migration of the contaminants to the shallow ground water table could result.

The Off-Site Disposal alternative would require that any soil which failed the KIA test be taken to an approved, permitted facility for ultimate disposal of the contaminated soil. The soils would be excavated from the stockpiles in lots of 100 cubic yards. The sampling protocol will provide for a variable sampling frequency per soil lot to ensure a high degree of sampling sensitivity. Any soil lots that do not exceed the key indicator limits will be backfilled on-site in area's having no planning future development. The site will be covered with an impermeable clay cap to prevent potential leaching of any residual contamination into the ground water. The material taken off-site for disposal would be manifested in accordance with RCRA. There are no technical uncertainties associated with this alternative. Standard construction, excavation, and earth moving equipment and techniques will be employed. Existing permitted hazardous waste facilities will be allowed to accept the waste from this site. In fact, this was the alternative implemented for the previous cleanup effort at this site. The environmental concerns associated with this alternative are minimal. This alternative provides the additional benefit of preserving the planned use of this site for a waste treatment facility.

The cost of the various alternatives range from $3.0M to $5.3M, excluding the No Action alternative. The following is a tabulation of the cost estimates for the alternatives.

Cost Summary for Remedial Actions

	Alternative	Estimated Capital Construction Cost	Estimated Post Closure Cost*
1.	Soil Aeration	$4,595,000	$ 66,000
2.	Land Treatment	4,238,000	66,000
3.	Composting	5,297,000	66,000
4.	On-Site Encapsulation	3,006,000	154,000
5.	No Action	- 0 -	154,000
6.	Off-Site Disposal	4,324,000	49,000

*Present worth computed over 30 years at a 7 3/8% discount rate.

COMMUNITY RELATIONS

The Draft Feasibility study was made available for public comment. Copies of the document were placed in repositories in the vicinity of the site. A notice was placed in the local newspaper regarding the availability of the Feasibility Study for public review, and to announce that a public meeting was scheduled for February 23, 1984. The meeting was held at the City of Philadelphia's Southwest Water Pollution Control Plant, and was attended by representatives of EPA, the Pennsylvania Department of Environmental Resources, the City of Philadelphia Water Department, and several citizen/ environmental action groups.

Basically, the comments received from the public expressed their displeasure with the lack of detailed information in the Feasibility Study, and indicated a strong preference for implementing the alternative requiring off-site disposal of all soil determined to be contaminated. They were adamantly opposed to implementation of any of the alternatives calling for on-site containment or treatment of contaminated soil. The public comment period closed three weeks after the study was made public.

In response to the public comments received, extensive revisions were made to the Feasibility Study, greatly increasing the degree of detail and supporting documentation for the alternatives considered for cleanup.

CONSISTENCY WITH OTHER ENVIRONMENTAL LAWS

All of the alternatives evaluated (except No Action) were formulated to be in compliance with RCRA land treatment, storage, and disposal technical and administrative requirements whenever possible. Included were the physical controls necessary (i.e., monitoring wells, leachate collection systems, liners, etc.) to implement the on-site treatment and disposal alternatives. The cost estimates developed for the alternatives took into account the RCRA technical and administrative requirements which apply to the individual remedial actions. The recommended alternate of off site disposal provides a beneficial effect on the 100 year flood plain.

RECOMMENDED ALTERNATIVE

Section 300.68 (j) of the National Contingency Plan (NCP) [47 FR 31180, July 16, 1982] states that the appropriate extent of remedy shall be determined by the lead agency's selection of the remedial alternative which the agency determines is cost-effective (i.e., the lowest cost alternative that is technologically feasible and reliable) and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, and the environment. Based on our evaluation of the cost-effectiveness of each of the proposed alternatives, the comments received from the public, informations from the Feasibility Study, and information from the City of Philadelphia, we recommend that the Off-Site Disposal alternative be implemented. This alternative includes: Resampling and analysis of the stockpiled soils in 100-cubic-yard lots for the key indicator parameters; on-site containment of soils which do not exceed established parameter limits; off-site disposal at RCRA approved facility of soils which exceed established parameter limits; grading, completion of clay cap and cover, and vegetating of the site.

The recommended alternative is the least cost alternative that is technically feasible and reliable, and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, and the environment. It also complies with RCRA by calling for off-site disposal of contaminated soil at a RCRA approved facility, and the level of cleanup was determined in a manner consistent with the RCRA methodology. In comparison, the alternatives evaluated calling for on-site treatment of contaminated soil by composting and aeration are more costly, and the reliability of the processes associated with treatment of the waste present in the soil on-site is uncertain; the Land Treatment alternative, although less costly than off-site disposal, has technical uncertainties associated with it, and failure to achieve the desired contaminant reductions could result in migration of hazardous substances to the shallow ground water table; the On-Site Encapsulation alternative is less capital cost intense, however, it will require a longer term O & M period at a much higher cost than the recommended alternative, is not as technically reliable as the Off-Site Disposal alternative, and the high ground water table and fill material at the Enterprise Avenue site are generally not suitable for construction of an on-site disposal facility so long as there is another viable cost-effective alternative for disposal. Although the on-site cell would be designed to guard against releases, the hydrogeologic conditions at the site (i.e., high ground water table, located within the 100-year flood plain) would multiply the adverse effects of any failure of the cell which may occur.

The capital cost for the recommended alternative is estimated to be $4,324,000. The monitoring and maintenance costs are estimated to be $49,000 (present worth value) for a period of thirty years. A breakdown of the capital costs appear in Appendix C.

OPERATION AND MAINTENANCE (O & M)

The O & M activities associated with the recommended alternative are inspection of the site (1 crew-day/year) and maintenance of the vegetated cover (5 crew-days/year) at an annual cost of approximately $4,200. The City of Philadelphia will assume full responsibility for O & M since it is a city-owned property.

PROPOSED ACTION

We request your approval of the removal of all soil from the Enterprise Avenue site which fails the established Key Indicator Parameter test. This action will complete the cleanup of this hazardous waste disposal site. The estimated total cost for this state-lead project is $4.82M, which includes the cost for construction management. We also request an allocation of $2.41M from the Superfund to fund this cleanup at the 50% level since it is a municipally owned site.

PROJECT SCHEDULE

- Approve Record of Decision	May 1984
- Award Cooperative Agreement for Construction	May 1984
- Start Construction	July 1984
- Complete Construction	November 1984

APPENDIX A

Summary of Analytical Results of Soil in the TOX Stockpile

Sample No.	Results	Sample No.	Results
S-0059	51	S-0243	82
S-0167	110	S-0246	150
S-0169	330	S-0247	259
S-0170	61	S-0248	5,350
S-0192	51	S-0250	148
S-0201	39	S-0284	135
S-0207	49	S-0295	39
S-0208	83	S-0296	65
S-0209	59	S-0300	29
S-0227	59	S-0302	1,921
S-0228	100	S-0303	213
S-0236	98	S-0304	78
S-0239	51	S-0306	29
S-0241	38		
S-0242	42		

Note

All results measured in parts per million.

Summary of Analytical Results of Soil in the Volatile Organic Stockpile

Sample No.	Benzene	Ethylbenzene	Toluene
S-0179		27	364
S-0180			24
S-0181		90	157
S-0183	28		22
S-0184			27
S-0188	17	24	35
S-0189			27
S-0193	19		
S-0217		93	30
S-0218		158	53
S-0219		41	
S-0249	86	47	330
S-0283			1,000
S-0287			25
S-0288		36	
S-0297		22	
S-0298		18	283
S-0305	18	49	36
S-0307	18	427	438
S-0309	43	33	54
S-0312	42		22
S-0313		42	
S-0315			19

Note

All results measured in parts per million.

APPENDIX B

Analytical Information on TOX Pile - March 1983

Quadrant	TOX ppm	Toluene ppm	Benzene ppm	Ethylbenzene ppm
A	0.52	0.58	0.25	0.13
B	0.17	1.10	0.26	0.24
C	0.56	1.10	0.63	0.42
D	0.42	7.80	2.00	1.30

	EP Toxicity - Metals (ppm)							
Quadrant	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
A	NF	0.32	NF	NF	NF	<0.001	NF	NF
B	NF	0.16	NF	NF	NF	<0.001	NF	NF
C	NF	0.20	NF	NF	NF	<0.001	0.012	NF
D	NF	0.09	NF	NF	NF	<0.001	0.011	NF

Composite of Quadrants (ppm unless noted otherwise)

Fl	- 6.7	CN (T)	- 1.11	Cu (T)	-	462
NH_3-N	- 4.9	Ag (T)	- NF	Fe (T)	-	45,600
NO_3-N	- 13.7	Zn (T)	- 1054	Pb (T)	-	960
pH	- 7.8 pH units	As (T)	- 35	Hg (T)	-	0.
VOC	- <3	Ba (T)	- 208	Se (T)	-	2.
SPCD	- 1300 mmho	Cd (T)	- 12	Ti (T)	-	21
TOC	- 83	Cr^{+3} (T)	- 5.01	Cr^{+6} (T)	-	<4.

