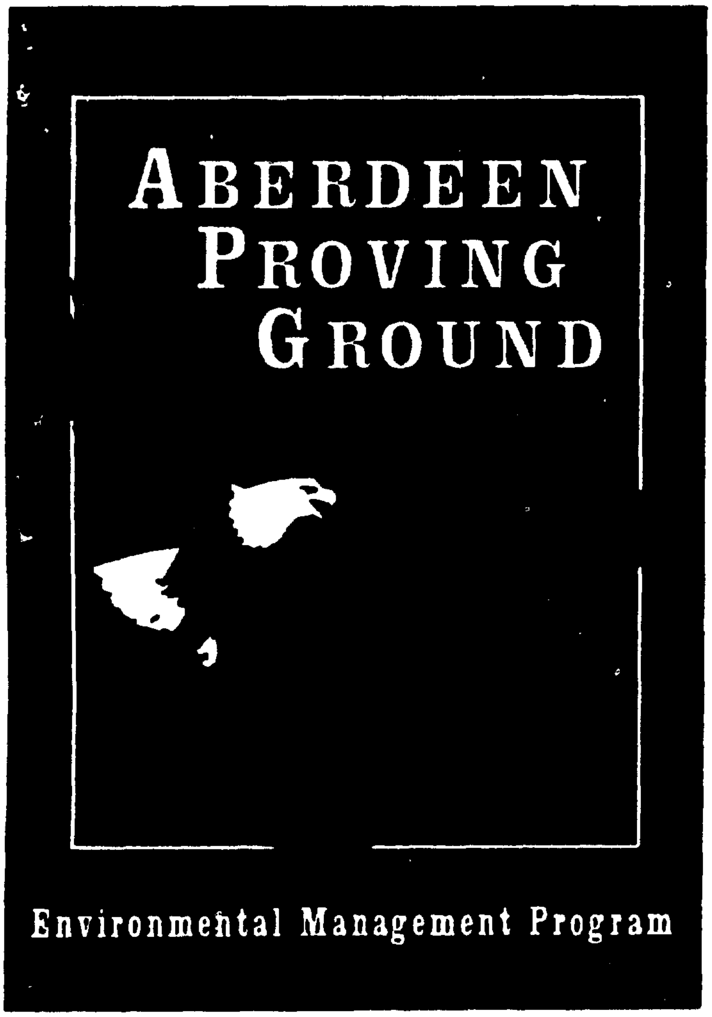
Beach Point Test Site
Aberdeen Proving Ground - Edgewood Area, Maryland

FOCUSED FEASIBILITY STUDY
FINAL PROJECT WORK PLAN



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BEACH POINT FOCUSED FEASIBILITY STUDY (FFS)

MDF COMMENTS	REPLY
Work Plan	
(1) **Page 1-1**. Since the proposed Phase I of the FFS does not adequately address the potential DNAPL plume at the site, WMA does not believe the term "comprehensive environmental investigation" is appropriate.	(1) The sentence which contains the term "comprehensive environmental investigation," refers to the purpose of the work plan which delineates all three phases of the FFS. The next sentence defines the goals of the investigation and references determining the nature and distribution of contamination. The term comprehensive will be changed to phased.
(2) **Page 2-5**, Groundwater usage. The section appears to be somewhat inaccurate. While surface water may currently play a significant role in Edgewood's water supply; during the forties and perhaps earlier, a significant number of wells were constructed to provide the base with water. Some of the wells, though officially condemned, are still in existence and have been activated as recently as 1991.	(2) This statement was referenced from the RCRA Facility Assessment Report (page 7). Though the existence of the wells is known, records of usage of the well system are believed to have been destroyed in the fire which occurred in a facilities engineering building in the Edgewood Area during 1971. The key word to be noted in the sentence commented on is secondary.
(3) **Page 2-17**. Review of the referenced USGS report indicates the inferred thickness of the confining unit beneath the Beach Point Area is open to interpretation.	(3) Thickness of the upper confining layer (aquitard) was approximated from thicknesses of the same unit found in three neighboring wells. Average thickness of the aquitard in these wells is approximately 88 feet. Data from the three wells suggest that the aquitard may become thinner in an east/southward direction. The language of this section has been changed to indicate that this interpretation is speculation from available data and subject to refinement as new data are generated.
(4) **Page 2-20**. If the groundwater at the site may truly be characterized as "sea water" as the report indicates, what is the source of the dissolved solids? Much of the surface water in the area is "fresh" or only slightly brackish.	(4) The statement has been changed to reflect that the water chemistry is indicative of fresh to slightly brackish water.

MDE COMMENTS	REPLY
(5) **Page 2-21, Figure 2-6.** The depiction of the LNAPL layer in the figure is misleading. LNAPL should form a layer at the interface of the saturated and unsaturated zones not a "pool" which significantly depresses the water table.	(5) Figure 2-6 was drawn to generalize the characteristics of dissolved LNAPLs and DNAPLs. The word "Dissolved" has been added to the figure as appropriate.
(6) **Page 2-32, Figure 2-8.** The entire Edgewood Peninsula is an NPL Site, therefore the arbitrary selection of a reference point as the source of "background" samples is unacceptable. Sediment samples in the marsh area north and south of the "circle" near the treatment plant would seem to be appropriate based on the historical discussion. Why have no wells been proposed for the southern end of the Beach Point Area? A well in this location might be useful in the early determination of the extent of contamination and the structural attitude of the clay aquitard. It would appear that some of the proposed soil borings could be deleted. Due to the proximity of the proposed wells to some of the soil borings, it would appear that sampling the soil during the well drilling operation could be substituted for some of the proposed soil borings. The elimination of some unnecessary borings will minimize the generation of investigatory derived material.	(6) Figure 2-8. • Terminology of "Background" sample has been changed to "Local Background." These sampling points were selected to determine whether or not any contaminant sources outside of the Beach Point Test Site are interfering with the definition of on-site contaminant sources. • Sediment samples have been added to the marsh areas north and south of the treatment plant. • USGS believes that detected contamination from clothing impregnating operations is well defined by the present monitoring well clusters. The proposed monitoring well locations are designed to fill gaps in vertical data not available from the USGS drilling and sampling program. Structural attitude of the upper confining unit will be defined by the geophysical program. Additional wells were proposed for the area west/southwest of the peninsula. However, these wells were removed from the FFS after a consensus was reached among JEG, USGS, and APG-DSHE. Wells are proposed for the RI/FS in the area around the treatment plant. Contingency wells are also planned in the RI/FS for any areas of the southwest portion of Beach Point where soil contamination is detected.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

MDE COMMENTS	REPLY
(6) Continued	**(6) Continued** • Any soil boring that is close to a proposed well location will be consolidated with the well drilling program to minimize generation of Investigation Derived Waste (IDW). The number of proposed boring locations is the minimum necessary to locate any possible areas of soil contamination. If significant soil contamination is located, additional soil borings will be needed to define the extent of such contamination so that appropriate remedial measures can be designed.
(7) **Page 2-34**. The text refers to Dithiane as a "degradation product of Mustard" this implies to the reader that Dithiane is a natural breakdown product of Mustard. However, on previous occasions Army chemists have indicated that the presence of Dithiane in groundwater is the result of the hydrolysis of chemicals derived from the incomplete thermal degradation of Mustard. If this is true, perhaps the RI should be looking for the source of Dithiane, a yet undiscovered burning operation which may have destroyed CSM or CSM contaminated material.	(7) You are correct in your understanding that 1,4-dithiane is a degradation product that may result from the thermal destruction of distilled mustard. However, 1,4-dithiane also is a result of other processes. It is a degradation product that is produced in the manufacturing of distilled mustard and, therefore may be found in areas where the agent was either produced or burned. There is also a large body of evidence suggesting that 1,4-dithiane is a degradation product resulting from natural processes. For example, recent studies conducted on the clothing of Iranian soldiers (gassed casualties of the Iraqi war) showed the presence of 1,4-dithiane in the soil adhering to their clothing. The RI is designed to determine the source of the 1,4-dithiane whether it be from the manufacture, natural degradation, or thermal degradation of distilled mustard.

MDE COMMENTS	REPLY
(8) **Page 2-41**. The paragraph notes that 10 µg/l of 1,1,2,2-tetrachloroethane was detected in surface water near Beach Point; however, Table 2-7 indicates that the maximum amount of 1,1,2,2-tetrachloroethane found in surface water was 5 µg/l. Please explain this discrepancy. Also please explain why no mention of the relatively high amount of vinyl chloride (39 µg/l and 33 µg/l) detected in CCSW-5 and CCSW-7 was made in the text. The presence of vinyl chloride at these concentrations may be a significant risk driver since the MCL for this chemical is 2 µg/l.	(8) Table 2-7 has been corrected to show the 10 µg/l maximum concentration for 1,1,2,2-tetrachloroethane. Available information indicates that no levels of concern for vinyl chloride have been established in the AWQC for fresh water. Because the fresh water AWQCs were used to establish chemicals of concern for the FFS, vinyl chloride was not included in the discussion.
(9) **Page 2-43, Table 2-7**. The table reports the maximum amount of Cadmium in surface water as 6.7 µ/l while a Table 2-5, item CCSW-8U, reports 42 µg/l for Cadmium. Please explain this. Cadmium at this higher level will certainly have an impact on aquatic life. Mercury is also significantly higher in CCSW-8U than is reported in Table 2-7.	(9) Table 2-7. Concentration for cadmium from sample CCSW-8U reads 4.2 µg/l, and Mercury is 1.7. The decimal point did not copy well on the reproduced pages of this table.
(10) **Page 2-44, Figure 2-9**. The method for depicting DNAPL and LNAPL is perhaps misleading.	(10) Changes have been made to Figure 2-9 to better conceptualize LNAPL and DNAPL contaminant transport.
(11) **Page 2-48, Table 2-8. Hydrogeologic Investigation**. The selection of "shallow and intermediate depth wells" to characterize DNAPL is questioned. Should wells screened at the base of the aquifer also be included in this investigation? (Page 3-11 indicates that the wells will be screened at an intermediate level and at the base of the surficial aquifer. Which plan is correct?)	(11) Text on page 3-11 is correct; Table 2-8 has been corrected to correspond to the text.
(12) **Page 2-50, Table 2-8. Analytical Method CLP, USATHAMA, EPA and ASTM**. Have analytical methods defined in the ICF Risk Assessment and WES QUAPP been considered in the preparation of this table?	(12) Analytical methods in Table 2-8 have been updated to reflect information from the TERA QAPP (IFC, 1993). (See General Comment.)
(13) **Page 2-57**. Should vinyl chloride be considered a potential concern?	(13) Please refer to response 8.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

MDE COMMENTS	REPLY
(14) **Page 2-57, Bullet "Federal Safe Drinking Water Act . . ."** The document makes the statement that ". . . The contaminated aquifer is brackish and is not used as a drinking water source; therefore the SDWA (Safe Drinking Water Act) MCLS are probably not applicable or relevant and appropriate." This infers that the authors are classifying this groundwater as Class III according to the classification system for groundwater promulgated by the US EPA. However, the EPA's definition of Class III groundwater is very specific: "Groundwater not consider a potential source of drinking water and of limited beneficial use (Class IIIA and Class IIIB) is saline, i.e., it has a total dissolved solids levels over 10,000 milligrams per liter (mg/l) . . .". Based on the information presented in the report on page 2-20 that ". . . groundwater at Beach Point contains 1000 to 3000 mg/l total dissolved solids (TDS) . . .", how is the presumption that the groundwater in question is Class III in nature supportable?	(14) Concurrence by MDE, EPA, and APG-DSHE to classify groundwater in the surficial aquifer at Beach Point as Class II-B suggests the statement that the "SDWA MCLs are probably neither applicable nor relevant and appropriate" may stand as written.
(15) **Page 2-58, Bullet "Maryland Drinking Water Law. . ."** Refer to comment above.	(15) Please refer to response 14.
(16) **Page 2-61**. In addition to the Maryland ARARs mentioned, the following should also be considered: Potential ARARs "Chesapeake Bay Critical Area Commission Criteria For Local Critical Area Program Development," COMAR 14.15.01, .02, .04, .07, .09, .10, & .11. "Threatened and Endangered Species," COMAR 08.03.08. "Water Appropriation or Use," COMAR 08.05.02	(16)
(17) In addition to the Maryland ARARs mentioned, the following should also be considered: Potential ARARs "Well Construction," COMAR 26.04.04 "Solid Waste Management," COMAR 26.04./07 "Board of Well Drillers," COMAR 26.05.01 "Erosion and Sediment Control," COMAR 26.09.01 "Storm Water Management," COMAR 26.09.02 "Oil Pollution," COMMAR 26.10.01	(17) The potential ARARs listed will be added and considered in the Feasibility Study.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

MDE COMMENTS	REPLY
(18) **Page 3-2, Figure 3-1**. How can "significant risk due to nature and extent of contamination" be determined if the extent of contamination is not fully defined until Phase II?	(18) This comment requires concurrence between EPA and MDE.
(19) **Page 3-9**. Will the surface soil sampling discussed here be for use in the Risk Assessment or is it for source identification/verification? The ICF Risk Assessment Work Plan for the Edgewood Area calls for surface soil samples to be taken in the depth interval 0 to 6".	(19) Results of the surface soil sample analysis (0-6" in depth) will be used for both the Risk Assessment and contaminant source identification/verification. Soil borings will also be used for source identification/verification.
(20) **Page 3-11**. Refer to comment 11 above.	(20) The question regarding continuous soil sampling is not clearly understood. Analyses of soil samples collected from the borings will be used primarily for contaminant source identification and evaluation of possible measures to protect groundwater and surface water from continued contaminant migration. Continuous soil sampling is necessary to obtain the volume of sample needed for the proposed suite of analyses.
Focused Feasibility Study Draft Field Sampling Plan Specific Comments	
(1) **Page 1-8**. The Army has previously chosen to utilize the WES Generic Work Plan for the entire Edgewood NPL Site. Will the Jacobs Engineering Group follow the sampling procedures outline in this document or will new procedures be developed?	(1) The Beach Point FSP has been modified to reflect adherence to the WESGWP SOPs.
(2) **Page 1-9, Table 1-1**. Please refer to the earlier comment concerning the arbitrary select of "background" on an NPL Site.	(2) Discussed in Work Plan response 6 regarding "Background" terminology.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

MDE COMMENTS	REPLY
(3) **Page 2-8, Baseline Risk Assessment.** It should be noted that the subject document was a draft document which was never finalized following regulatory comments.	(3) It is noted that the Baseline Risk Assessment is a draft document. In light of the fact that this document has not been finalized, limited reference to information in the draft copy may be appropriate.
(4) **"Field parameter. . ."** One of the most critical parameters which should be evaluated before a sample is collected is visual clarity or turbidity. Current guidance indicates that readings of less than 10 NU is acceptable for groundwater samples.	(4) The FSP has been modified to include the EPA-recommended procedures for well purging and field parameter measurements. It is understood that this is the accepted procedure for groundwater sampling at APG-EA.
(5) **"Well Purging"** Surging of the well is an appropriate procedure during well development. However, during well purging prior to sampling it is not a good practice. For typical purging of a well, the pumping operation should begin with the pump in the upper part of the water column. Purging should continue by gradually lowering the pump into the well as water is removed from the well. This will remove the stagnant water from the well first and result in minimal mixing. This method is discussed in the WES Generic Work Plan for the Edgewood Area. Modification of this procedure may be in the development stage so the contractor should consult with WES concerning currently approved procedures.	(5) The FSP has been modified to include the EPA-recommended procedures for well purging and field parameter measurements. It is understood that this is the accepted procedure for groundwater sampling at APG-EA.
(6) **Page 3-16.** The parameters that are monitored also include oxidation reduction potential (Eh), specific conductance (SC), dissolved oxygen (DO) and turbidity. Refer to WES SOPs for monitoring requirements.	(6) The FSP has been modified to include the EPA-recommended procedures for well purging and field parameter measurements. It is understood that this is the accepted procedure for groundwater sampling at APG-EA.