NF = Not Found
T = Total Metals

Analytical Information on Volatile Organic Pile - March 1983

Quadrant	Tox ppm	Toluene ppm	Benzene ppm	Ethylbenzene ppm
A	0.24	0.50	1.20	0.53
B	0.26	1.60	4.00	0.69
C	0.08	1.00	0.17	0.20
D	0.47	1.40	0.84	0.50

	EP Toxicity - Metals (ppm)							
Quadrant	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
A	NF	0.30	NF	NF	NF	<0.001	0.012	NF
B	0.01	0.13	NF	NF	NF	<0.001	0.013	NF
C	NF	0.14	NF	NF	NF	<0.001	0.013	NF
D	NF	0.10	NF	NF	NF	<0.001	0.012	NF

Composite of Quadrants (ppm unless noted otherwise)

Fl	- 9.1	CN (T)	- 1.55	Cu (T)	- 344
NH_3-N	- 3.9	Ag (T)	- NF	Fe (T)	- 42,405
NO_3-N	- 259	Zn (T)	- 1166	Pb (T)	- 954
pH	- 7.9 pH units	As (T)	- 8	Hg (T)	- 0.85
VOC	- <3	Ba (T)	- 226	Se (T)	- 2.0
SPCD	- 820 mmho	Cd (T)	- 11	Ti (T)	- 39
TOC	- 122	Cr^{+3} (T)	- 69	CR^{+6} (T)	- <4.0

NF = Not Found
T = Total Metals

ANALYTICAL INFORMATION ON TOX PILE - MARCH 1984

Sample No.	Quadrant	TOX ppm	Toluene ppm	Benzene ppm	Ethylbenzene ppm
A-1	A	570	<5.0	<5.0	<5.0
A-1 (duplicate)	A				
A-2	C	1,150	<5.0	<5.0	<5.0
A-3	C				
A-4	D				
A-4 (duplicate)	D				
A-5	D	2,860	<5.0	<5.0	<5.0
A-5 (duplicate)	D				
A-6	B	1,660	<5.0	<5.0	<5.0
A-6 (duplicate)	B				
A-7	B				
A-8	A	47	<0.001	0.0059	<0.001
Field blank (distilled water)	-				

ANALYTICAL INFORMATION ON VOLATILE ORGANIC PILE - MARCH 1984

Sample No.	Quadrant	TOX ppm	Toluene ppm	Benzene ppm	Ethylbenzene ppm
B-1	A				
B-2	C	530	<5.0	<5.0	<5.0
B-2 (duplicate)	C	490	39	52	<5.0
B-3	C				
B-4	D				
B-4 (duplicate)	D	460	7.9	<5.0	<5.0
B-5	D				
B-5 (duplicate)	D				
B-6	B				
B-7	B				
B-8	A				
B-8 (duplicate)	A	2,320	54	9.8	59
Field Blank (soil)	-				

ADDITIONAL ANALYTICAL INFORMATION ON TOX AND VOLATILE ORGANIC PILES - MARCH 1984

Sample No.	Pile	Quadrant	TOX ppm	Toluene ppm	Benzene ppm	Ethylbenzene ppm
A-1	TOX	A		<1.0	<1.0	<1.0
A-2	TOX	C		14	2.2	3.4
A-4	TOX	D		10	12	23
A-4 (duplicate)	TOX	D		23	7.6	59
A-5	TOX	D		3.0	1.5	5.9
A-6	TOX	B		53	1.1	2.3
A-6 (duplicate)	TOX	B		34	<1.0	<1.0
A-8	TOX	A		1.2	<1.0	<1.0
B-1	Vol	A		1.5	5.8	1.1
B-3	Vol	C		<1.0	<1.0	<1.0
B-4	Vol	D		1.2	1.4	<1.0
B-5	Vol	D		5.0	14	7.6
B-5 (duplicate)	Vol	D		7.7	25	6.0
B-6	Vol	B		9.0	28	1.3
B-7	Vol	B		2.4	2.9	4.9
B-8	Vol	A		1.4	<1.0	6.2
Field Blank (soil)	-	-		<1.0	<1.0	<1.0

ANALYTICAL INFORMATION ON VOLATILE ORGANIC PILE - MARCH 1984

Sample No.	Quadrant	TOX ppm	Toluene ppm	Benzene ppm	Ethylbenzene ppm
B-1	A				
B-2	C	530	<5.0	<5.0	<5.0
B-2 (duplicate)	C	490	39	52	<5.0
B-3	C				
B-4	D				
B-4 (duplicate)	D	460	7.9	<5.0	<5.0
B-5	D				
B-5 (duplicate)	D				
B-6	B				
B-7	B				
B-8	A				
B-8 (duplicate)	A	2,320	54	5.8	59
Field Blank (soil)	-				

APPENDIX C

Construction Cost Estimate
Off-Site Disposal
(Alternative 6)

	Description	Quantity	Unit Cost	Total Cost
1.	Flood controls	1800 cu.yd.	$10/cu.yd	$ 18,000
2.	Excavate material from stockpiles and transfer on-site	18,000 tons	$4/ton	$ 72,000
3.	Segregate construction rubble	15 crew days	$1,000/ crew day	$ 15,000
4.	Analyze samples for key indicators	200 samples	$200 ea.	$ 40,000
5.	Backfill acceptable material and rough grade	9,000 tons	$2/ton	$ 18,000
6.	Dispose of contaminated material at an approved off-site facility	9,000 tons	$150/ton	$1,350,000
7.	Bury debris/rubble on-site	500 cy	$2/cy	$ 1,000
	Complete site final cover	25 ac	$58,000/ac	$1,450,000
		Subtotal (rounded)		$2,946,000
		Mobilization, demobilization and site services (10%)		$ 295,000
		Subtotal		$3,241,000
		Contractor's Fee (16%)		$ 519,000
		Subtotal		$3,760,000
		Contingency (15%)		$ 564,000
		TOTAL		$4,324,000

Post Closure Cost Estimate - Alt 6 (Off-Site Disposal)

	Description	Annual Quantity	Unit Cost ($)	Annual Cost ($)
1.	Inspect the site	1 crew day	$500/crew day	$ 500
2.	Maintain the vegetated cover	5 crew day	$600/crew day	$ 3,000
		Subtotal		$ 3,500
		Contingency (20%)		$ 700
		TOTAL Annual Cost		$ 4,200
		TOTAL Present-Worth Cost*		$49,000

* Present-worth cost is computed over 30 years @ 7 3/8% discount rate; present-worth factor = 11.7

ATTACHMENTS

DRAFT

CITY OF PHILADELPHIA
ENTERPRISE AVENUE SITE
REMEDIAL ACTION PROGRAM

HOT SPOT SOIL HANDLING PROTOCOL

September, 1981

W.O. 1290-06-01

Technical Report #5

ORIGINAL
(Red)

ROY F. WESTON, INC.
Weston Way
West Chester, PA 19380

HOT SPOT SOIL HANDLING PROTOCOL
ENTERPRISE AVENUE SITE

1.0 INTRODUCTION

The closure activities at the Enterprise Avenue Site will involve the excavation, handling and off-site disposal of drummed waste previously disposed of on-site. A ground penetrating radar (GPR) survey of the site is being performed to locate and map suspected pockets (groups of buried drums. Specifications are being prepared for incorporation into a bid document which will form the basis for inviting bids for removal of the drummed waste and hot spots followed by site closure by a contractor.

Records indicate that the burial of drums occurred during the period of 1971 through mid 1976. From the time the drums were buried on site it is possible that contents from the drums have leaked and contaminated soils surrounding the drum pocket. The term "hot spot" refers to any soils in or around a drum pocket that are highly contaminated and saturated by waste materials that have leaked from the drums. Leakage from the drums may have occurred due to

- damage to the drums during handling and burial
- failure of the drums due to chemical activity and rusting in the landfill environment.

2.0 PURPOSE AND OBJECTIVES

The protocol for removal of hot spots must meet the following objectives.

- the handling of hot spots must be accomplished under field conditions so that excavation and earth moving activities can proceed on an expeditious basis
- the protocol must be applicable to only those soils where hot spots are most likely to occur
- the protocol must differentiate between the normal background landfill conditions and those conditions that represent highly contaminated soils due to waste material leakage from drummed waste
- the protocol must be consistent with the overall objective for site closure and removal of drummed waste

- the ultimate handling and disposition of hot spot soil material must be in a manner such that further leaching and migration of contaminants from these soils will be minimized

- the protocol should not involve any damage or disruption to the clay layer which underlies the site and serves to protect the lower water bearing zone from contamination impacts.