Focused Feasibility Study Draft Quality Assurance Program Plan
General Comment

A brief review of the subject document finds that it is a unique document, which is inconsistent with concurrent and related work at Edgewood. As an example the subject document proposes to use analytical methods which are inconsistent with the ICF Risk Assessment QAPP, yet one of the main thrusts of the proposed FFS is to determine the risk posed by the soil and groundwater at the Beach Point site. Also, in light of comments made above, it appears that the WES Generic Work Plan was not consulted in the preparation of this document. In light of this, the subject document will not be reviewed at this time.

<table>
<tr><th>MDE COMMENTS</th><th>REPLY</th></tr>
<tr><td colspan="2">QAPP GENERAL COMMENT RESPONSE</td></tr>
<tr><td colspan="2">The Beach Point FFS QAPP and all other Canal Creek QAPPs will reflect the Task 10 Terrestrial and Ecological Risk Assessment (TERA) QAPP. The TERA QAPP is an updated and USAEHA-approved version of the O-Field QAPP. Areas which differ from this version will be highlighted and further explained in a summary of deviations. Chiefly, the differences result from changes made for site-specific and instrument-specific considerations. WES SOPs will be included.</td></tr>
</table>

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS)

EPA COMMENTS	REPLY
Draft Project Work Plan	
(1)	(1)
The objectives of the work plan seem to be inconsistent with the proposed implementation of the work and the FFS in the document. It is stated on pages 1-2 and 1-3 that the results of seismic surveys and sampling of sediments, groundwater, soil borings and assays will be supplied to ICF for development of risk assessment of the Beach Point site, based on ecological preliminary remediation goals. This objective is consistent with the introduction on page 1-1 where it is stated that contaminants from the site may be impacting water quality and aquatic life in nearby Kings Creek and near-shore areas of the Bush River. Additionally it is noted here that the study will only deal with the surficial aquifer at Beach Point which is brackish. Therefore, it would seem that the investigation is focused on the ecologic impacts on the surface water bodies and not on groundwater as an actual or potential potable water source (it has Class III characteristics). Based on the statement on page 2-42, "because VOCs typically persist in surface water for only a short time period because of volatilization, they are likely to be present only in the immediate vicinity of source areas (e.g., groundwater plumes)", it would appear that the interest in groundwater would be if it were discharging into the surface water bodies at levels exceeding those in Table 2-7 (which should be checked as they are not in agreement with those used by EPA).	Page 1-4 refers generally to a risk assessment without further qualifying it, while page 3-3 qualifies it saying "it . . . will be conducted to assess the influence of past site activities on living biota in the area of Beach Point and to qualitatively determine human health risk from limited pathways". Page 1-3 refers generally to a risk assessment and further states that it will be based on ecological preliminary remediation goals (PRGs) and page 3-1 refers to an ecological risk assessment. The ICF Risk Assessment Plan which is Appendix D of this document describes the proposed risk assessment. As stated in the plan it will ". . . focus on potential impacts in aquatic life inhabiting nearby areas in Kings Creek and the Bush River, because aquatic species are the receptors potentially at greatest risk from exposure to chemicals released from groundwater. Potential human health risks associated with exposures to chemicals released to surface water from groundwater will be evaluated qualitatively." It goes on to state that ". . . based on groundwater and surface water sampling data collected to date, such (human) exposures are not likely to be large, given the relatively low concentrations of most volatile organic chemicals and the distance to potential receptor points". (See Section 4.2 of the plan for greater detail). Therefore the major thrust of the risk assessment is the ecological assessment. To avoid confusion, the word primarily will be added before ecological on page 1-3 and the word ecological will be removed from page 3-1.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

EPA COMMENTS	REPLY
(1) Continued Therefore, it is not clear why the investigation is proposed to initially "evaluate potential on-site sources, define morphology and limited flow patterns of the surficial aquifer" and include soil borings and groundwater samples from existing wells. This type of information is typically required to better define the extent and nature and transport characteristics of contamination in groundwater. Without determining if there is a risk to the environment and where it occurs, theta da theta da data collection would seem superfluous and inconsistent with the objectives described in the document and reiterated above. Furthermore, a proposal to do a human health risk assessment is described in some instances in the document (e.g., page 1-4 and 3-3) while elsewhere in the document only the ecological risk assessment is noted (e.g. Site objectives, page 3-1, and page 1-3). The inconsistency in the definition of the objectives is reflected in the description of potential remedial actions outlined on page 3-4 where the only action presented (other than no action) is long-term groundwater monitoring to measure the natural biodegradation of the contaminant plume and determine its long-term persistence in the groundwater system. The utility of this as a "remedial action" is questioned.	**(1) Continued** Options listed on page 3-4 include three categories not two. They are (1) no treatment (2) limited action and (3) pilot/treatability study/remedial alternatives for the contaminants of concern. A further definition of the alternative development process is contained in Section 3.2.3.3 and is projected to be the focus of Phase III.
(2) **Table 2-7**. The values in the table should be verified with the EPA biologist and the criteria should indicate either fresh or marine environment.	**(2)** W/O Dennis Burton. Table 2-7 is changed to provide fresh water aquatic toxicity criteria

EPA COMMENTS	REPLY
(3) **Table 2-8**. The analytes should include CSM degradation products. Additionally, the purging stabilization parameters should be consistent with those used in the SOPs relevant to other portions of APG. The timing of water elevation measurements and groundwater sampling events should be dependent on any tidal cycle influences.	(3) **Table 2-8/page 3-8**. The analytes do include CSM degradation products as noted under the DQ for chemical data. (See discussion under the columns for Hydrogeologic Investigation, Sediment Investigation, Surface Soil and Soil Boring Investigation and Biological/Ecological Investigation. Additional details can be found in Section 3.2.14 of this plan and Section 4.4 of the Draft Field Sampling Plan. Section 3.2.14 details the specific degradation products which will be grouped. 1,4 Dithiane has been added. Chlorides and fluorides are on the list of analytes for groundwater parameters. As for the timing of measurements and sampling, a 24-hour groundwater flow metering of well 33-B and B.1 will help determine the nature of any tidal influences. Periods of lesser duration will be flowmetered in the shallow wells. WES SOPs will be used.
(4) **Page 3-3**. It is stated here that it is critical to understand the physical geomorphology of the surficial aquifer because the DNAPLs will rest upon an impermeable stratum such as bedrock or clay. This is not strictly true; the DNAPLs will actually move until reaching a relatively less permeable layer and until sufficient head exceeds the pore entry pressure in the material breakthrough will not occur. Therefore, it is important to note that the layer limiting DNAPL movement may not actually be the hydrologic confining clay unit.	(4) The clay aquitard underlying the surficial aquifer is approximately 88 feet thick which could minimize DNAPL gravitational movement. There is no current evidence that sufficient head exists to exceed pore entry pressure into the aquitard. The aquifer underlying the aquitard exhibits positive head in relation to the overlying strata. The clay aquitard appears to be regionally significant and appears to be the most significant hydrologic border.
(5) **Page 3-8**. Groundwater analysis should include 1,4 dithiane, fluorides and chlorides.	(5) See response to comment Table 2-8.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

EPA COMMENTS	REPLY
(6) **Page 3-9.** Criteria should be included in the soil boring section for drilling to cease if DNAPLs are encountered in the subsurface.	(6) In the soil boring section, the following criteria will be added: A sample will be taken just above the water table, except if a photionization device detects a hit (hot spot) at a point before the top of the water table. In this case, the sample will be taken for analysis and the boring will be properly abandoned at that point.
(7) **Page 3-11.** The timing of groundwater flow measurements should be based on tidal cycle influences derived from the 24 hour flow meter testing.	(7) Refer to response to Table 2-8.
(8) **Page 3-14.** It is stated in Section 3.2.3.2. that a limited action alternative will include monitoring of groundwater to assure that further environmental degradation has not occurred. It should be noted that monitoring groundwater does not assure that further degradation of the environment does not occur; only an action, natural or manmade, acting upon the contamination can assure this.	(8) Page 3-14. "To assure that further environmental degradation has not occurred" will be stricken.
(9) **Page 3-20.** References regarding the first paragraph should be provided or the paragraph should be omitted. The statements appear to be a personal opinion of the author.	(9) Page 3-20 paragraph will be deleted.
(10) **Appendix C.** The proposed flowmeter logging program is missing pages.	(10) Appendix C. There are no missing pages. This description was taken out of a letter contract with contains other information not relevant to the specific technical aspects of the flowmeter study.

BEACH POINT FOCUSED FEASIBILITY STUDY (FFS) (Continued)

EPA COMMENTS	REPLY
Draft Field Sampling Plan	
(1) This document does not reflect the SOPs used sitewide at APG and should be modified to do so.	(1) The Draft Final Beach Point Field Sampling Plan reflects WES SOPs.
Draft Health and Safety Plan	
(1) Insofar as this plan addresses groundwater sampling (Section 2.1.1), it should be modified to reflect the APG SOPs.	(1) This plan will follow WES SOPs.

EXECUTIVE SUMMARY

Jacobs Engineering Group, Inc. (JEG) has been contracted by Environmental Management Operations (EMO)[1] to develop a Focused Feasibility Study (FFS) for Beach Point in the Edgewood Area of Aberdeen Proving Ground (APG-EA). This task has been performed under the provisions of Master Agreement 071914-A-D7, Task Order 142133, Supplemental Number 8 and under the purview of the U.S. Army, EPA Region III, and the Maryland Department of Environment.

Beach Point is a peninsula located immediately adjacent to the mouth of Kings Creek, a major tributary to the Bush River that drains the majority of chemical storage and research and development areas at APG. As the former location of propellant, smoke and polytechnic testing activities, as well as chemical-protective clothing-impregnating operations, the site is known or suspected to be contaminated with various industrial solvents and military-related compounds. Contaminants at the site may be impacting water quality and aquatic life in nearby Kings Creek and near-shore areas of Bush River. It should be noted that this study will deal with the surficial aquifer at Beach Point, which is a brackish aquifer. The deeper aquifers will be addressed in the Canal Creek Remedial Investigation Feasibility Study (RI/FS).

This work plan develops a framework for a phased environmental investigation at Beach Point that will utilize a risk-based approach. The overall goals of the investigation will be: (1) to determine the nature and distribution of contamination at the site (and to differentiate between site-related contamination and naturally-occurring background levels or contributions from other sources); (2) to evaluate whether human or environmental impact are potentially or actually occurring as a result of site-related contaminations; and (3) to determine whether remedial actions are necessary to mitigate these effects. The major objectives of the work plan in achieving these overall goals are to:

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[1] EMO is operated for the U.S. Department of Energy by Battelle Memorial Institute.

- Provide a complete background characterization of Beach Point Test Site, including physical characteristics and environmental setting; operations and disposal history; summary of previous investigations; and contamination assessment;
- Perform a preliminary contamination assessment related to groundwater, surface water and other types of contamination detected at Beach Point through previous studies, focusing on identifying contaminants, exposure pathways, and human and environmental receptors of potential concern.
- Develop an environmental sampling program, including specific biological tests as well as groundwater, soil, and sediment sampling, to address data gaps and provide the basis for conducting a detailed risk assessment and feasibility study.

At the direction of the APG-Department of Safety, Health and Environment, the project has been separated into three work phases to allow for data evaluation and risk analysis within Phase I to determine the need for further study and development of remedial alternatives. Phase I of the project consists of an aerial photography investigation, surface/marine geophysical surveys, a flowmeter logging program, sampling of surface and subsurface soils, and analysis of chemical groundwater data, generated through a separate Canal Creek Groundwater Monitoring Program.

Tasks described for Phase II of the FFS will be performed upon evaluation of data needs, subsequent to completion of the Phase I tasks. Phase II investigations include installation of additional groundwater monitoring wells, sampling of the new and previously existing monitoring wells, a flowmeter logging program, downhole geophysics of new monitoring wells (and one previously existing well) using a gamma ray survey and possible soil gas surveys.

Phase III tasks, which include the evaluation of remedial alternatives, may be performed after Phase II and at any point, thereafter, if it is determined that contamination found in the Beach Point Test Site warrants treatment.

The tasks performed by JEG will run concurrently and in cooperation with other studies being performed by a variety of other consultants. These include; a risk assessment (ICF Kaiser Engineers), biomonitoring (University of Maryland Agricultural Experiment Station), and geophysical surveys (Argonne National Labs). The results of these efforts will be included in the FFS.

In addition to a work plan which includes a technical approach to conducting the Focused Feasibility Study, companion documents include the Field Sampling Plan, the Quality Assurance Project Plan, and the Health and Safety Plan. These plans were developed from applicable information contained in plans prepared for similar work at APG and other military installations and modified for site specific considerations. Procedures detailed in each of these documents will be used while performing the activities outlined for the FFS at Beach Point.

The Field Sampling Plan describes the technical approach that will be used to conduct field work for the project.

The Quality Assurance Project Plan delineates the purpose, policies, Standard Operating Procedures, and organization of the Quality Assurance Program that will be used to establish the integrity of APG-EA project activities.

The Health and Safety Plan delineates policies and procedures that will be used to ensure worker health and safety throughout project activities at Beach Point.