3.0 DEVELOPMENT OF PROTOCOL

3.1 Model of Drum Pocket

Information indicates that drums were delivered in truckload quantities and dumped into the landfill. After the drums were deposited, they were covered with incinerator residue and buried. As a result buried drums will be found in groups or pockets of many drums. Based on this scenario for drum burial Figure 1 depicts a typical cross-section through the landfill site and a drum pocket.

The ground penetrating radar (GPR) survey work being conducted at the EAS site is being used to plot the location of "buried targets." These targets relate to the probable location of a pocket or group of buried drums. Each pocket of drums in turn corresponds to a truckload of drums that was delivered to the site and buried.

From Figure 1 it can be seen that any leakage of contents from the drums located in the unsaturated zone will be expected to migrate in a generally vertical direction under the influence of gravity. Lateral migration due to chemical diffusion is minimal and can be assumed to be restricted to a few inches of soil around the drum pocket. During excavation of the drums these soils along the sides of the pocket will be removed as the drums are located and dug out. With the primary migration pathway being in a vertical direction leakage could contaminate soils within the pocket of drums and below the drum pocket and thereby create hot spots in these soil locations.

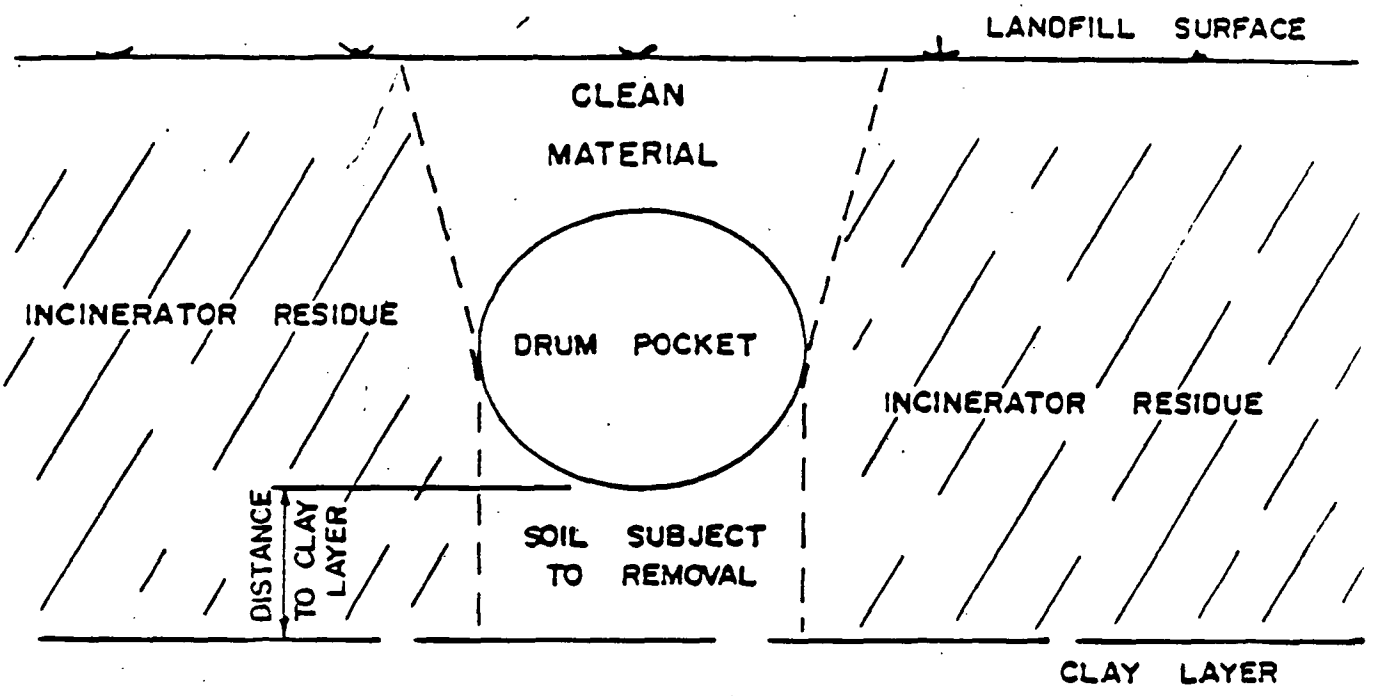
Based on this analysis of the drum pocket, surrounding the soils, and potential hot spot material, a soil handling protocol has been developed that addresses the identification of potential hot spots according to

- physical condition of the drums

- location of the soils with respect to the drum pocket

- analytical testing of soils for key indicator parameters.

Two approaches will be employed for handling the soils that may have been contaminated from the contents of the drums. In those cases when the soils have been highly contaminated by the drum contents and are classified as hot spots they will require off site disposal. For those soils that are located in close proximity to the drums and for which there is no evidence



TYPICAL CROSS-SECTIONAL VIEW OF DRUM POCKET

ORIG. (Red)

FIGURE 1

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS & DESIGNERS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.

of high levels of contamination reburial on-site will be employed. On-site areas designated for receiving the soils must be located at least 3 feet above the first water bearing zone so that the soils are not placed in areas that are subject to continued leaching by groundwater.

3.2 Temporary Storage/Staging Areas

Temporary on-site storage will be required for handling materials excavated from the drum pocket as follows:

Storage Area	Function
1. Drum Staging Area	- Temporary drum storage for analysis and identification, staging, materials bulking, repackaging and transfer for off-site disposal.
2. Clean Soil Staging Area	- Temporary storage of clean soils for use as backfill as drum pocket excavation and materials removal is completed.
3. Soil Holding Area	- Temporary storage of soils for analytical testing followed by use as select fill on-site or transfer for off-site disposal.

Table 1 summarizes the soil handling protocol to be used during the drum excavation activities. The soil categories identified in this table relate to the drum pocket concept as shown in Figure 1. In this table eight soil categories are identified along with the handling procedures, analytical testing requirements and final disposition for that soil category.

3.3 Soil Categories and Handling

3.3.1 Soil Cover over Drum Pocket

Soil Category 1 relates to that soil found above the drum pocket. This soil has not been contaminated due to the leakage of drum contents and therefore is not subject to classification as a hot spot. The procedure will be for removing this soil material to a clean soil staging area where it can be temporarily stored. After the drum pocket has been excavated and drums removed according to this protocol soil from the clean soil staging area can be used for backfilling of the excavation.

3.3.2 Soil Mixed with Drums

The soil which is mixed with the drums in the drum pocket will be handled using several procedures. If the drums are found to be intact with no signs of leakage or spillage the soil mixed with the drums (shown as Soil Category 2) can be removed to the clean soil staging area. This protocol requires that the clean soil be successfully separated from the buried drums during excavatior

SOIL HANDLING PROTOCOL

FOOTNOTES

(1) Select Backfill:	To be used as backfill on-site in areas that are at least 3 feet above the high elevation of upper water bearing zone.
(2) Minor Spillage (Solid):	Spillage being in non-liquid (not freely flowing) form; and spillage residue located within 1 foot of the drum; and no more than 5 drums in each pocket showing signs of minor spillage.
(3) Drums in Good Condition:	Drums capable of being handled without additional leakage/spillage of contents.
(4) Spot Check	Based on field conditions and inspections, composite samples will be collected for verification purposes, using the key indicator parameters.

TABLE 1
SOIL HANDLING PROTOCOL

Soil Category	Handling Procedure	Analytical Testing of Soils	Disposition of Soil
Soil above drum pocket.	1. a. Remove soil to clean soil staging area	1. a. Spot check[4]	1. a. Redeposit clean soil in excavation after drums have been removed.
Soil mixed with drums - drums are intact or contain solids that have not leaked or spilled.	2. a. Separate drums from soil and remove. 2. b. Remove soil to clean soil staging area.	2. a. Spot Check	2. a. Redeposit clean soil in excavation after drums have been removed.
Soil mixed with drums - drums are in good condition[3] and contain solids with only minor spillage [2] of solids around the drums.	3. a. Separate drums from soil & remove drums to drum staging area. 3. b. Collect solid spillage residues; containerized & remove to drum staging area. 3. c. Remove soil to clean soil staging area.	3. a. Spot Check	3. a. Redeposit clean soil in excavation after drums have been removed.
Soil mixed with drums - drums are in poor condition and visual evidence indicates that drums have leaked contents.	4. a. Separate drums from soil and remove drums to drum staging area. 4. b. Collect solid spillage residues; containerize & remove to drum staging area. 4. c. Remove soil to soil holding area for testing.	4. a. Test one composite. 4. b. If off-site disposal required, test as per requirements of disposal facility.	4. a. Off-site disposal if key indicator limits are exceeded. 4. b. Use as select fill[1] on-site if key indicator limits are not exceeded.