The background information presented in this work plan was gathered primarily from unpublished data, from previous investigations performed at Beach Point by the U.S. Geological Survey (USGS) Water Resources Division, and from the Edgewood Area RCRA Facility Assessment and other studies conducted by the U.S. Army Environmental Health Agency (USAEHA). The guiding document in this work plan is the unpublished USGS Canal Creek Hydrogeologic Assessment (HGA) dated April 1992 (Final Draft). This work plan is based on US EPA RI/FS Work Plan Guidance.

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APPENDICES

1.0 INTRODUCTION

This Focused Feasibility Study (FFS) work plan has been prepared by the Jacobs Engineering Group (JEG) to address areas of known groundwater contamination and sediment contamination at Beach Point, located in the Edgewood Area of Aberdeen Proving Ground (APG), MD. The work plan has been prepared at the request of Battelle Memorial Institute Environmental Management Operations (EMO) and Aberdeen Proving Ground Directorate of Safety, Health, and Environment (APG-DSHE) under Contract DE-AC06-76RLO1830 and Master Agreement 071914-A-D7 Task Order No. 142133, Supplement 8.

Beach Point is a peninsula located immediately adjacent to the mouth of Kings Creek. Kings Creek is a major tributary to the Bush River that drains the majority of chemical storage and research and development areas at APG. As the former location of propellant, smoke, and pyrotechnic testing activities, as well as chemical-protective clothing-impregnating operations, the site is known or suspected to be contaminated with various industrial solvents and military-related compounds. Contaminants from the site may be impacting water quality and aquatic life in nearby Kings Creek and near-shore areas of the Bush River. It should be noted that this study will deal only with the surficial aquifer at Beach Point which is brackish. The deeper aquifers will be addressed in the Canal Creek Remedial Investigation/Feasibility Study (RI/FS).

The purpose of this work plan is to develop a framework for a phased environmental investigation at Beach Point that will utilize a risk-based approach. The overall goals of the investigation will be: (1) to determine the nature and distribution of contamination at the site (and to differentiate between site-related contamination and naturally-occurring background levels or contributions from other sources); (2) to evaluate whether human or environmental impacts are potentially or actually occurring as a result of site-related contamination; and (3) to determine whether remedial actions are necessary to mitigate these effects. The major objectives of the work plan in achieving these overall goals are:

- Provide a complete background characterization of Beach Point Test Site, including physical characteristics and environmental setting; operations and disposal history; summary of previous investigations; and contamination assessment;
- Perform a preliminary contamination assessment related to groundwater, surface water, and other types of contamination detected at Beach Point through previous studies, focusing on identifying contaminants, exposure pathways, and human and environmental receptors of potential concern;
- Develop an environmental sampling program, including specific biological tests as well as groundwater, soil, and sediment sampling, to address data gaps and provide the basis for conducting a detailed risk assessment and feasibility study.

The background information presented in this work plan was gathered primarily from unpublished data, from previous investigations performed at Beach Point by the U.S. Geological Survey (USGS) Water Resources Division office in Towson, MD, and from the Edgewood Area RCRA Facility Assessment (RFA) and other studies conducted by the U.S. Army Environmental Health Agency (USAEHA). The guiding document in this work plan is the unpublished USGS Canal Creek Hydrogeologic Assessment (HGA) dated April 1992 (Final Draft). This work plan is based on EPA RI/FS work plan guidance.

This work will run concurrently and in cooperation with other studies being performed by a variety of other consultants. These include a risk assessment [ICF Kaiser Engineers (ICF)], biomonitoring [University of Maryland Agricultural Experiment Station (UM)], and geophysical surveys [Argonne National Lab (ANL)]. The results of these efforts will be included in the FFS.

1.1 EVOLUTION OF WORK PLAN

Under the guidance and direction of APG-DSHE this work plan was developed as a three phase approach. The first phase (Phase I) will include sediment sampling, groundwater sampling, soil boring, and seismic surveys, in conjunction with chemical and biological assays. The results of these surveys and sampling events will be supplied to ICF for development of a risk assessment of the Beach Point site, based primarily on ecological preliminary remediation goals (PRGs). Initiation and conduct of Phases II and III will be dependent on the results of this risk assessment and the regulatory review conducted by the appropriate state and federal agencies. However, this work plan also outlines and describes Phases II and III, including relevant standard operating procedures (SOPs), in anticipation of any possible further site definition or remedial alternatives analysis which may be required. All three FFS phases are discussed in detail in Section 3.0 of this work plan.

1.2 ELEMENTS OF THE FFS

1.2.1 Scoping Documents

Supporting documentation for the implementation of the field phase of the Beach Point FFS Work Plan and the final data analysis, Quality Assurance/Quality Control (QA/QC) and reporting is included with the Project Work Plan. It includes three documents: a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), and a Health and Safety Plan (HASP).

1.2.1.1 Field Sampling Plan. The FSP presents the approach for conducting the sampling program, geophysical and soil gas surveys, and soil boring/monitoring well installations. It is based on historical sampling and analysis data and specifically designated analytes. The plan also address sample handling, documentation and sampling. All initial phase field programs and surveys will be identified and detailed.

1.2.1.2 Quality Assurance Project Plan. The QAPP has been prepared in order to support the conduct of the FSP for the FFS at Beach Point. The QAPP will satisfy all quality assurance requirements of the Environmental Protection Agency (EPA) Region III and APG—DSHE.

1.2.1.3 Health and Safety Plan. The HASP is a comprehensive plan to support the implementation of the FSP at Beach Point. The HASP will satisfy all health and safety information and procedures required by EPA Region III and APG-DSHE.

1.2.2 Supporting Consultants and Subcontractors

1.2.2.1 Supporting Consultants.

Surface Geophysics -- Argonne National Laboratory will recommend and supply all appropriate surface geophysical surveys (e.g., seismic, EM, etc.) for the FFS at Beach Point.

Biological Assessment — The University of Maryland will provide the bioassessment of the groundwater and sediment at Beach Point.

Risk Assessment — ICF will provide a risk assessment for groundwater from the Beach Point surficial aquifer.

1.2.2.2 Subcontractors. JEG will be using subcontractors for the following activities:

UXO Surveys — UXO surveys will be conducted by a qualified company in connection with any subsurface field activities (e.g., soil sampling, drilling, etc.) associated with the Beach Point FFS.

Land Surveying — A land surveying company will provide a Maryland certified surveyor for any validation of well installation locations and elevation data (as needed).

Analytical Services — A subcontract laboratory will provide analytical services for all groundwater, surface water, soil, and sediment samples. The laboratory will be a participant in EPA's Contract Laboratory Program and follow the analytical methods identified in the Quality Assurance Project Plan. The data will be provided as Level IV data and suitable for entry into the Installation Restoration Data Management Information System.

Downhole Geophysical Logging — The geophysical company will provide support for all downhole geophysical requirements (e.g., gamma ray, velocity log, etc.).

Drilling — The contractor will provide all drilling support and provide an on-site Maryland licensed driller. The expected activities are soil borings and groundwater monitoring well installation.

Pilot Treatment Study — The selected company (if needed) will provide all support, equipment and maintenance over the prescribed time period and, after completing the study, provide a detailed treatability report of the activity.

2.1 INSTALLATION REGIONAL SETTING — EDGEWOOD AREA, APG**

This section provides the general regional description of APG-EA. A more detailed description of the Beach Point study area is presented in Section 2.3. Figure 2-1 identifies APG-EA and local study areas.

Climate. The climate of the APG area is temperate and somewhat humid. The climate is moderated by the Chesapeake Bay, with milder winters than locations farther inland. The mean annual precipitation is 45 inches and is fairly uniformly distributed throughout the year. The mean annual temperature is approximately 54°F.

Physiography, Topography, and Surface Drainage. APG lies within the Coastal Plain physiographic province. The land surface of the Coastal Plain is characterized by low hills, shallow valleys, and flat plains. Elevations within the main Aberdeen and Edgewood areas of APG range from sea level to approximately 60 feet above sea level. Soils vary in thickness and soil types range from silty sands to clays. Surface drainage is to the Chesapeake Bay, the Bush or Gunpowder River estuaries, or to creeks which discharge to these water bodies.

Regional Geology. APG lies on coastal plain sediments (Figure 2-2) that form a series of concentric bands sub-parallel to the Fall Line which lies just north of the installation. The Fall Line is the boundary between old resistant crystalline rocks of the Piedmont Plateau and the younger, softer sediments of the Coastal Plain. The Coastal Plain sediments are of Cretaceous and Quaternary ages and consist of unconsolidated beds of clay, silt, sand, and occasional gravel lenses. The sediments dip southeasterly, generally at an angle of less than one degree, and thicken to several hundred feet under the eastern shore of Chesapeake Bay. The crystalline rocks which underlie the Coastal Plain sediments are Precambrian to lower Paleozoic in age and consist chiefly of schist, gneiss, gabbro,

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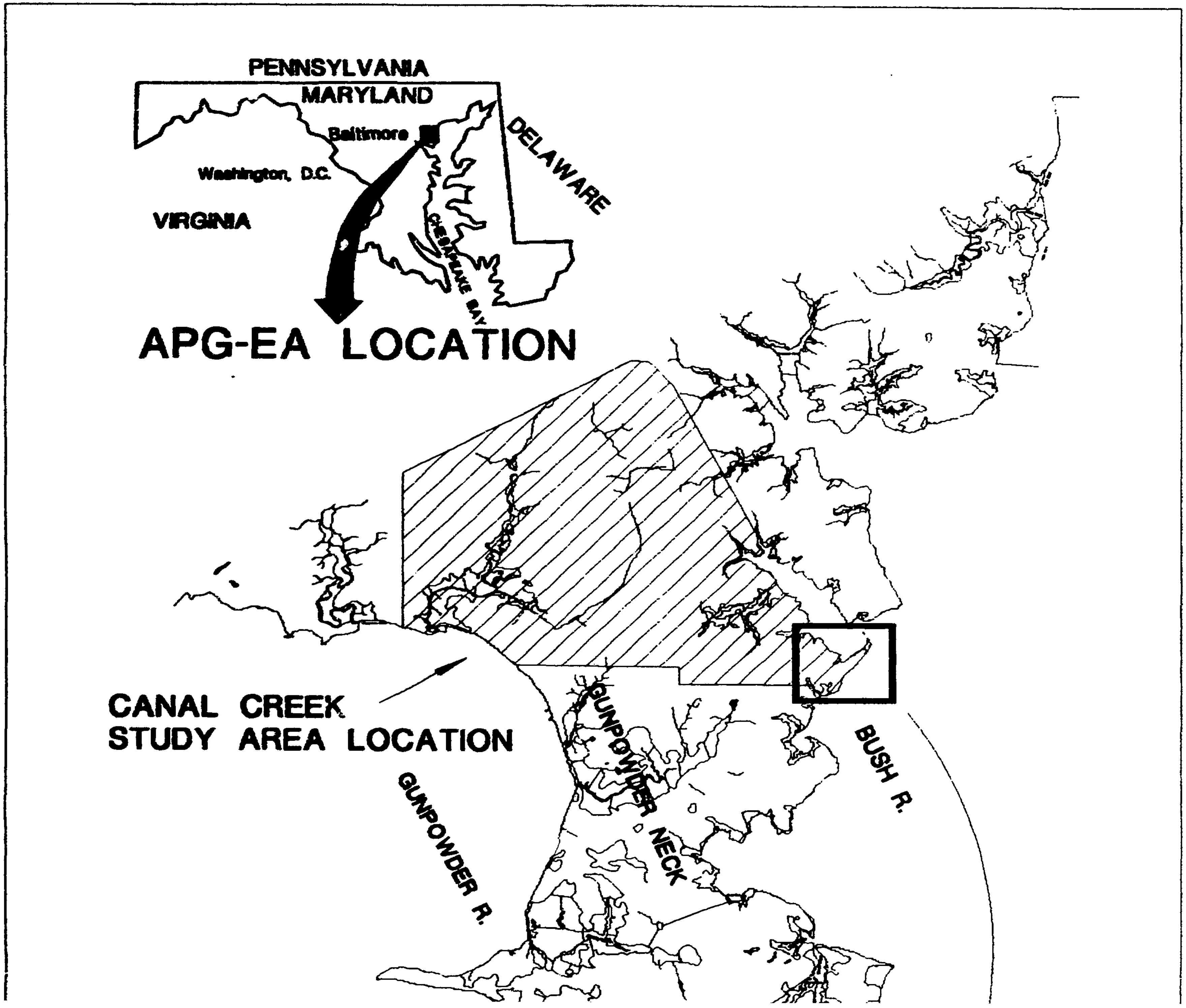
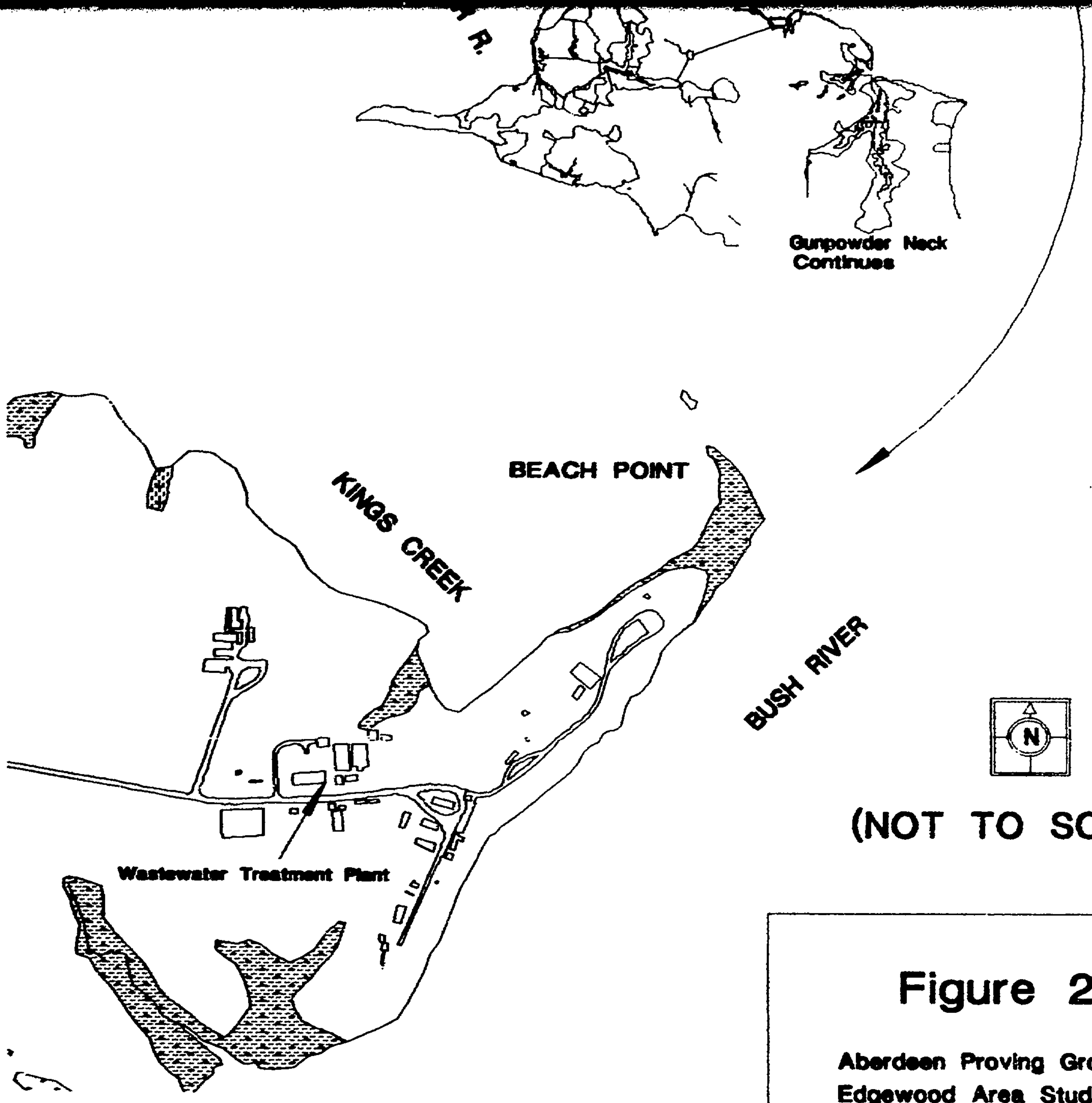
** **This information has been derived from the RFA, 1986.**


PENNSYLVANIA
MARYLAND
Baltimore
Washington, D.C.
VIRGINIA
DELAWARE
CHESAPEAKE BAY
APG-EA LOCATION
CANAL CREEK
STUDY AREA LOCATION
GUNPOWDER R.
GUNPOWDER NECK
BUSH R.