Soil Category	Handling Procedure	Analytical Testing of Soils	Disposition of Soil
Soil below drums - drums are intact or contain solids that have not leaked or spilled.	5. a. No excavation.	5. a. Spot Check	5. a. Remain in-situ.
Soil below drums - drums are in good condition and contain solids with only minor spillage of solids around the drums.	6. a. No excavation.	6. a. Spot Check	6. a. Remain in-situ.
Soil below drum that have leaked - depth to clay layer being 2 feet or less.	7. a. Excavate soil to top of clay layer; do not excavate into clay layer. 7. b. Remove soil to soil holding area for testing.	7. a. Test one composite soil sample for key indicators. 7. b. If off-site disposal is required, test as per requirements of disposal facility.	7. a. Off-site disposal if key indicator limits are exceeded. 7. b. Use as select fill on-site if key indicator limits are not exceeded.
Soil below drums that have leaked-depth to clay being greater than 2 feet.	8. a. Remove 2 feet of soil to the soil holding area for testing. 8. b. Excavate and removal additional soil layer if composite sample of in-situ	8. a. Test one composite sample of soil in the excavation for key indicators. 8. b. Test one composite soil sample from holding area for key indicators that will determine disposition.	8. a. Off-site disposal if key indicator limits are exceeded. 8. b. Use as select fill on-site if key indicator limits are not exceeded

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(Red)

Soil Category 3 involves soil mixed with drums in the drum pocket with drums containing solid waste material and being in good condition. Visual inspection of the drum pocket should indicate that only minor spillage of solid material may have occurred and is limited to the soils immediately adjacent to the drums. The recommended procedure for this category of soils is to separate the drums from the soil and remove the drums to a drum staging area. Any solid spillage residues will be properly containerized and removed to the drum staging area. Soil will then be collected and removed to the clean soil staging area. Guidelines are provided in this protocol in the form of footnotes for determining when drums can be classified as being in "good condition" and spillage can be viewed as being "minor" in extent.

The Soil Category 4 addresses those soils mixed with drums in the drum pocket when the drums are in poor condition and visual evidence indicates that drum contents have leaked. In this situation the soils in the drum pocket have been exposed to the contents of the drums and therefore will require special handling so that they do not become a future source of contamination. In this case the soils may be classified as a hot spot depending upon the level and type of contamination.

The Category 4 soils will be separated from the drums and removed to a soil holding area for analytical testing. Two composite soil samples will be collected from these soils and one of the samples tested for the Key Indicator Parameters as shown in Table 2. Sample collection protocol is shown in Table 3.

3.3.3 Soil Below the Drum Pocket

The next category of soils, Category 5, involves those soils located below a drum pocket. This layer of soil is located between the bottom of the drum pocket and the top of the clay layer. Soil Category 5 addresses those soils below a drum pocket where the drums are shown to be intact or contain solids that have not leaked or spilled. This corresponds to the Soil Category 2 previously discussed. For the Category 5 soils no excavation, testing or removal is required.

The Category 6 soils encompass the soils located below the drum pocket where the drums are in good condition and contain only solid materials with evidence of only minor spillage around the drums. This correlates with the condition described for Soil Category 3 previously discussed. In this situation any sources of potential contamination will have been removed when the drums are excavated and when any spillage is collected from the soils in the drum pocket. For the Category 6 soils no excavation, testing or removal is required.

Category 7 soils are those soils located below a drum pocket where the drums have leaked and the distance between the bottom of the drum pocket and the clay layer is 2 feet or less. In this particular case the soils below the drum pocket may have received contamination due to leakage of contents from the drums. The protocol for this soil category calls for the excavation of the soils down to the top of the clay layer. Under no circumstances should

Table 2

Soil Analysis - Key Indicatos

Indicator	Limit	Analytical Protocol
1. TOX (Total Organic Halogen)	25 ppm	
2. Organic Scan (1)		
o Benzene	12 ppm (2)	
o Toluene	15 ppm (3)	
o Ethylbenzene	15 ppm (4)	
3. EP Toxicity (5)		40 CFR Part 261 Appendix II
o Arsenic	5 ppm	
o Barium	100 ppm	
o Cadmium	1 ppm	
o Chromium	5 ppm	
o Lead	5 ppm	
o Mercury	0.2 ppm	
o Selenium	1 ppm	
o Silver	5 ppm	
4. Other Tests		To be based on, field inspections and specific conditions of individual drum pocket.

Footnotes discussed in Appendix A.

Table 3

Soil Handling Analytical Protocol

1. Sampling of soils in soil holding area.

   a. Two composite samples will be obtained from each drum pocket soil category designated for testing.

   b. Each composite will consist of 4 surface grab samples; the grab samples for the conposite will be of roughly equal quantities.

   c. One grab sample should be collected from each of the quadrants of the soil pile.

   d. The surface grab samples will be collected as representative samples. The EPA 600/2-80-018 January 1980 document will be used as guidance for representative sampling techniques.

   e. One composite sample will be analyzed for key indicators and the second will be retained for retesting if necessary.

2. Sampling of Category 8 Soils in Excavation Below Drum Pocket.

   a. Two composite surface soil samples will be obtained from the excavation below the drum pocket as it relates to the Category 8 soil protocol.

3. Analytical Testing.

   a. Analytical testing will be performed in accordance with the protocol as shown in Table 3.

   b. If any one of the analytical testing limits are exceeded, the soil will be removed for off-site disposal; additional testing may be required to meet the requirements of the disposal facility.

excavation continue into the clay layer or result in damage to the clay layer. These soils are to be removed to the soil holding area for testing. If the key indicator limits are not exceeded the soil can be used as select fill on site however if the limits are exceeded off site disposal is required.

The Soil Category 8 are similar to that described at Category 7 however the distance between the bottom of the drum pocket and the clay layer is greater than 2 feet. In this case contamination of the bottom soils may have occurred due to drum leakage however the depth to which this contamination may have migrated is not known. The first two feet of soil below the drum pocket is to be removed to the soil holding area for testing. After excavating this 2 foot layer of soil a composite sample collected from the bottom of the excavation should be tested for key indicator parameters to determine if additional excavation is required. The sample collection protocol is shown in Table 3. If the key indicator limits are exceeded an additional 2 foot soil layer should be excavated or to the top of the clay layer whichever comes first. If additional soil is excavated below the initial 2 foot layer the soil should be removed to the holding area for testing and ultimate disposition.

3.4 Key Indicator Analyses

A key indicator methodology will be used for the testing of soil samples. The key indicators which will be used have been selected from a review of the existing records pertaining to the type and quantity of waste materials buried in the landfill.

3.4.1 Organic Scan

In general the waste materials are organic in nature. The primary constituents of these organic waste materials include oil sludges, waste oils, toluene, xylene, and other generic descriptions such as waste acids, soaps, latex, and laboratory wastes. Many of these materials may not be hazardous by their chemical nature and, therefore, will not require secure off site disposal. The objective of the key indicator analysis is to identify those contaminants that are most likely to be found on-site and are of greatest concern with respect to potential environmental impacts.

The results of WESTON's August 1979 Phase I site investigation work basically confirmed these existing records. On site contamination of the upper water bearing zone was organic in nature with only isolated evidence of possible contamination from heavy metals. Records indicate that metallic bearing wastes were deposited on-site but Phase I did not indicate that heavy metals are a major potential contaminated problem. Organic contaminants that were identified included benzene, toluene, ethylbenzene, and xylenes. It should be noted that these contaminants are generally found in relatively low levels and were also detected in back groundwater samples. The highest level of benzene was found in a background monitoring well.

The key indicators selected for analysis are shown in Table 2 . With the exception of EP toxicity, analytical limits have not been established for characterizing these parameters as relating to hazardous or nonhazardous levels. To establish these types of limits several literature sources were used to provide guidance as follows:

- 1981 background levels in soils at the Enterprise Avenue site
- 1981 groundwater readings in the Enterprise Avenue site
- Fresh water criteria
- Salt water criteria
- Human health criteria
- Chemical characteristics including solubility and toxicity
- The levels of contaminants in groundwater as measured during the Weston's Phase I (August 1979) Site Investigation Report.

The objective in establishing limits for the key indicators is to provide guidance for identifying hot spots. Hot spots are those soils that have been highly contaminated due to the leakage of contents from the buried drums. The levels of contaminants in a hot spot should be many times greater than the concentration of these contaminants in background samples. The chemical levels in the hot spot soils should be similar to the original or chemical composition of the drum contents.

During WESTON's Phase I field investigation it was suspected that the PWD #1 monitoring well was placed in or through a pocket of buried drums. This evidence is based on the fact that this well reflected levels of contamination that were much greater than that observed in other wells and the fact that this well continued to foam for many months after it was developed. The TOC readings in this particular well were 100 times (2 orders of magnitude) greater than TOC levels recorded in other wells located within the site perimeter as measured in 1979. This well was resampled and retested in 1981 and the findings indicated that TOC readings in PWD #1 are generally 20 to 50 times greater than TOC readings in other wells within the site. The analytical readings for thse wells are presented in tabular form in Appendix B. These readings provide a yardstick with respect to assessing the relative levels of contamination that may be found in a hot spot as compared to other soils at the site.

In developing the limits for the key indicators the present maximum background levels for the various parameters were identified. The upper limit for the key indicator was computed at 75 times the maximum background level. The multiplier of 75 was selected based on the relative readings measured in the PWD #1 monitoring well for TOC. As the limits were set they were compared to the maximum freshwater criteria for reasonableness and found to be comparable.

This approach is consistent with EPA's methodology which uses 100 times drinking water standards for establishing the limits for EP toxicity under RCRA. The human health factors under the water quality criteria also utilizes a two order of magnitude (100 x) methodology for assessing an incremental increase of cancer risk over a lifetime.

3.4.2 EP Toxicity

The EP toxicity test will be applied for analysis of EP metals only. The EP limits as published in the RCRA part 261 criteria will be used as limits. Only the EP toxicity for metals will be applied due to the fact that the TOX indicator will detect the presence of pesticides/herbicides.

3.4.3 TOX

TOX levels in background surface soils on the landfill area ranged from 0.27 - 0.33 ppm. These levels are generally higher than the concentrations of pesticides and chlorinated organic volatiles as measured in groundwater monitoring wells during the 1979 Phase I study. The highest concentration recorded in the Phase I study was 134 ppb measured in a deep well outside the landfill perimeter.

The hot spot limitation for TOX utilizes the same 75 x methodology discussed for the other organic key indicators. Using the highest recorded TOX in background the computed limit is 25 ppm.

As a reasonableness comparison for this limit the RCRA EP toxicity limits for pesticides were reviewed. The EP limits for 2.40 and methoxychlor are 10 ppm. The TOX limit of 25 ppm is reasonable considering that chlorinated pesticide compounds may be found in the presence with other chlorinated organics.

3.4.4 Other Tests

Depending upon specific conditions observed in individual drum pockets other analytical tests may be needed for identifying hot spots. These tests, if needed, would be initiated based on field observations during excavation. Tests which may be conducted include:

- pH of the soil
- PCB of oils
- Cyanide
- Specific conductivity
- Ignitability
- TOC

APPENDIX A

Analysis of Key Indicator Limits

APPENDIX A

KEY INDICATOR FOOTNOTES

(1) Organic Scan: Compounds were selected based on types of compounds dumped at the site as determined by existing records.

(2) Benzene:

- o 1981 background levels in soils - <10 - 168 ppb
- o 1981 groundwater in landfill area - <10 - 102 ppb
- o Fresh water criteria - 5,300 ppb
- o Salt water criteria - 5,100 ppb
- o Human health - 0.066 - 6.6 ppb
- o Characteristics of benzene
  - "slightly soluble" in H_2O 1:1450 parts H_2O ~ 690 ppm
  - Oral-human LDL_o: 50 mg/kg*
- o In August 1979 background ranged to 500+ ppb in a groundwater sample outside of landfill parimeter.

Analysis

(1) Benzene levels in background soils correlates with that in landfill groundwater ~ 1:1 (both 10-100+ ppb range)

(2) Benzene is only "slightly soluble" in water

(3) Fresh water criteria maximum range 3-7 ppm

(4) Assume that "1.5-2 (50-100) order of magnitude"++ greater than maximum 1981 background levels in soil and groundwater = identifies a hot spot (e.g. 75 x 168 µg/l = 12,600 ppb): 12 ppm - this is basically consistent with fresh water criteria (5.1 ppm).

++ Consistent with TOC reading @ PWD #1 which is a "hot spot" which is 20-50 x TOC in other wells per 1981 measurements and 100 x TOC per 1979 measurements.

(3) Toluene:

- o 1981 background in soils - <10-50.1 ppb
- o 1981 groundwater in landfill area - <10-200 ppb (generally in range of 75 ppb)
- o Fresh water criteria - 17,500 ppb
- o Salt water criteria - 5000-6300 ppb
- o Human health - 14.3 ppm
- o Characteristics of Toluene
  - "Very slightly soluble" in water (less soluble than benzene)

- In August 1979, Toluene ranged to 1240 ppb inside landfill perimeter in groundwater and 300+ ppb outside landfill perimeter.

Analysis

(1) Toluene levels in background soils correlates with that in landfill groundwater ≈ 1:1

(2) Toluene is "practically insoluble" in water

(3) Fresh water criteria range 2.3-5.2 ppm

(4) Assume that "1.5-2 50-100) order of magnitude" greater than maximum 1981 background levels in groundwater or soil ≈ identifies a hot spot (e.g. 75 x 200μg/1 = 15,000 ppb)...
15 ppm is generally consistent with fresh water maximum criteria of 17.5 ppm and benzene limit of 12 ppm

(5) Toxicity levels for Touene and benzene are comparable

(4) Ethylbenzene:

- 1981 background in soils - <10 ppb
- 1981 groundwater in landfill area - <10-199 ppb
- Fresh water criteria - 32,000 ppb
- Salt water criteria - 43 ppb
- Human health - 1.4 ppm
- Characteristics of ethylbenzene
  - "insoluble to practically insolubel" in water
  - Oral-rat LD_{50}: 3,500 mg/kg
- In August 1979 background ranged to 486 ppb in landfill groundwater to 50 ppb outside landfill perimeter

Analysis

(1) Ethylbenzene was not found in 3 soil samples
(2) Ethylbenzene is "practically insolube" in water
(3) Human health criteria is 1.1 ppm
(4) Assume that ≈ 1.5-2 (50-100) order of magnitude greater than the maximum 1981 background levels in soil and groundwater ≈ identifies a hot spot (e.g. 75 x 199 μg/1 - 15,000 ppb)...
15 ppm which is basically consistent with that for benzene and Toluene and the fresh water criteria of 32 ppm.

(5) EP Toxicity:

EP Toxicity analysis will be performed only for EP metals. The presence of pesticides will be gauged from the results of the TOX Analysis.

REFERENCES

1. "Study of Enterprise Avenue Landfill", City of Philadelphia, Philadelphia, Pennsylvania, VOl. 1 Investigations Report, Roy F. Weston, August 1979.

2. "NIOSH Registry of Toxic Effects of Chemical, Substances", U.S. Department of Health Education & Welfare, January 1979.

3. Federal Register, Environmental Protection Agency, Vol. 45, No. 168, 40 CFR Part 141, Interim Primary Drinking Water Regulations, August 27, 1980.

4. Federal Register, Environmental Protection Agency, Vol. 45 No. 231 Water Quality Criteria Documents, November 28, 1980.

APPENDIX B

Analytical Data

Hot Spot Determination

City of Philadelphia Water Department
Enterprise Avenue Site

Background Analysis for Classifying Drums and Associated Soil

ation	Specific Conductance[1]	pH	TOC[1]	As[1]	Cr[1]	Pb[1]	Benzene[2]	Toluene[2]	Ethyl Benzene[2]	TOX[1]
-1S	5,000	6.9	(3)	0.145	<	24.0	(3)	(3)	(3)	(3)
-4S	1,700	7.5	145	0.011	<	1.04	NA	NA	NA	NA
-6S	2,600	7.0	75	0.030	0.09	0.71	84.6	191.0	51.4	NA
-18S	2,400	6.5	240	0.367	<	0.79	102.0	<	<	NA
-19S	2,500	6.8	100	<	0.14	0.68	41.3	<	35.3	NA
-22S	3,100	6.6	257	0.105	<	0.44	79.7	<	63.5	NA
-29S	1,700	6.7	50	0.068	0.06	1.17	35.1	<	67.1	NA
-30S	2,800	6.7	238	0.015	0.09	1.20	<	76.3	199.0	NA
-32S	3,200	7.0	255	0.185	0.12	0.59	96.3	<	<	NA
-33S	2,000	6.9	200	<	<	0.44	69.8	70.2	22.3	NA
-36S	3,000	7.5	55	<	<	0.43	65.4	<	<	NA
-37S	3,400	7.1	210	0.034	0.05	0.76	<	77.5	41.3	NA
-58S	1,900	7.6	29	<	<	0.20	NA	NA	NA	NA
L (RFW #7058)	NA	8.2	119	NA	50.0	1,175	135.0	12.3	<	0.31
L (RFW #7059)	NA	8.4	120	NA	67.5	1,400	168.0	50.1	<	0.27
L (RFW #7353)	NA	7.0	121	NA	50.0	300	<	<	<	0.33