(NOT TO SCALE)

BEACH POINT FOCUSED
FEASABILITY STUDY LOCATION

Figure 2-1

Aberdeen Proving Ground -
Edgewood Area Study Locations

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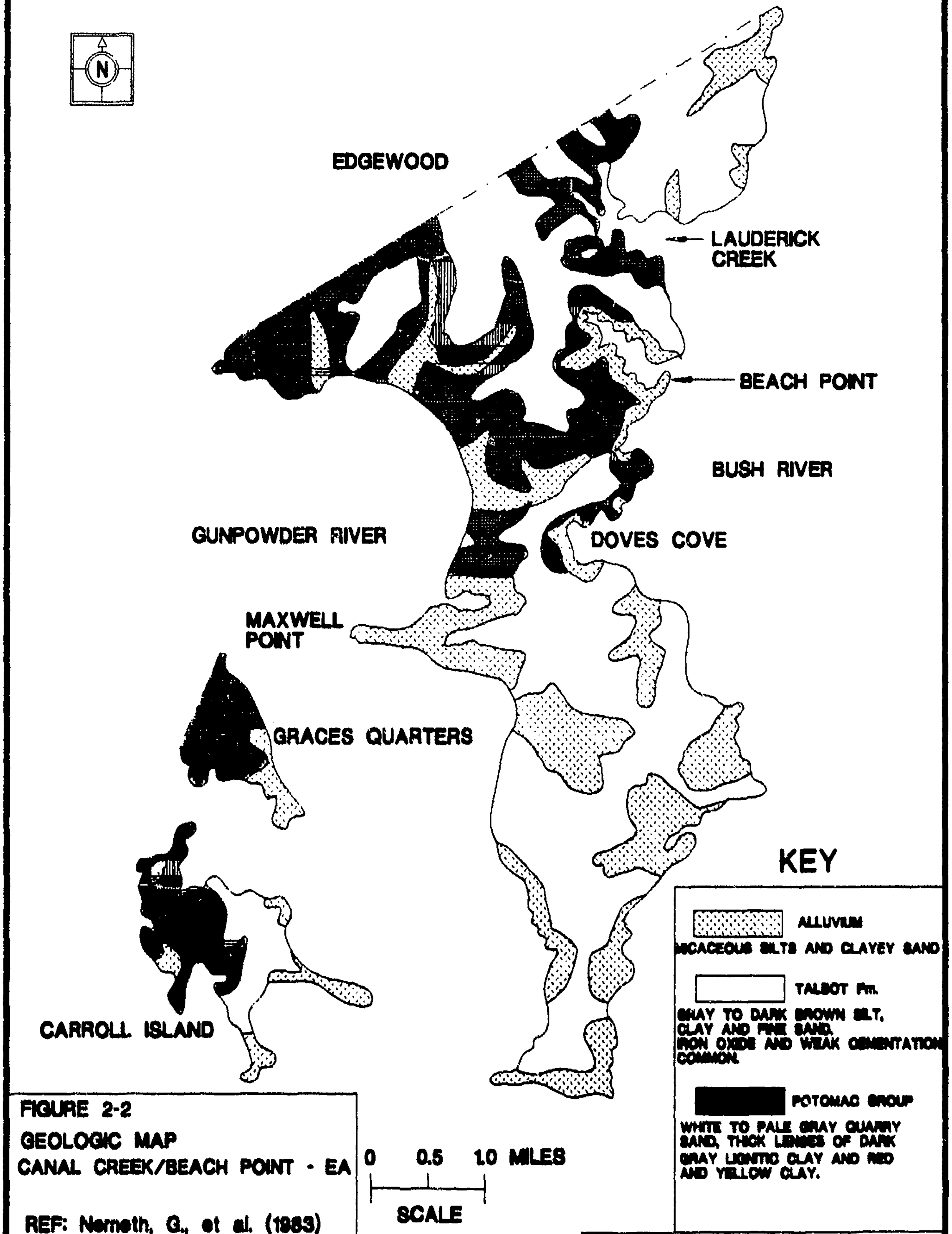


FIGURE 2-2
GEOLOGIC MAP
CANAL CREEK/BEACH POINT - EA

REF: Nemeth, G., et al. (1983)

JACOBS ENGINEERING GROUP INC.
[illegible] NEW YORK AVE, SUITE [illegible], WASHINGTON, D.C. [illegible]

granite, marble, and quartzite. The surface of this crystalline basement rock also dips to the southeast at an angle of less than one degree [Bennett and Meyer, 1952; Dingman et al., 1956; Southwick and Owens, 1969].

The geologic formations that outcrop within APG, from oldest to youngest, are the Potomac Group, Talbot Formation, and recent alluvium. The Potomac Group is Cretaceous in age and is subdivided into the Patuxent, Arundel, and Patapsco Formations. The Talbot Formation (the Talbot may be absent at Beach Point) is Pleistocene in age and occupies the higher ground, while the alluvial deposits are recent in age and occur at the lower elevations.

The Potomac Group sediments are continental in origin and were deposited in the floodplain of rivers, lakes, and swamps. The lowest member, the Patuxent, consists generally of light gray to orange, moderately sorted, angular to sub-rounded sands with gray silt and clay beds. The silt and clay can constitute over 50 percent of the material in localized areas. The clays are usually white but may be brown, red, or purple. Gravel occurs mostly in abandoned channels and may be cemented by iron oxide. The Arundel Clay overlies the Patuxent and is primarily a red and brown clay with iron oxide stains. Where iron stains are absent, the colors are gray to dark gray. Sand lenses along with thin seams of cemented sandstone also occur. The uppermost sediments of the Potomac Group, the Patapsco Formation, are somewhat similar to the Patuxent Formation. The noticeable difference is that the Patuxent contains more sand and gravel and the Patapsco is marked by a higher percentage of clay. The Patapsco sediments are composed essentially of red, brown, white, or gray gravel, sand, sandy clay, and clay. Crossbedding is common. Most beds are lenticular and change rapidly in character over short distances. The sands are fine-to-medium grained and sub-rounded with a minor amount of gravel.

The Talbot Formation and recent alluvium cap the Cretaceous sediments throughout most of APG. The Talbot is the youngest of five terraces and originally consisted of a series of clays, silts, sands, and gravels. the recent alluvium consists of silts, clays, and sands which border the drainage-ways and occupy the topographic lows.

Regional Hydrogeology. The principal water bearing formation in the Coastal Plan is the Patuxent Formation. The Patapsco Formation also contains beds of sand and gravel which yield large quantities of water. The Arundel Clay is considered to be a confining layer, but it can yield small quantities of water for domestic supplies. Clear differentiation of these Potomac Group formations in Harford County is reportedly difficult [Southwick and Owens, 1969]. The Pleistocene age deposits can yield significant quantities of water where the sand and gravel beds are thick. The Potomac Group and the Pleistocene age formations all provide, or have provided, water for usage on APG. The groundwater resources of Harford County are discussed in Nutter [1977], and Nutter and Smigaj [1975].

Surface Water Usage. The primary source of water for APG-EA has been from surface water. The system which has supplied potable water to the area is the Van Bibber system. During World War II (WW II) a system was also used which supplied water from the Bush River for use in production facilities.

Groundwater Usage. Groundwater has been a secondary source of water, and wells have been used to supply water when needs could not be satisfied by surface water supplies. The principal water-bearing unit on a regional basis is the Patuxent Formation, which yields significant quantities of water for domestic and municipal supply wells. In addition, the Patapsco Formation is considered an important aquifer at some locations where coarse-grained sand and gravel beds are present. However, neither of these units is used for water supply within APG-EA. Furthermore, significant water-bearing units of these formations are found at considerable depth throughout much of the installation, and thus are protected from surface contamination by multiple overlying confining beds. Although surface water has always been the predominant source of water on the installation, some water supply wells have been completed at depths greater than 100 feet; none of these wells (located within the Canal Creek industrial area and test range areas of Gunpowder Neck) are currently used for potable water supply, and most have been abandoned. There are no operating production wells in the Beach Point Test Site.

2.2 HISTORICAL PAST INSTALLATION RESTORATION PROGRAM (IRP) STUDIES - EA

2.2.1 Previous Investigative Studies

Previous investigations and studies that have addressed the Beach Point Test Site include the United States Geological Survey (USGS) Canal Creek study and several investigations by United States Army Environmental Hygiene Agency (USAEHA). These studies are described in the following subsections. Concentrations of contaminants of concern (COCs) are discussed in more detail in Section 2.4.

2.2.2 Preliminary Base Line Risk Assessment

A preliminary baseline risk assessment (ICF; Durda and others, 1991) was performed between October 1989 and January 1991 for eight priority areas at APG, one of which was the Canal Creek area. The risk assessments provide information on potential adverse effects on humans and wildlife from chemical contamination at these sites. The assessments, which are considered preliminary because of data limitations, are most useful for identifying the chemicals of concern, exposure pathways, and populations of greatest potential concern for each area. Data collected by the USGS (1986 to 1989) were used for this risk assessment, along with some previously referenced data. For the Canal Creek area, ICF concludes (1) that it is not possible to fully evaluate potential human health risks with the available data, (2) that acute and chronic toxicity from contaminants in Canal Creek probably has affected the composition and structure of the resident aquatic communities, and (3) that terrestrial wildlife feeding in Canal Creek appear to be at risk from dietary exposure to heavy metals.

2.2.3 USGS Canal Creek Study

The USGS Canal Creek study, conducted from 1986 to 1989, focused mainly on the East and West Branches of Canal Creek, but included some work at Beach Point and the Kings Creek/Bush River area. USGS installed and sampled two well clusters, with a total of six groundwater monitoring wells on or near Beach Point. USGS also collected a limited number of soil samples. In addition, eight surface water sampling stations were established along the Beach Point shoreline (four stations each in the Bush River and Kings Creek), along with five stations in upstream areas of Kings Creek. These surface water locations were sampled twice (September 1988 and June 1989).

Groundwater and surface water samples collected in the USGS study were analyzed for volatile organic compounds (VOCs), metals and other inorganic water quality parameters, and semi-volatile organic compounds (SVOCs). Soil samples were also analyzed for VOCs, SVOCs, and selected metals. The results of USGS's investigation are contained in several reports, including the following:

- Hydrogeology of the Canal Creek Area, Aberdeen Proving Ground, MD; USGS Water-Resources Investigations Report 89-4021; same as draft final HGA.
- Inorganic and Organic Groundwater Chemistry in the Canal Creek Area, Aberdeen Proving Ground, MD; USGS Water-Resources Investigations Report 89-4022;
- A series of letter reports (April 1989 and March 1990) from USGS to APG-DSHE, containing unpublished surface water data from sampling conducted at Beach Point, Kings Creek, and Canal Creek; and
- An unpublished USGS Canal Creek HGA* data report dated April 1992 (currently in final draft form April 1992) containing chemical data, soil boring and monitoring well construction data, and hydrogeologic data on Beach Point and the Canal Creek area.

It should be emphasized that the focus of the USGS study was on evaluating the hydrogeology and groundwater chemistry of the Canal Creek area, not Beach Point or Kings Creek. These latter areas were included in the USGS study because of similar geologic conditions (i.e., the surficial and Canal Creek aquifers identified by USGS in the Canal Creek also extend into the Kings Creek area). However, detailed discussions of the local hydrogeology, surface-water hydrology, and groundwater chemistry at Beach Point

* **This study was the guiding document for Beach Point FFS Work Plan.**

are not presented, or are included within other sections of the reports. Nonetheless, these reports represent the most recent and complete studies of groundwater and surface water contamination associated with Beach Point. USGS found that the surficial aquifer at Beach Point was contaminated with 1,1,2,2-tetrachloroethane and other chlorinated VOCs, and that measurable levels of these substances were present in surface water on both the Kings Creek and Bush River shorelines of the peninsula.

2.2.4 USAEHA Edgewood Area Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA)

As noted previously, the Edgewood Area RFA (Nemeth, USAEHA, 1989) is a detailed source of information on historical operations at Beach Point and surrounding areas. The RFA did not include environmental sampling at Beach Point, but contains a summary of existing data on SWMUs in the Kings Creek drainage area, including waste types and quantities, contaminant behavior and migration pathways, and recommendations for further study. In addition, the RFA contains detailed information of major processes performed at Edgewood (e.g., clothing impregnating, chemical agent production) and data on the environmental transport and fate of military-unique compounds related to these activities.