Toxicity - Composite of soils /-> Results attached

ppm

ppb

< = less than detectable

analysis pending, available October 2, 1981

DATA SUMMARY SHEET FOR Sep 4,1981: CLIENT- 1290060100 ENTERPRISE LANDFIL

KFWSN: 10113 DATE RECEIVED: 9/ 4/81 SAMPLE DESCRIPTION: COMP OF 7058,59,7353

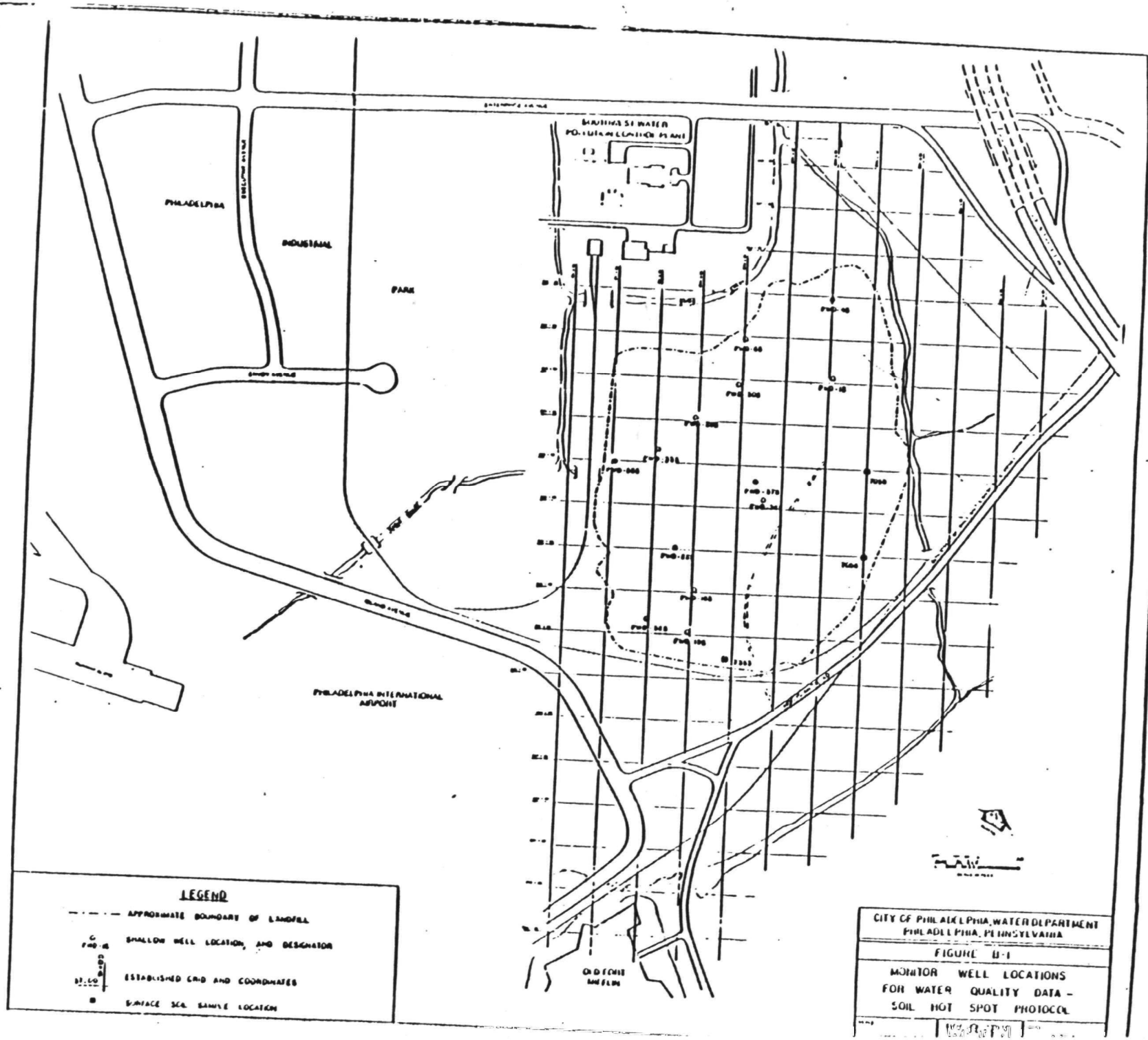
PCOD EPEX

UNITS MG/L
RESULTS (.....)

KFWSN: 10114 DATE RECEIVED: 9/ 4/81 SAMPLE DESCRIPTION: LEACHATE OF 10113

PCOD EPMS

	Ag	Ba	cd	cr	Pb	Hg	Se	As
UNITS	MG/L							
RESULTS (.....)	<.5	0.26	<.05	<.05	<.05	<.001	<.001	<.010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OLD FORT MIFFLIN
LEGEND
APPROXIMATE BOUNDARY OF LANDFILL
SHALLOW WELL LOCATION, AND DESIGNATOR
ESTABLISHED GRID AND COORDINATES
SURFACE SOIL SAMPLE LOCATION
CITY OF PHILADELPHIA, WATER DEPARTMENT
PHILADELPHIA, PENNSYLVANIA
FIGURE II-1
MONITOR WELL LOCATIONS
FOR WATER QUALITY DATA -
SOIL HOT SPOT PROTOCOL

CITY OF PHILADELPHIA
ENTERPRISE AVENUE SITE
REMEDIAL ACTION PROGRAM

GROUNDWATER AND SURFACE WATER MONITORING GENERAL REPORT

SEPTEMBER, 1981

W.O. 1290-06-01

TECHNICAL REPORT #3

ROY F. WESTON, INC.

Weston Way
West Chester, PA 19380

ORIGINAL
(Red)

1. SUMMARY

The City of Philadelphia Water Department has retained WESTON for engineering services relative to a Remedial Action Program for the Enterprise Avenue Site. Under the program, a groundwater and surface water monitoring program will be performed to identify potential migration of contaminants from the site.

WESTON has determined, by inspecting the monitoring wells installed in 1979, which wells could be used for monitoring during the current remedial action program.

Nearly one-third of the 1979 wells could not be located or were blocked. These included three wells which were to be used for montioring during this phase of the project. Therefore, three new wells were constructed. Including the new wells, a total of nine wells were chosen for monitoring purposes. Of the nine, five were into the deep water-bearing-zone and four were into the shallow water-bearing-zone. All monitoring wells are cased and capped.

2. INTRODUCTION

In March 1981, the City of Philadelphia Water Department retained WESTON for engineering services relative to a Remedial Action Program for the Enterprise Avenue Site. Under the program, a groundwater and surface water monitoring program will be performed to identify potential migration of contaminants from the site. The program calls for monitoring the lower water-bearing-zone with five wells located in background locations west, north and east, as well as down gradient of the site. In addition, four wells constructed in the shallow water-bearing-zone will be sampled. The objective is to use wells constructed during the 1979 Phase I study whenever possible.

3. BACKGROUND

In 1979, WESTON performed a study of the Enterprise Avenue Site, which included characterization of the groundwaters. A total of 68 groundwater monitoring wells were constructed as part of this study. The 68 borings were made with six-inch hollow stem augers or by driving four-inch steel casings and washing the soils with a cutting bit. Upon completion the test borings were converted to monitoring wells by insertion of PVC plastic well screens and riser pipes.

Fifty-six shallow wells were completed into the fill or silty clay and 12 deep wells into the gravelly sand. Of the 56, 36 penetrated the fill on-site and the remaining 20 were installed around the perimeter of the fill to examine background values of water quality. Eight of the 12 wells completed in the gravelly sand lie downgradient of the site. The remaining four were located to represent background conditions in the deeper water-bearing-zone.

4. SURVEY OF PRESENT CONDITIONS

In April 1981, WESTON surveyed the site to determine the status of these wells. The survey was difficult due to the extreme vegetation cover which restricted access and visibility. The results of the survey are shown in Table 1.

5. SELECTION OF MONITORING WELLS

The results of the survey of present conditions were reviewed with the Philadelphia Water Department in May 1981. Nine monitoring wells were selected as follows:

- Four wells for shallow zone water monitoring (PWD's #12S, 64S, 65S and 55S). The latter would be a new well.
- Five wells for deep zone water monitoring (PWD's #14D, 44D, 64D, 55D, 57D). Numbers 55D and 64D were new wells. The location of these wells is shown in Figure 1.

All wells selected for monitoring purposes were fitted with locking caps to preserve the integrity of the monitoring program.

The location arrangement provides three well pairs (shallow well near a deep well). Pair PWD #64S and 64D is located south of the site and pair PWD #12S and 44D is located east of the site. These two pair provide down-gradient measurements. Pair PWD #55S and 55D are located northwest of the site and provide up-gradient background measurements.

Since PWD #55D and #64D will also be used for water level monitoring and recording, both of these wells were constructed as to accomodate monitoring equipment.

6. WELL CONSTRUCTION

Wells selected for monitoring were inspected for integrity and, in the case of pairs of wells (shallow and deep), to confirm isolation between wells.

The drilling of the new wells, installation of casings, caps and water level records was completed in July 1981.

The sampling program was initiated in August, 1981. The analytical program description and initial results are presented in Technical Report #4.

Table 1

Monitor Well Survey

Well #(1)	Total Depth (ft)	Screen Setting (ft)	Present Depth(2) (ft)	Depth to Water(2) (ft)
PWD-1S	20	10	--	--
-2S	8.5	5	7.6	3.8
-3S	10	7	10.0	4.0
-4S	11.5	8	5.0	4.7
-5S		Not Found		
-6S	17.5	7	9.3	3.42
-7S	11.5	9	--	--
-8S	36.5	14	--	--
-9S	15	14	--	--
-10S	26.5	20	--	--
-11D	45.5	42	32.5	8.84
-11S		Not Found		
-12S	15	15	13.5	5.00
-13S	15	Not Found		
-14D	24.5	23	23.0	7.62
-14S	15	14	14.0	2.26
-15S	16.5	Not Found		
-16D	26.5	Not Found		
-16S	15	Destroyed in 1979		
-17S	25.5	21	Blocked	
-18S	20	20	20	12.72
-19S	21.5	20	18	13.25
-20S	20	Not Found		
-21S	20	20	20	13.30
-22S	20	18	18	14.3
-23S	20	20	--	--
-24S	36.5	33	33	14.0

(1) "S" denotes shallow well, "D" deep well.

(2) Blank indicates not checked

ORIGINAL (Red)

Table 1

Monitor Well Survey
(Continued)

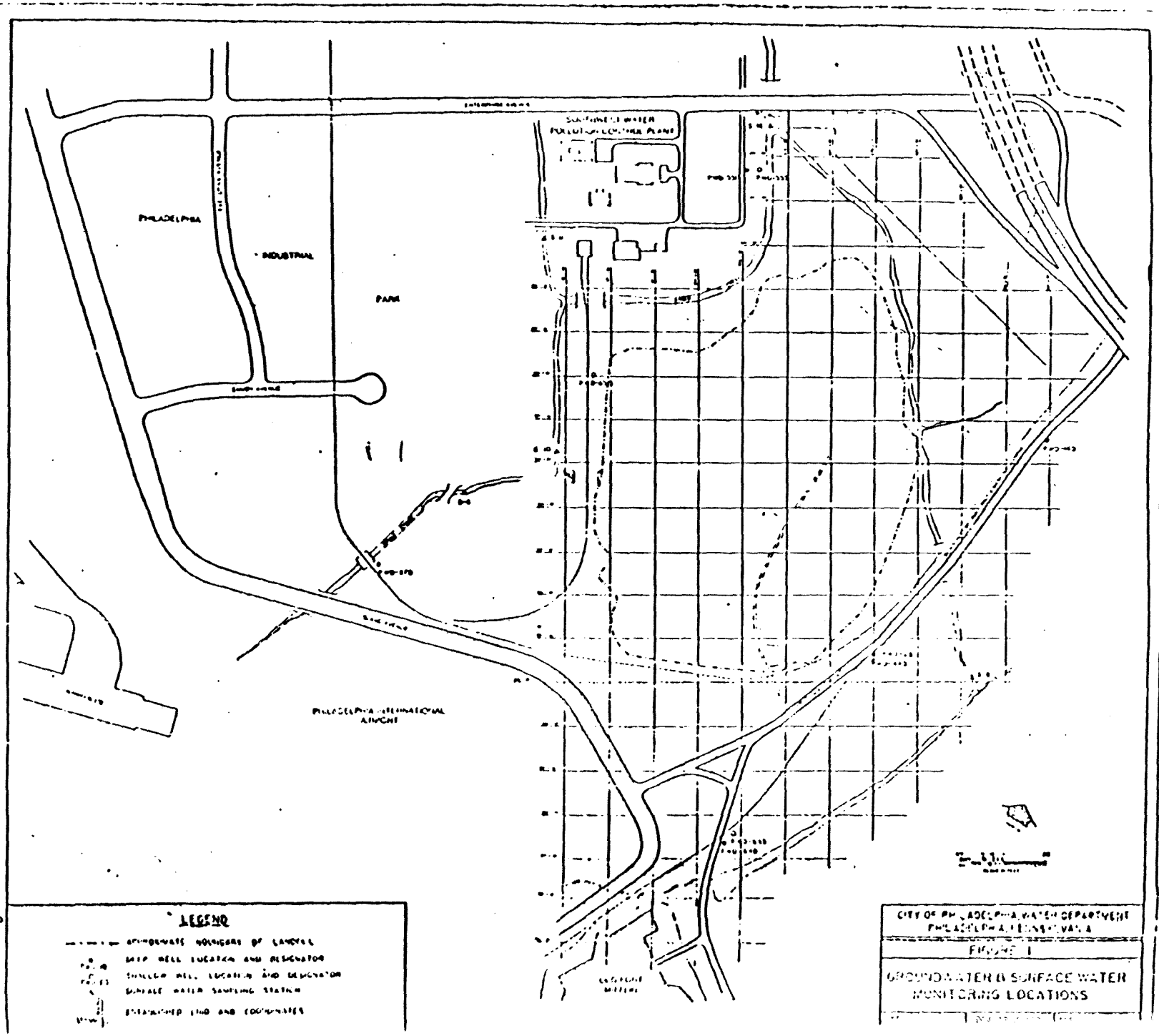
Well #	Total Depth (ft)	Setting	Present Depth (ft)	Depth to Water (ft)
PWD-25S	20		Not Found	
-26S	21.6		Not Found	
-27S	20		Not Found	
-28S	20		Not Found	
-29S	20		Not Found	
-30S	20	19	13.0	6.65
-31S	15.5	15	9.75	3.65
-32S	21.5	19	19.	9.27
-33S	20	19	13.7	7.47
-34S	26.5	23.5	Not Found	
-35S	25	23	Not Found	
-36S	25	23.5	20.0	12.95
-37S	25	24	16.7	14.40
-38S	25		Not Found	
-40D	40		Not Found	
-41D	40		Not Found	
-42D	35		Not Found	
-43D	35		Destroyed in 1979	
-44D	32	30	30	9.10
-45D	40		Not Found	
-46S			Not Found	
-47S			Not Found	
-48S			Not Found	
-49S			Not Found	
-55D	33.5		Not Found (Redrilled)	
-56S	9.5	9.5	15	4.75

ORIGINAL (Red)

Table 1

Monitor Well Survey
(Continued)

Well #	Total Depth (ft)	Screen Setting (ft)	Present Depth (ft)	Depth to Water (ft)
PWD-57D	50	41.5	41.5	14.30
-58S	19.5	16	16	8.47
-59S	16.5	13	14.5	4.15
-60S	29	27	27	3.82
-61S	25	21	21	7.05
-62S	21 5	20	20	2.86
-63S	15	13	10	2.42
-64S	21.5	21	21	6.55
-64D	35.0	34	34	6.75
-65S	11.5	9	13.8	9.05
-66S	11.5		Not Found	
-67S	15		Not Found	
-68S	16.5		Not Found	
-69S	31.5		Not Found	
-70S	28.5		Not Found	



ORIGINAL (Red)

CITY OF PHILADELPHIA
ENTERPRISE AVENUE SITE
REMEDIAL ACTION PROGRAM

Groundwater and Surface Water Monitoring Program: Monthly Analysis Results Report

September, 1981
W.O. 1290-06-01

TECHNICAL REPORT #4

ROY F. WESTON, INC.
Weston Way
West Chester, PA 19380

WESTON

1. SUMMARY

The City of Philadelphia Water Department has retained WESTON for engineering services relative to a remedial action program for the Enterprise Avenue Site. One element of the program involves a groundwater and surface water monitoring program. The objective of the program is to identify potential migration of any contaminants from the site.

The water quality monitoring program involves monthly sampling of both groundwater and surface water. An expanded analyses will be performed every sixth month beginning with the first month.

The first monthly sampling round has been performed and analysis results are presented.

2. INTRODUCTION

In March, 1981 the City of Philadelphia Water Department retained WESTON for engineering services relative to a remedial action program for the Enterprise Avenue Site. As part of the program, a groundwater and surface water monitoring program is being performed to identify potential migration of contaminants from the site. The program requires monitoring the shallow and deep water-bearing-zones as well as several surface water locations.

3. GROUNDWATER QUALITY MONITORING

As described above, the shallow and deep water-bearing-zones are being monitored utilizing groundwater wells. There are four wells (PWD #12S, 55S, 64S and 65S) constructed into the shallow zone and five wells (PWD#14D, 44D, 55D, 57D, and 64D) constructed into the deep zone. The locations of these wells are indicated on Figure 1.

The nine wells described are being used to collect groundwater samples needed to monitor potential migration of any contaminants from the site.

Samples are being taken from each well on a monthly basis. Initial samples were taken in August, 1981. Sampling will continue throughout the field work and for twelve months subsequent to site closure. Every six months, from the initiation of the sampling, an expanded set of analyses will be performed until twelve months after site closure.