2.2.5 USAEHA Assessment of Surface Waters, Edgewood Area

This study (USAEHA Water Quality Biological Study No. 24-0043-78, 1977) was conducted during July 1977 to assess the impact of Edgewood Area domestic, industrial, and chemical point and non-point source discharges to the receiving water bodies and biota. It included 33 sampling sites throughout Edgewood Area, including four locations in Kings Creek. The sampling program included: (1) the collection and analysis of surface water samples for metals, nutrients, general water quality parameters, and cholinesterase inhibitors; (2) sediment sample analyses for metals, nutrients, and pesticides; (3) tissue residue analyses of resident fish and clams from selected sites for metals; and (4) tissue residue analyses of controlled populations of clams that were placed in wire cages at the water column-bottom interface for 10 weeks (again for metals only).

The results of this 15-year old study must be treated with caution because of the major changes that have taken place at the installation since the study was completed. The most significant of these changes is that nearly all of the point-source discharges noted at the time of the investigation have been discontinued. Wastewater is now generally handled through the sanitary or industrial sewer systems and treatment plants, and direct discharges from individual operations to nearby surface water bodies have essentially ceased. This situation contrasts sharply with the 1977 scenario described in the report in which 16 separate point-source discharges were identified to Kings Creek from surrounding chemical and ballistics testing and development operations at the time of the USAEHA investigation. This water body currently receives no direct point-source discharges.

Despite these limitations, the study provides valuable historical information on surface water quality and sediment and biota characteristics within Kings Creek. Major findings include severe nutrient overloading to Kings Creek; significant contamination of sediments with silver, mercury, and zinc; and clams, fish, and crabs containing among the highest levels of zinc, mercury, cadmium, and copper found within the installation.

2.2.6 USAEHA Sediment Analysis — Aberdeen and Edgewood Areas

This study (USAEHA Water Quality Engineering Study No. 32-24-0700-87, 1987) was conducted in July 1986 to determine the presence of APG-related contaminants in sediments from receiving water bodies near APG, and to evaluate macroinvertebrate community diversity in these sediments. Sediment samples were collected from 33 locations (16 stations in the Aberdeen Area and 17 stations in the Edgewood Area), including three locations within Kings Creek, and analyzed for nutrients, metals, and pesticides/PCBs. Macroinvertebrate species were also collected and taxonomically classified at all locations.

The study found that samples from Kings Creek, as well as other Edgewood Area sampling locations, contained moderate to high levels of arsenic, chromium, and lead. Several chlorinated pesticides were present at low levels. PCBs, however, were not detected in samples from Kings Creek. Community diversity in the creek appeared to fall within the range of conditions observed throughout the installation (i.e., no major impacts to the macroinvertebrate community were apparent); however, this aspect of the study was limited in scope and should not be considered definitive.

2.2.7 USAEHA Biological Survey for Canal, Kings, and Watson Creeks

In 1985, USAEHA performed a study to determine the presence and biological effects of priority pollutants in water, sediment, fish, and macroinvertebrates in Canal, Kings, and Watson Creeks (USAEHA Water Quality Biological Study No. 32-24-0404-86, 1985). Three stations were established in each of the creeks (i.e., total of nine sampling locations), and a four-phase sampling program encompassing surface water, sediment, fish, and benthic invertebrates was implemented. The program included four rounds of surface water sampling for VOCs, SVOCs, metals, pesticides/PCBs, and nutrients; two rounds of sediment sampling for metals and pesticides/PCBs; one round of fish tissue residue analyses for metals and pesticides/PCBs; and one round of macroinvertebrate sampling for species diversity.

Results for Kings Creek (including one station at the mouth of the creek near Beach Point) indicated contamination with SVOCs (phthalates, dinitrotoluene) and metals (most notably copper, lead, and zinc) in surface water; metals, pesticides, and N-chloro-bis(2,4,6 trichloroephenyl)urea contamination in sediments; and chlordane, DDT, PCBs, mercury, selenium, and zinc contamination in fish tissues. Macroinvertebrate community diversity was considered intermediate to poor; however, diversity indices showed downstream improvement from the headwaters area of Kings Creek to the Beach Point Test Site.

2.3 SITE ENVIRONMENTAL SETTING — Beach Point Test Site, APG-EA

This section presents a description of the physical and environmental setting at Beach Point; provides a brief operations and disposal history for the site; and is followed by a historical contamination assessment based on existing data.

2.3.1 Suspected Contaminant Sources

As indicated in the summary descriptions that follow, widely varying levels of information are available on these potential solid waste management units (SWMUs), ranging from limited environmental sampling to very limited information on production activities. However, three important factors should be recognized in the context of the Beach Point Investigation: (1) other potential contaminant sources are located in the Kings Creek drainage basin: these sources are addressed in other studies outside the scope of the Beach Point FFS; (2) many of these contaminant sources are facilities that historically discharge wastewater via drainage ditches directly to Kings Creek; and (3) most of those facilities were involved in operations similar to those conducted on Beach Point, including pyrotechnic and smoke testing, chemical agent storage, and ordnance testing. Investigating and addressing these factors is outside the scope of this FFS.

Several testing and production activities that may have contributed to environmental contamination in the Kings Creek/Bush River area were formerly located at Beach Point. These operations included the following major activities (USAEHA, 1989):

- Mobile and fixed-based clothing-impregnating plants were operated at Beach Point during and after World War II; these plants were used to treat clothing with a waxy material that provides resistance to penetration by chemical warfare agents such as mustard. The clothing-impregnating process involved several hazardous solvents as well as the impregnating chemical CC2 (N,N'-dichloro-bis(2,4,6-trichlorophenyl)urea) and chlorinated paraffin wax.
- Liquid rocket fuel testing, including the evaluation of fire and vapor suppression methods for these materials, was conducted in the northern area of the point from the early 1960s through the 1970s. Test materials included hydrazine, unsymmetrical dimethylhydrazine (UDMH), red fuming nitric acid (RFNA), nitrogen tetroxide, and other propellants and fuels.

- Pyrotechnic testing was performed by the Chemical Research Development Engineering Center (CRDEC) Research Directorate from the post-World War II period until about 1970; this testing included work with grenades and pots filled with obscurant (i.e., white) smoke, with limited testing of colored smokes. Fog oil was also used extensively in smoke and pyrotechnic testing at Beach Point.

In addition to these major operations, Beach Point was also used for small-scale storage of lethal agents (G-agents) during the 1950s, and was used as a firing position for testing of 4.2-inch mortars in the 1940s. However, neither of these activities is considered to be of major environmental significance compared to the clothing-impregnating, pyrotechnic, and rocket-fuel testing (USAEHA, 1989).

More detailed descriptions of these potential waste-generating operations, including information on the possible types and quantities of waste materials as well as waste storage and disposal methods, are described in the following subsections. (NOTE: The information included in the remainder of this section has been summarized from the Edgewood Area RFA [Nemeth, USAEHA, 1989]).

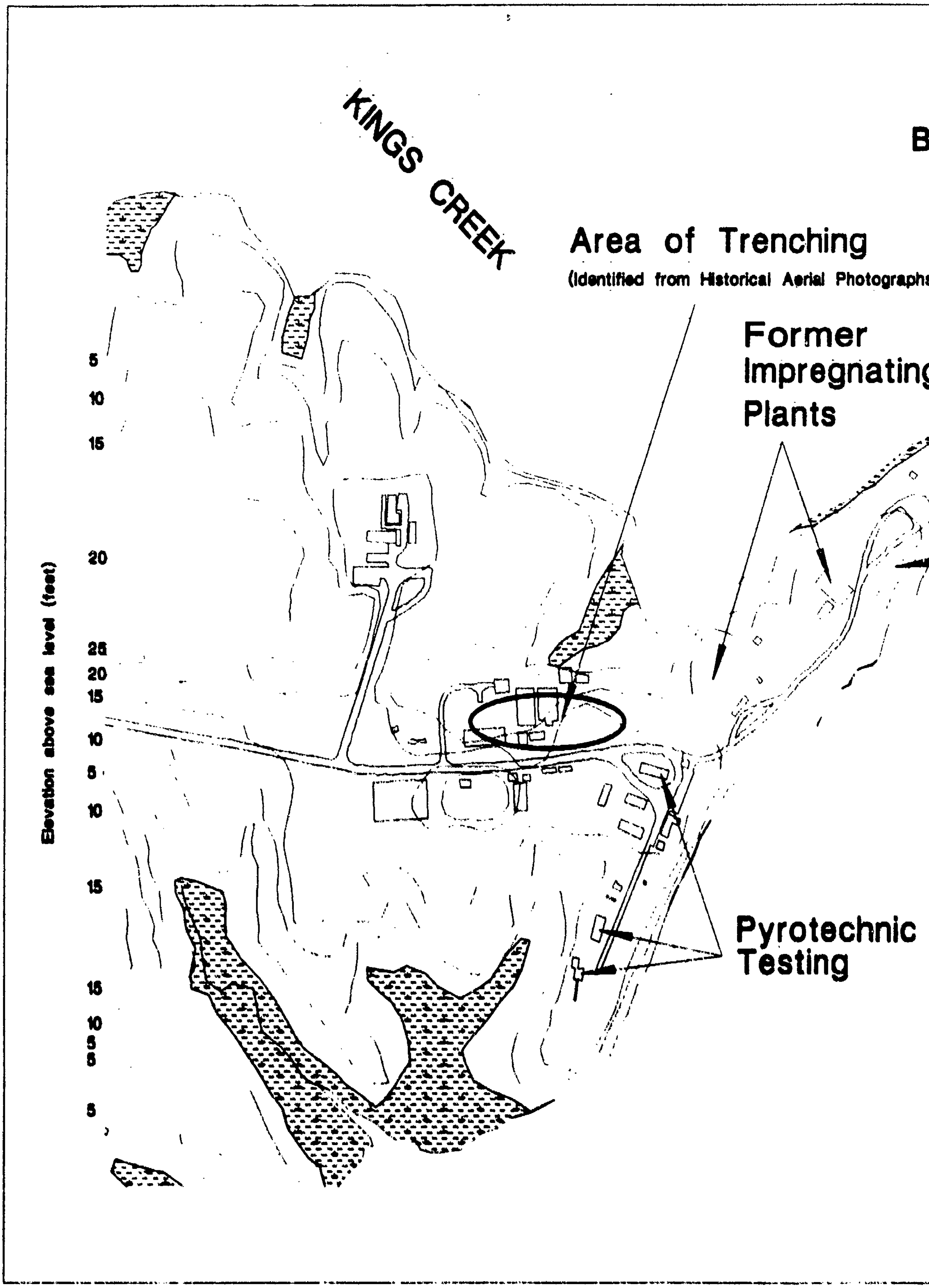
2.3.1.1 **Clothing-Impregnating Operations**. Beginning in 1943, Beach Point was the site for pilot-scale testing and full-scale operation of mobile clothing-impregnating operations. Operations at the point included both the M1 (solvent-based) and M2 (water-based) processes, using the impregnate CC2 (N,N-dichloro-bis(2,4,6-trichlorophenyl)urea). These plants were located in the central portion of the Beach Point peninsula.

Both the water-based and solvent-based processes utilized CC2 and chlorinated paraffin waxes, as well as 1500 to 1800 pounds of chlorobenzene over the period of operation 1943 to 1947. The solvent-based process was also estimated to have used approximately 100,000 pounds of 1,1,2,2-tetrachlorethane during this period (USAEHA, 1989). Other chemicals that may have been used in the impregnating processes include zinc oxide and the solvents polyvinyl alcohol and 1,2-

dichloroethane. Reports also indicate that carbon tetrachloride, paraformaldehyde, formaldehyde, tetrachloroethylene, kerosene, dichloromethylhydantoin, and chlorinated kerosene may have been used in pilot-scale or developmental clothing impregnating processes (USAEHA, 1989).

Losses of tetrachloroethane, chlorobenzene, impregnate materials, and other solvents (if used) may have occurred through volatilization, spillage, or leakage, as well as direct discharge of off-specification batches, dirty or spent solvents, or contaminated materials to Kings Creek and/or the Bush River. Historical aerial photographs indicate the presence of several small pits near the clothing-impregnating plants that were probably used for disposal of liquid wastes (USAEHA, 1989). In addition, historical evidence suggests that wastewater from the plants was most likely discharged directly to nearby surface water bodies without treatment.

2.3.1.2 Rocket Fuel Testing. Testing to evaluate fire and vapor suppression methods for liquid rocket fuels was performed in the northern portion of Beach Point (see Figure 2-3) from the early 1960s through the 1970s. Although testing appears to have been varied and extensive, a typical procedure involved the mixing of the hypergolic propellants, such as hydrazine, UDMH, RFNA, and nitrogen tetroxide, in a large burn pan (16 feet square by 1 foot deep) to form a fireball, and attempting to suppress the flame with water deluge or mist (USAEHA, 1989). There is also evidence to suggest that "halon"-type materials (i.e., chlorofluorocarbons [CFCs]) were used as fire suppressants in some tests. As an example of typical operations, during the period 1963 to 1965, a series of 47 tests were performed, using approximately 10,000 pounds of fuel and oxidizers. Although definitive information regarding wastewater handling at the rocket fuel testing area is not available, it appears that wastewater from tests was either discharged directly to the Bush River or Kings Creek, or allowed to run off onto the ground surface. Either method would have resulted in potential contamination of surface water, sediment, and possibly groundwater with propellant residues and other waste materials.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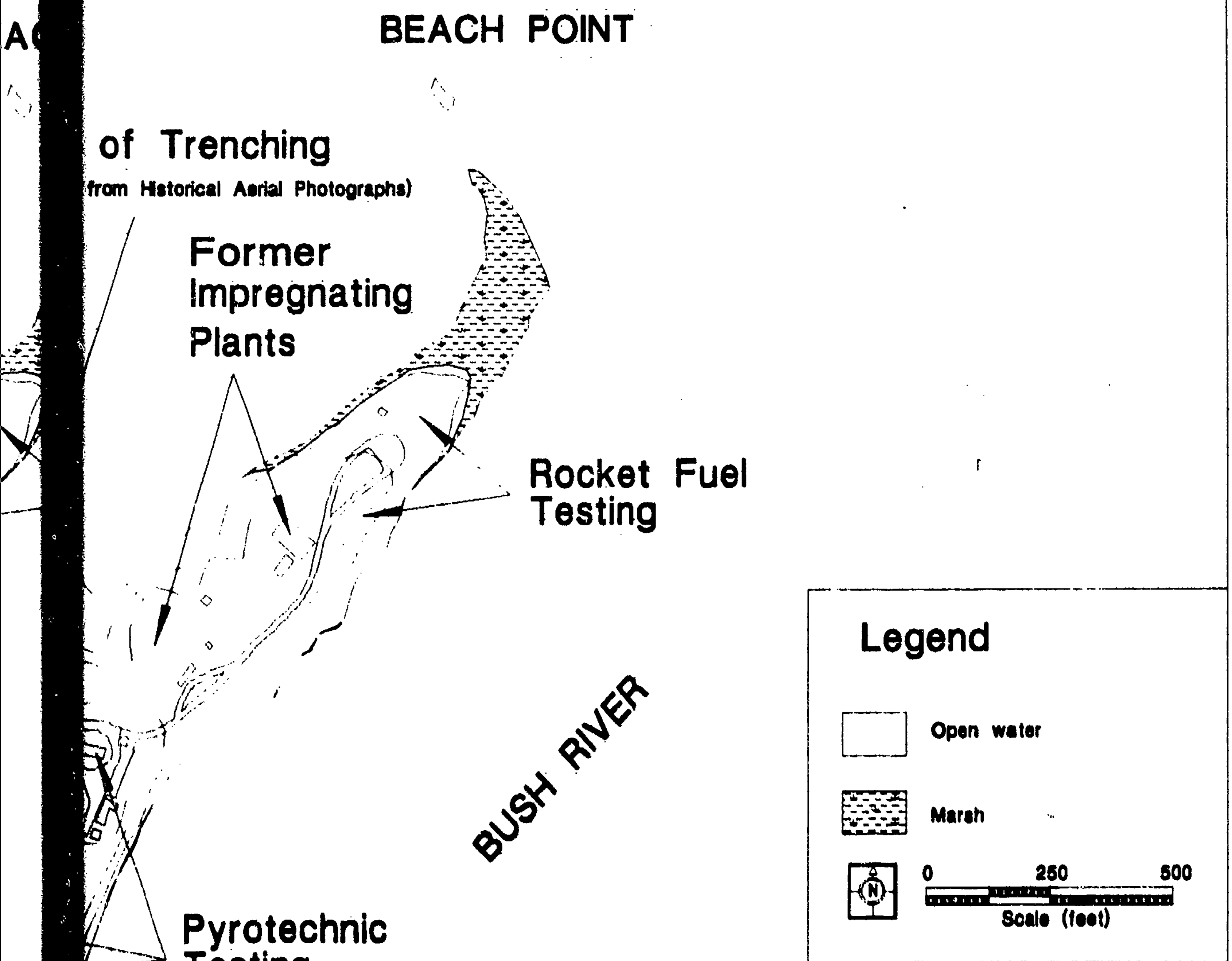