The following monthly key indicator analyses will be performed on the water samples:

- pH
- TOC
- VOC
- TDS
- Specific Conductance

ORIGINAL (Red)

Twice per year, from initiation of sampling, an expanded set of analyses will be performed. The expanded analyses includes:

- Priority pollutant analysis
- Fluoride
- Ammonia-Nitrogen
- Nitrate-Nitrogen
- pH
- TDS
- Specific Conductance
- TOC
- VOC
- Cyanide
- Silver
- Zinc
- Arsenic
- Barium
- Cadmium
- Chromium
- Hex. Chromium
- Copper
- Iron
- Lead
- Mecury
- Selenium
- Titanium

A WESTON/City Water Department team will collect the samples and the analyses will be performed in WESTON's laboratory. The results are to be reported to the City with appropriate interpretation as applicable.

4. SURFACE WATER MONITORING

Surface water samples are being collected on a monthly and biannual frequency concurrently with the groundwater samples. Five surface water sampling stations as indicated on Figure 1, are included as follows:

Station	Location
S-4	Background on Eagle Creek.
S-8	Background south of the landfill at Fort Mifflin.
S-10	Eagle Creek adjacent to the landfill.
S-11	Background on tributary to Eagle Creek.
S-12	Eagle Creek downstream from landfill.

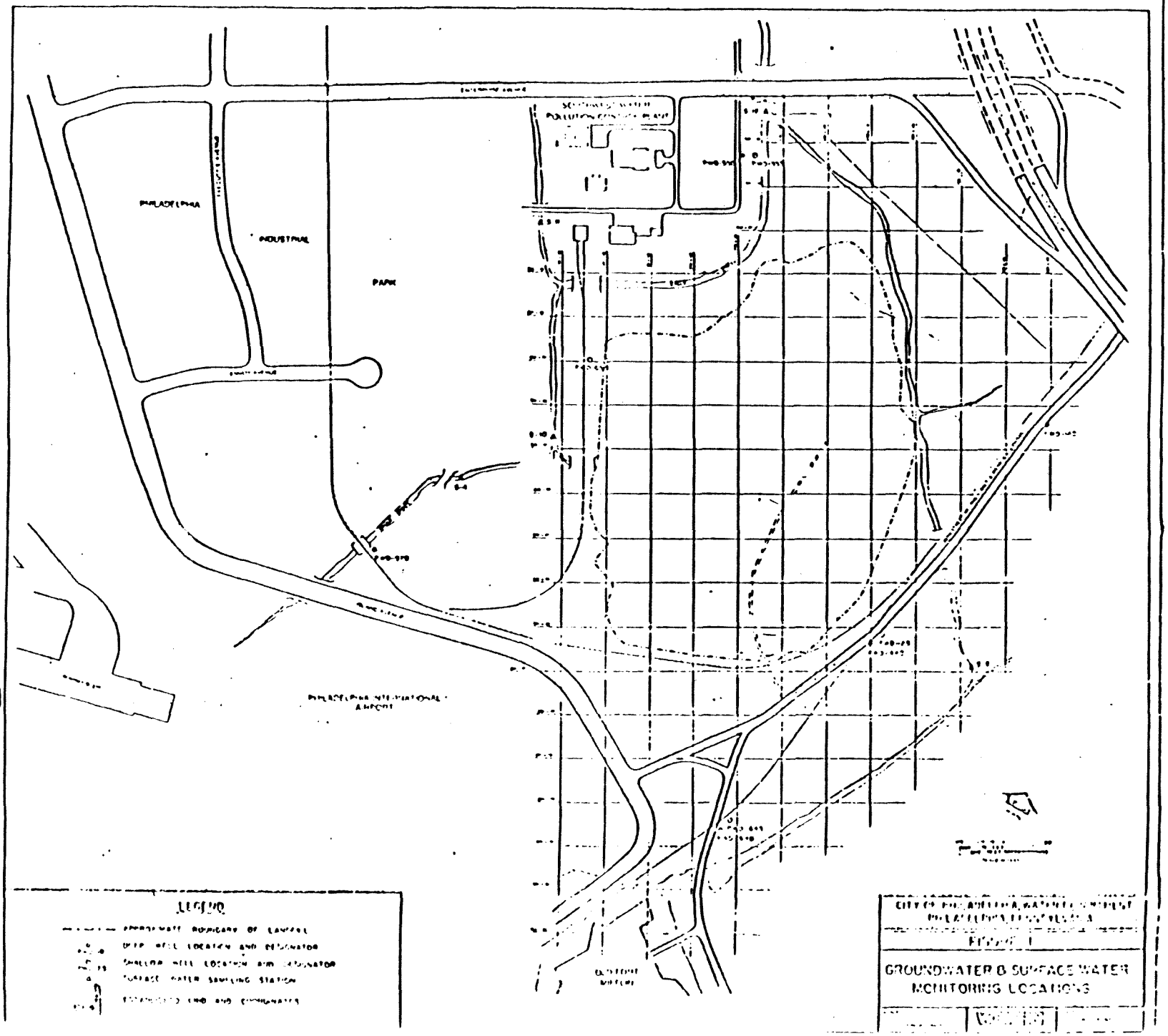
Samples are being collected at these stations and analyzed for the same parameters as the groundwater samples. The need to collect and analyze surface water samples during actual storm runoff conditions is being assessed and the surface water sample collection schedule may be altered accordingly.

5. ANALYSIS RESULTS

Presently, the first monthly sampling round has been performed. Table 1 presents the results for August, 1981.

Due to the time of year, and the minimal rainfall some wells were dry. In these instances, the expanded set of analyses were postponed until the second month.

The sampling protocol involves pumping the wells for 10-15 minutes to "normalize" the contents of the wells. Then, the appropriate volumes are collected and returned to WESTON's laboratory for analysis.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LEGEND
GROUNDWATER & SURFACE WATER
MONITORING LOCATIONS

Table 1

Groundwater and Surface Water Monitoring
Monthly Analyses

August, 1981

Indicator[2]	Groundwater Monitoring Wells, PVD #'s									Surface Stations				
	125	555	645	655	140	440	550	570	640	S-4	S-8	S-10	S-11	S-12
urity Pollutants	(3)	(1)	(1)	(3)	(1)	(1)	(1)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
oride	(3)	0.48	<	(3)	<	<	<	(3)	<	0.55	0.34	0.48	0.40	0.35
mia-Nitrogen	(3)	1.1	36.4	(3)	14.3	25.9	0	(3)	21.5	2.2	1.3	2.4	0.42	2.90
rate-Nitrogen	(3)	0.41	0.60	(3)	(3)	0.57	0.46	(3)	(3)	0.865	0.33	0.45	0.36	0.31
	(3)	5.3	6.8	(3)	5.9	6.6	5.9	(3)	6.3	7.2	7.1	7.2	6.8	7.4
ific Conductance	(3)	776	347	(3)	(3)	304	445	(3)	(3)	554	555	573	1,074	596
	(3)	890	970	(3)	1,200	915	680	(3)	950	780	730	830	1,900	880
	(3)	14	54	(3)	(3)	21	38	(3)	(3)	25	44	19	20	29
	(3)	46	109	(3)	(3)	81	(3)	(3)	(3)	83	43	84	53	56
ide	(3)	<	<	(3)	<	<	0.03	(3)	0.09	<	<	<	<	<
er	(3)	<	<	(3)	<	<	<	(3)	<	<	<	<	<	<
	(3)	0.25	0.04	(3)	1.50	0.03	0.04	(3)	1.20	0.06	0.07	0.06	0.06	0.06
ic	(3)	<	0.042	(3)	0.047	<	<	(3)	0.020	0.010	0.017	<	0.015	<
m	(3)	0.65	0.38	(3)	0.71	0.23	0.09	(3)	1.60	0.22	0.07	0.18	0.05	0.11
ium	(3)	0.65	<	(3)	0.05	<	<	(3)	0.10	<	<	<	<	<
alum	(3)	<	<	(3)	<	<	<	(3)	0.43	<	<	<	<	<
Chromium	(3)	<	<	(3)	<	<	<	(3)	<	<	<	<	<	<
er	(3)	<	<	(3)	0.29	<	0.06	(3)	0.45	<	<	<	<	<
	(3)	9.1	44.0	(3)	(3)	23.0	77.0	(3)	(3)	2.1	5.1	2.3	7.2	5.0
ry	(3)	0.09	0.09	(3)	(3)	<	<	(3)	(3)	<	0.09	0.67	0.05	<
ium	(3)	<	<	(3)	0.001	0.001	<	(3)	0.002	<	0.001	<	0.001	0.001
ium	(3)	<	0.016	(3)	<	<	<	(3)	<	<	<	0.05	<	0.040
	(3)	<	<	(3)	0.65	<	<	(3)	2.70	<	<	<	<	<

Analysis pending, available 30 September 1981.
Results in ppm, unless specified otherwise.
Well was dry, no sample available.

< = less than detectable