Figure 2-3

Probable Contamination Source Areas on Beach Point

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[illegible] NEW YORK AVE, SUITE [illegible], WASHINGTON, D.C. [illegible]

In addition to rocket fuel testing, small quantities of explosive mixtures and compounds were tested in the northern area of Beach Point during the 1970s (McKown, personal communication). Test materials may have included trinitrotoluene (TNT), tetryl, RDX, HMX, and other explosive/propellant compounds.

2.3.1.3 Pyrotechnic Testing. As noted, pyrotechnic and smoke testing was performed at Beach Point by CRDEC from the 1940s to about 1970. These tests were performed in test chambers in Buildings E3861, E3871, E3870 as well as at outdoor locations in the southern portion of the peninsula (Figure 2-3). The primary materials tested were white obscurant smokes (e.g., HC) in grenades and pots, and fog oil. Other pyrotechnic materials (e.g., FS, WP) also may have been tested, but records on the types and quantities that may have been tested are not available. Materials associated with pyrotechnic testing often include aluminum, magnesium, zinc, lead, and titanium, as well as petroleum compounds, hexachloroethane, and other organic compounds.

2.3.1.4 Other Beach Point Operations. Additional environmentally significant activities that have been conducted at Beach Point include the storage of small quantities of lethal chemical agents (G-agents) during the 1950s, and test firing of 4.2-inch mortars during the 1940s. The nerve agents were reportedly stored in Building E3990 or another small structure near the northern end of the peninsula, and there is no evidence to suggest that any spillage or leakage occurred from this unit. Mortar firing could potentially release small quantities of explosive compounds (including dinitrotoluene, nitrocellulose, dibutylphthalate, and diphenylamine) to the environment. However, the nature of the testing performed at Beach Point (direct firing of loaded munitions) makes significant environmental contamination from these operations unlikely (USAEHA, 1989).

2.3.1.5 Edgewood Area Sanitary Wastewater Treatment Plant (WWTP). This wastewater plant has operated since 1942, originally as a primary treatment plant and currently as a secondary treatment trickling-filter plant with a design capacity of 3 million gallons per day (MGD). The plant received very high loadings of toxic substances during early operation, especially 1,1,2,2-tetrachloroethane from production activities during and after World War II. Currently, wastewater containing hazardous substances is pre-treated before discharge to the sanitary system or is diverted to the industrial wastewater treatment plant, and sludge from the WWTP has been determined to be non-hazardous by RCRA testing. The plant discharges directly to the Bush River under the National Pollutant Discharge Elimination System (NPDES) permit.

2.3.2 Geology

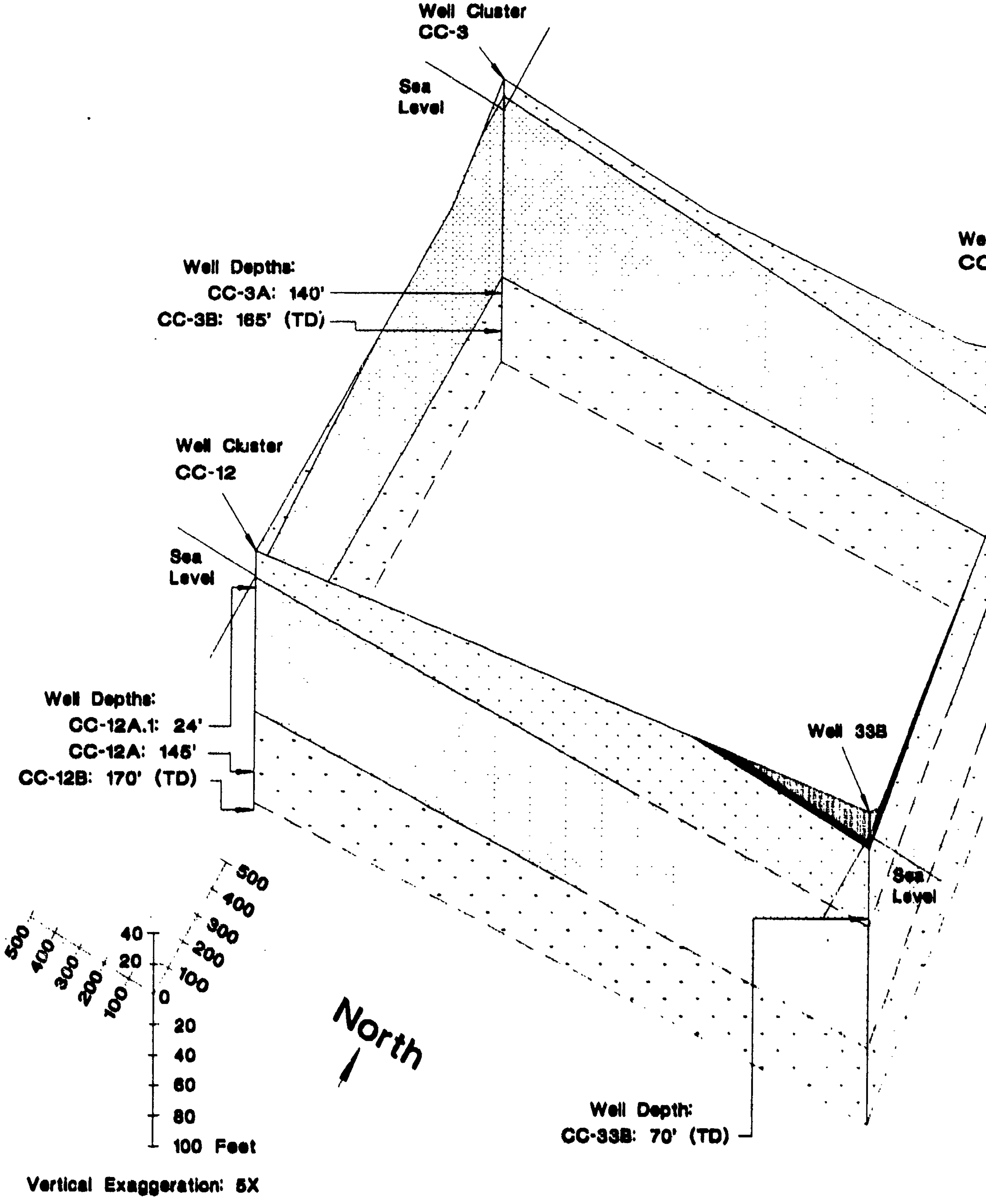
APG-EA is underlain by coastal plain sediments consisting of unconsolidated clay, silt, and sand layers with occasional gravel lenses. The coastal plain sediments are several hundred feet thick in the vicinity of the installation, and consist predominantly of the Potomac Group (subdivided into the Patuxent, Arundel, and Patapsco Formations), the Talbot Formation (probably absent at Beach Point), and recent alluvium. Within the Potomac Group, the Patuxent Formation is comprised mostly of medium-grained sand with some silt and clay, while the Arundel Formation is predominantly red to brown clay. The uppermost member of the group, the Patapsco Formation, consists of sand and gravel with subsidiary clay lenses. The younger Talbot Formation (consisting of a terrace sequence of sands, silts, and clays) usually overlies the older Potomac Group sediments, and is more often encountered in upland areas of APG. Recent alluvium is mostly associated with stream channels and other areas of active deposition.

Within the Beach Point study area only the surficial aquifer will be addressed, the lower aquifers will be studied as part of the Canal Creek RI/FS. Surficial sediments consist of a clayey soil to a depth of about four feet, underlain by approximately 60 feet of fine- to medium-grained, well-sorted sand, interfingered with thin lenses of clay and silty sand and sometimes containing coarse sand and gravel layers (USGS, 1989a). This unit, which appears to be part of the Potomac Group, is underlain by a clay layer identified in the USGS Canal Creek study (1989) as the upper confining unit. This unit was not penetrated at Beach Point, but based on interpretation of boring logs from nearby areas suggest a thickness of approximately 88 feet and thinning in east-southest direction. The upper confining unit may consist of mainly Potomac Group sediments (possibly Arundel Clay). The CC-33B well is the deepest penetrating well in the surficial aquifer (see Figures 2-4 and 2-5). Beach Point surficial sediments and clay confining unit appear to dip gently (about 50 feet/mile) to the southeast coast (USGS, 1989).

2.3.3 Groundwater

Groundwater at Beach Point is encountered at shallow depths (e.g., from less than 13 feet to about 16 feet below ground surface in most areas) under unconfined conditions. The water-table aquifer in many areas is hydraulically interconnected to creeks, wetlands, and other surface water features, and is tidally influenced at locations in proximity to the Bush and Gunpowder Rivers and associated tidal creeks/wetlands. Net groundwater flow direction in the water-table aquifer at most locations is toward nearby major water bodies, but tidal effects and the influence of wetlands and smaller water bodies can make groundwater flow patterns locally complex. Gradients are generally flat (reflecting surface topography and fluctuating tidal and seasonal water levels), resulting in relatively slow groundwater flow rates in most areas of the water-table aquifer.

The water-table aquifer at Beach Point appears to be an isolated part of the surficial aquifer identified throughout the Canal Creek area of APG by USGS (1989 and 1992). As noted above, this unit is most likely comprised mainly of sediments associated with the Potomac Group, and consists of fine- to medium-grained sand. Some hydraulic testing (e.g., slug) was performed on wells installed within the Beach Point Test Site (test results not available), but slug tests from other areas of the surficial aquifer within the Canal Creek


Well Cluster
CC-3
Sea
Level
Well Depths:
CC-3A: 140'
CC-3B: 165' (TD)
We
CC
Well Cluster
CC-12
Sea
Level
Well Depths:
CC-12A.1: 24'
CC-12A: 145'
CC-12B: 170' (TD)
Well 33B
Sea
Level
500
400
300
200
100
40
20
0
20
40
60
80
100 Feet
500
400
300
200
100
North
Well Depth:
CC-33B: 70' (TD)
Vertical Exaggeration: 5X

A

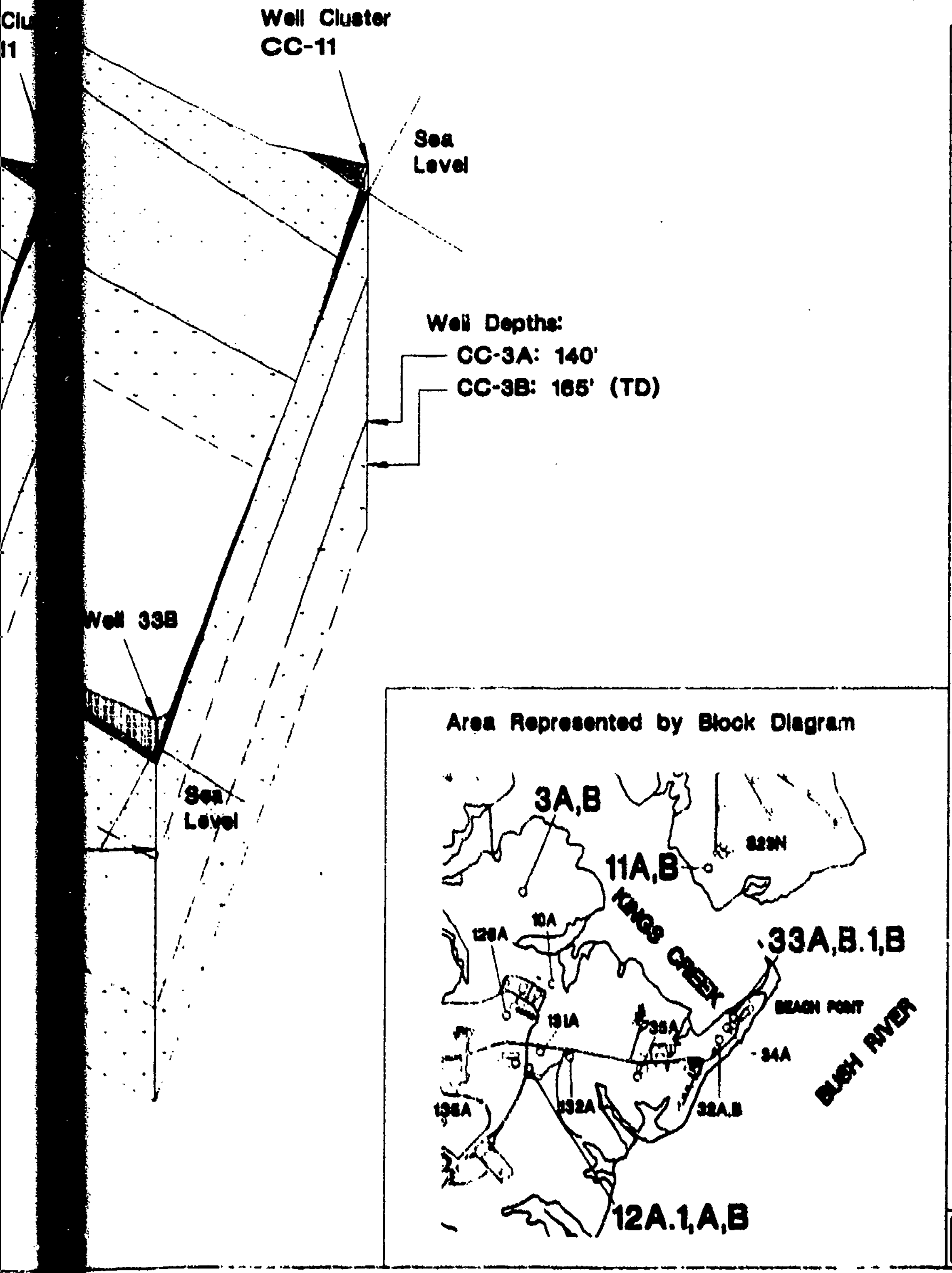


Figure 2-4

Block Diagram Depicting Regional Geologic Strata Proximate to Beach Point (as interpreted from gamma ray logs in referenced wells)

11/21/92

▦	Sand and gravel
▤	Clay and silt
⬚	Surficial Aquifer
☐	Aquitard
⬚	Canal Creek Aquifer
- - -	Interface location approximate
(TD)	Total Depth of Deepest Well in Each Cluster

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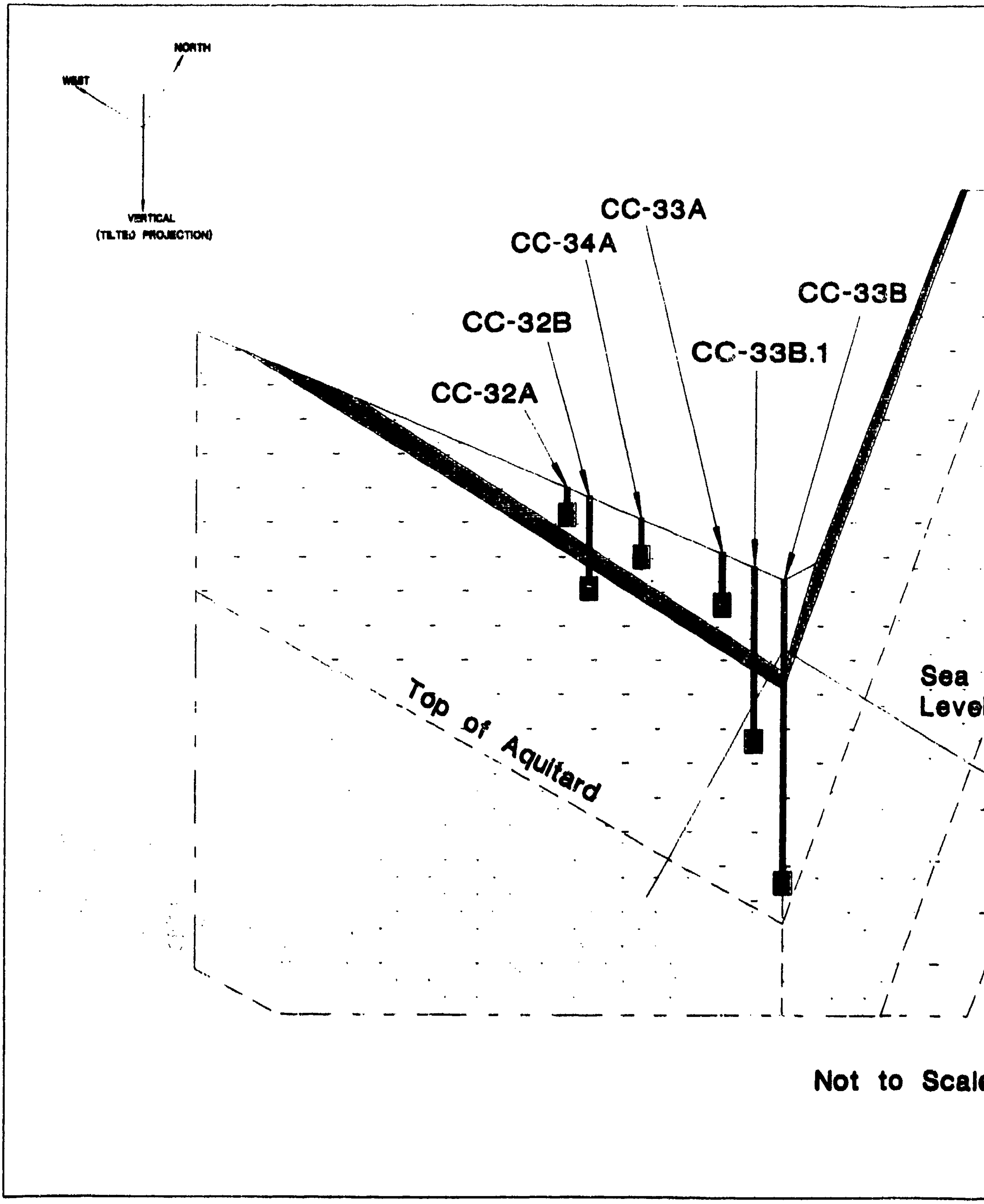
B


NORTH
WEST
VERTICAL
(TILTED PROJECTION)
CC-33A
CC-34A
CC-33B
CC-32B
CC-33B.1
CC-32A
Top of Aquitard
Sea
Leve
Not to Scal

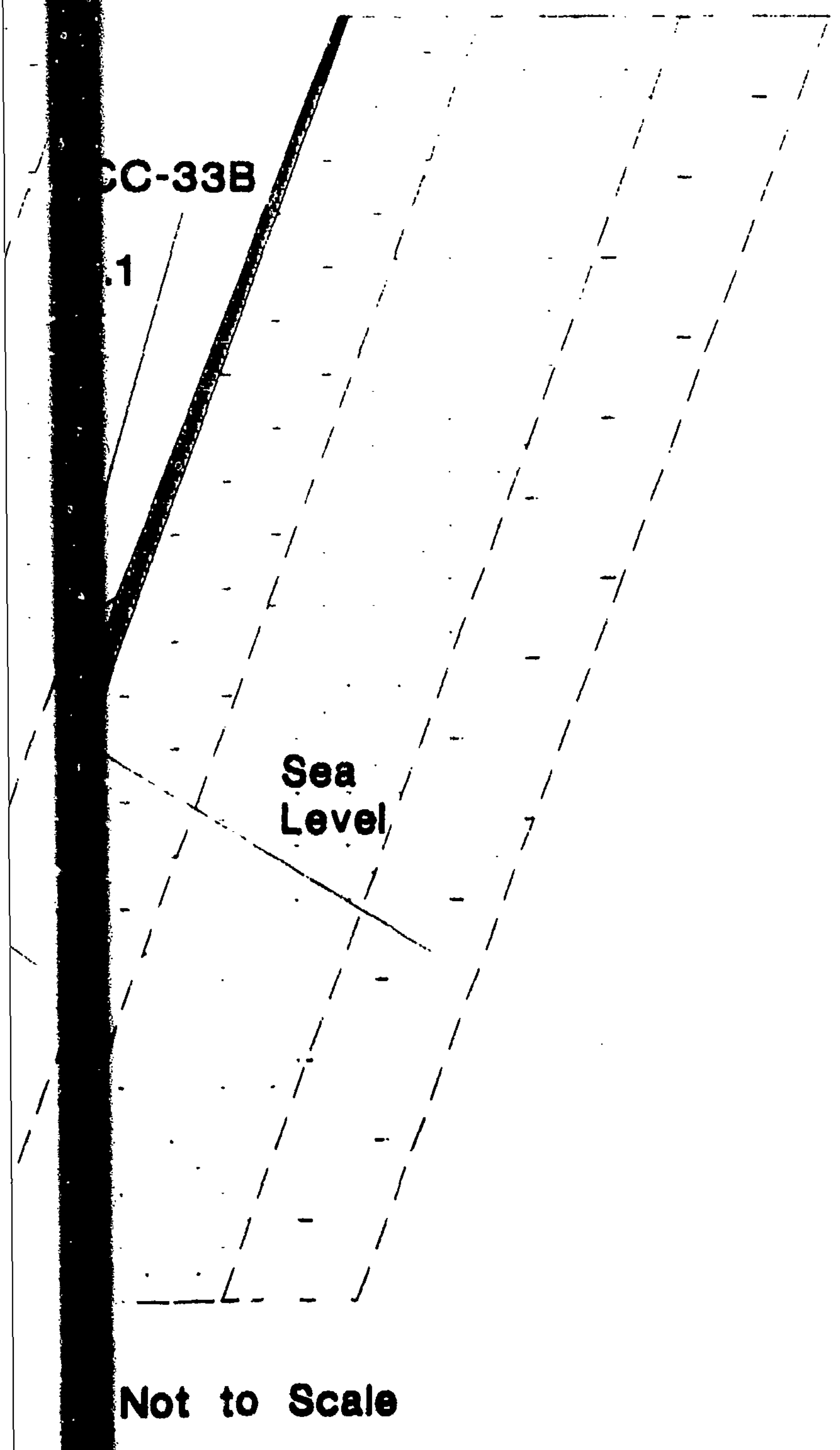


Figure 2-5

Schematic Diagram of Local Geologic Strata and Well Screen Locations at Beach Point

11/28/92

☐	Sand and gravel
▤	Clay and silt
⁘	Surficial Aquifer
☐	Aquitard
⁙	Canal Creek Aquifer
— —	Interface location approximate
— - - -	Stratum continues horizontally

▮ — Grounwater Monitoring Well
▮ — Screen Location

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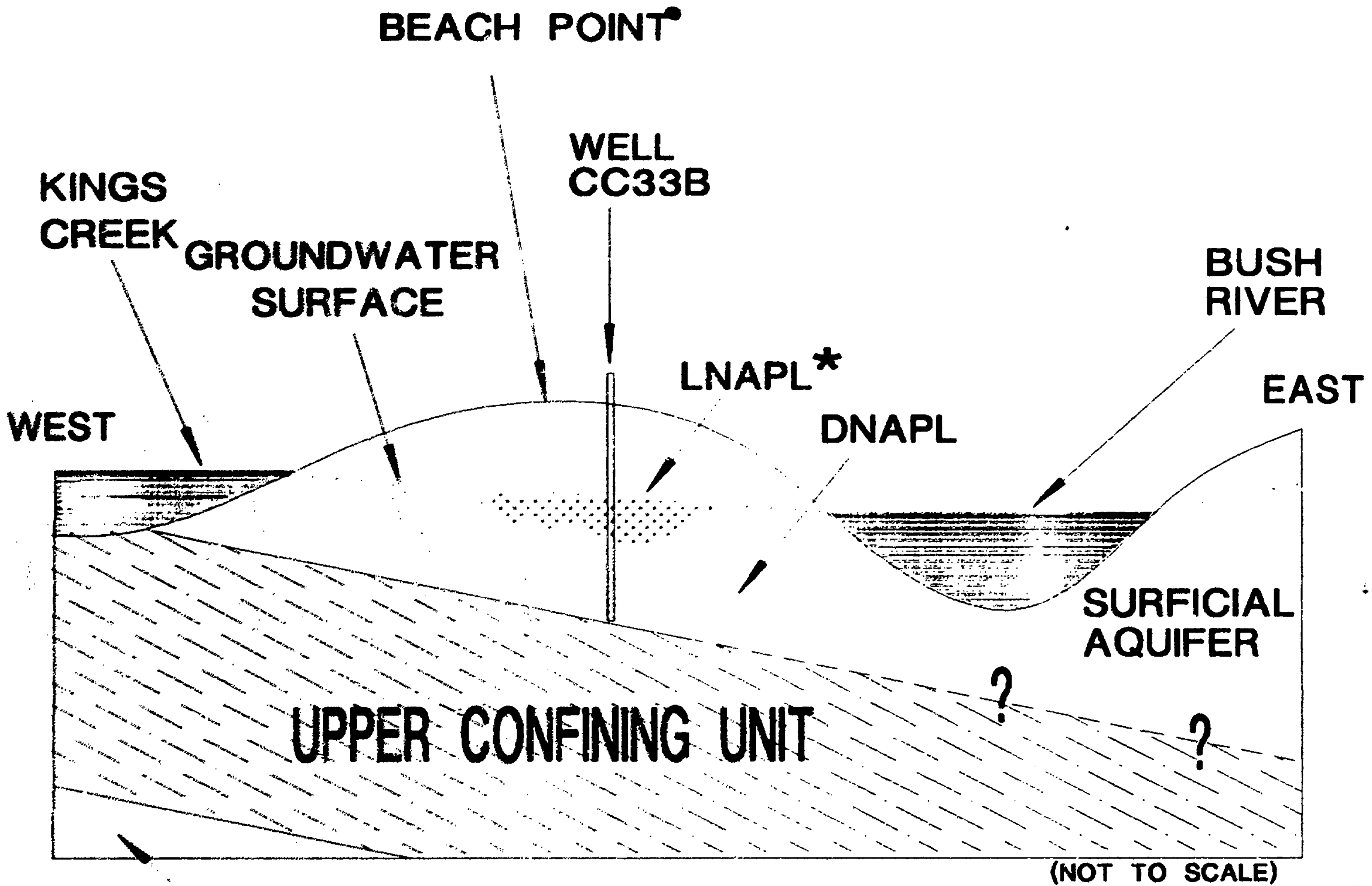
L

drainage suggest a hydraulic conductivity of 10 to 50 feet/day (10^{-2} to 10^{-3} c,/sec). The confining unit beneath this surficial aquifer appears quite thick (88 feet) and laterally continuous at Beach Point. Therefore, the underlying sand and gravel unit (the Canal Creek aquifer) is not likely to exhibit significant hydraulic interconnection with the water-table aquifer. A generalized hydrogeologic section of the Beach Point Canal Creek area is presented in Figure 2-6. The deeper aquifers at Beach Point will be addressed in the Canal Creek RI/FS.

Very limited water level information from the Beach Point Test Site collected by USGS as part of their Canal Creek study indicates that the water-table aquifer is tidally influenced. It appears that the aquifer may discharge to both Kings Creek and Bush River, depending on the specific location on the Point. Vertical gradients appear to be generally downward from the surficial unit to the Canal Creek aquifer. However, the thickness and continuity of the clay unit make it unlikely that significant vertical groundwater movement (and associated contaminant migration) into the deeper aquifer actually occurs at Beach Point (USGS, 1989). Overall, the water-table groundwater system within Beach Point appears to be characterized by local recharge, short flow paths, and tidal influences (USGS, 1989). Tidal effects result in variable horizontal gradients and possible short-term fluctuations in groundwater flow rates and recharge-discharge relationships.

Quarterly groundwater elevation monitoring performed by USGS from 1988 to 1989 in wells installed at Beach Point (see Table 2-1) indicates relatively constant water levels (within tidal variations) over the year, with little seasonal variation (USGS, unpublished data). This suggests that the surficial aquifer at Beach Point is more strongly influenced by tidal conditions than by recharge from infiltrating precipitation. However, a complete set of short-time water-level measurements that would allow tidal head differences and gradient fluctuations to be quantified is not available.



*Represents dissolved phase only

Figure 2-6

Generalized Hydrogeological Section of Beach Point

6/9/93

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Table 2-1. Synoptic Water-Level Measurements from Wells in the Beach Point Test Site

		Groundwater Elevations, in Feet Above Sea Level				
Local Number	**Aquifer**	**08/08/88**	**12/02/88**	**04/13/89**	**07/19/89**	**10/30/89**
CC-32A	S	1.19	.79	1.03	1.51	1.18
CC-32B	S	1.16	.58	1.29	1.85	1.18
CC-33A	S	1.09	.76	.94	1.38	1.12
CC-33B.1	S	.88	.11	1.18	1.87	.93
CC-33B	S	.97	.17	1.25	1.94	1.00
CC-34A	S	.20	.69	1.05	1.61	1.12
CC-35A	S	-3.87	-3.97	-3.40	-3.24	-3.58

Studies by USGS (1989 and 1992) indicate that groundwater at Beach Point contains 1000 to 3000 mg/L total dissolved solids (TDS), and is characterized by a distinct sodium chloride chemistry typically associated with fresh to slightly brackish water. The TDS values and major-ion chemistry observed in groundwater are very similar to the surface chemistry in Kings Creek and the Bush River, and indicate a significant interconnection with these nearby surface water bodies.

2.3.4 Surface Water Hydrology

Beach Point is located at the mouth of Kings Creek, which drains approximately 800 acres of the northeastern portion of the Gunpowder Neck peninsula (see Figure 2-1). The Kings Creek drainage basin is located completely within the boundaries of APG-Edgewood Area and, as noted, encompasses the majority of chemical and ballistics laboratory and R&D facilities on the installation.

Kings Creek is essentially a tidal estuary associated with the Bush River, and flow from the creek appears to occur mainly as a result of tidal flushing (i.e., net adjective flow resulting from stream gradient appears minimal). Drainage into the main body of the creek is through numerous subsidiary or "feeder" streams and wetlands. The tidal range for the creek is typically less than 1 foot, and salinity generally varies from approximately 1 to 3 salinity units (parts per thousand, or ppt) (USAEHA, 1986). A bathymetric map of the creek is not available, but surrounding topography suggests that most of the creek is likely to be shallow (i.e., less than 10 feet deep).

The Bush River at Beach Point is also tidal, with a range of 0.5 to 1.5 feet. The river is approximately one mile wide at Beach Point, and is generally less than six feet deep except in the shipping channel, where the depth is about 20 feet. Major tributaries to the river include Otter Point Creek, Lauderick Creek, and Kings Creek. Net daily or annual flow information on the Bush River in the Gunpowder Neck area is not available.

2.3.5 Natural Resources and Habitat

The National Oceanic and Atmospheric Administration (NOAA) identifies the entire Kings Creek shoreline, with the exception of Beach and Tapler Points, as freshwater wetland and marsh habitat. The Kings Creek and Bush River shorelines of Beach Point and Tapler Point are classified as coarse sand beaches.

APG provides important wildlife habitat for many aquatic organisms, including several endangered or threatened species (e.g., striped bass), and commercially important species such as the blueback herring. Many types of wading birds, waterfowl, and raptors (e.g., bald eagle, osprey) are found in near-shore habitats at APG, and much of the base is managed for wildlife, which include white-tailed deer, beaver, and wild turkey.

Concurrent studies by ICF and the University of Maryland will address biomonitoring and risk assessment. Further studies by ICF will provide a detailed analysis of the ecology of Kings Creek.

2.3.6 Preliminary Aerial Photography Analysis

This preliminary analysis of the available aerial photographs at APG-DSHE has large data gaps due to the limited range of photos. (Additional photos will be obtained from various sources to address these gaps and Beach Point data will be re-evaluated during Phase I of the FFS.)

Analysis of available aerial photographs was performed to examine the history of construction and excavation at the Beach Point Test Site. This review assists with locating any pits, trenches, landfills, and lagoons that are possible source areas for environmental contamination of the site. Photo pairs were viewed with a stereoscope to achieve a three-dimensional view of the site and surrounding areas. The following stereo pairs from APG-DSHE archives were reviewed:

Photo Number (pair)	Date	Approximate Scale
16-V05-36 (37)	circa 1944	1:9000,
ANK-3K-128 (129)	July 1952	1:10000,
ANK-3T-165 (166)	August 1957	1:10000, and
GS-VCLI 3-135 (136)	February 1970	1:10000.

The 1944 stereo pair shows the Beach Point peninsula is heavily vegetated with large trees. One major structure appears on the peninsula at the midpoint of the south side of the site. Several small sheds are located north and northwest of this building. A pipeline is shown leading from the building into the Bush River. No pits or other excavations are apparent on the peninsula.

The 1944 photos show that the wastewater treatment plant (WWTP) is constructed immediately west of the peninsula. The WWTP consists of two circular trickling filters, or clarifiers, along the south side of Beach Point Road; two lagoons, approximately 40 feet wide and 125 feet long, along the north side of the road; and three smaller lagoons, or sludge drying beds, west of the larger lagoons. A filled flat area, approximately one acre, extends south from the clarifiers toward Bush River. Both of the larger lagoons appear filled with liquid. Liquid in the northern lagoon shows as light to medium gray, approximately the same shade of gray as shallow water in Bush River. Liquid in the southern lagoon appears black, suggestive of a liquid that is not water. No liquid is apparent in the three smaller lagoons. A trench, or borrow pit, is shown immediately north of the lagoons. The pit starts approximately 250 to 300 feet west of the smaller lagoons and extends eastward into Kings Creek. Material from this area may have been used to level the land upon which the WWTP was built.

The 1952 stereo pair shows two additional buildings erected on Beach point in a cluster within the area of the originally mentioned structure. A small pit shows approximately 200 feet northeast of these buildings about half the distance between the buildings and the end of the peninsula. The size of the pit is estimated as 10 feet wide and 25 feet long. Liquid is not visible in the pit. At least eight new structures are located east of the WWTP and southwest of the Beach Point building cluster. Two nearly circular objects less than 10 feet in diameter appear approximately 100 feet southwest of the building cluster. These objects may be small pits; however, shadows from nearby trees make interpretation difficult.

In the 1957 stereo pair, the cluster of three buildings on the Beach Point peninsula are demolished. The pit northeast of these former structures appears to have been filled and reclaimed. The small, nearly circular pits are also not visible in the photographs. The two large lagoons at the WWTP have been filled and replaced by three smaller lagoons. Many trees make viewing difficult for observing other lesser changes in the area.

The 1970 stereo pair shows that the tip of Beach Point extending approximately one-quarter the length of the peninsula is cleared of trees. A dark area appearing in the center of this cleared area is probably the rocket fuel fire-suppression test area. A pit appears at the site of the building described in the 1944 aerial photos. No liquid is seen in the pit. The WWTP has been modified to include two large trickling filters; one located south of Beach Point Road and east of the older clarifiers, the other located north of the road and east of the three lagoons. A small, irregularly-shaped area, possibly an excavation, shows approximately 150 to 200 feet east of the northern trickling filter. Numerous small structures exist in the tree-covered area of the peninsula.

All aerial photos will be re-evaluated as part of this study when a complete set has been received and interpreted.

2.4 HISTORICAL CONTAMINATION ASSESSMENT

This section describes the nature and distribution of chemical contamination at Beach Point. The assessment is based on the results of previous investigations and sampling events, and includes an evaluation of chemical conditions in groundwater, surface water, soil, sediment, and biota (although the data sets for the latter two media are very limited). In addition, a discussion of potential migration pathways, as well as fate and transport characteristics of site-related chemicals, is also included, and a comparison to background conditions in Kings Creek is presented (again, based on very limited data). The section concludes with a brief summary and discussion of data gaps. Table 2-7 at the end of this section contains a list of the present chemicals of concern (COC).

Chemical Contamination in Environmental Media. As described previously, past industrial and ordnance-testing operations in the Beach Point Test Site have potentially contaminated surface and subsurface soils, groundwater, surface water, sediment, and biota. These contaminants include metals, propellant and fuel compounds, VOCs, and clothing-impregnating compounds. This section presents a summary of existing data on chemical contamination in these media.

2.4.1 Soil

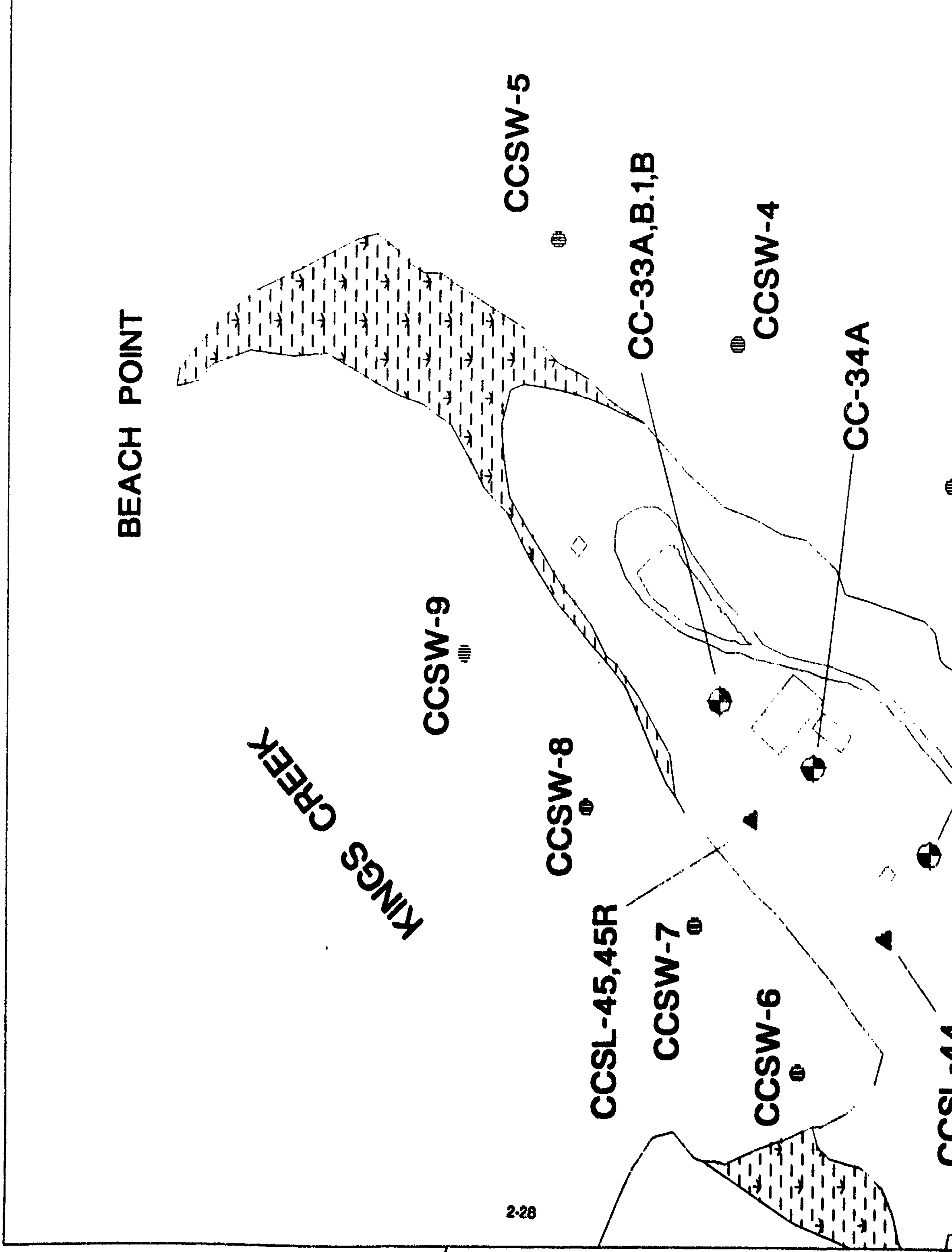
Two surface soil samples (#44 and #45) from Beach Point were collected near the former location of the mobile and fixed-base clothing-impregnating plants (Figure 2-7) and analyzed for VOCs, SVOCs, and selected metals. These samples were collected by USGS as part of the Canal Creek investigation, and were analyzed according to USATHAMA protocols by a United States Army Toxic and Hazardous Materials Agency (USATHAMA) class laboratory.

Analytical results for the samples are presented in Tables 2-2 and 2-3. Detected parameters included several metals (iron, manganese, calcium, magnesium, sodium, and arsenic) and the organic compounds phenol and trichlorofluoromethane (TCFM). Although a background sample for direct comparison was not collected, all of the detected metals are common soil components, and it appears that the measured concentrations are within naturally occurring ranges for soils in the Eastern U.S. It should be noted that zinc, which was used in the XXCC3 clothing-impregnating process and is a major component of many pyrotechnic and smoke mixtures, was not detected in the surface soil samples.

The organic compounds phenol and TCFM are present in site soils only at trace levels (less than 1 ug/g), and cannot be directly linked with past site operations based on information regarding clothing impregnating. However, phenol is a common industrial chemical that could be derived from numerous sources, and TCFM may be present as a result of rocket fuel testing in which CFC compounds were used as fire suppressants.

2.4.2 Groundwater

Groundwater data for VOCs, SVOCs, metals, and major ions are available from six monitoring wells installed in the Beach Point Test Site by USGS as part of their Canal Creek study. As shown in Figure 2-8, monitoring wells 32A, 32B, 33A, 33B, and 34A are located on Beach Point in the vicinity of the former clothing-impregnating operations. Well 35A represents a potential background location for the point; however, this well may be located downgradient from other source areas.


BEACH POINT
CCSW-5
CC-33A,B.1,B
CCSW-4
CC-34A
CCSW-9
CCSW-8
KINGS CREEK
CCSL-45,45R
CCSW-7
CCSW-6

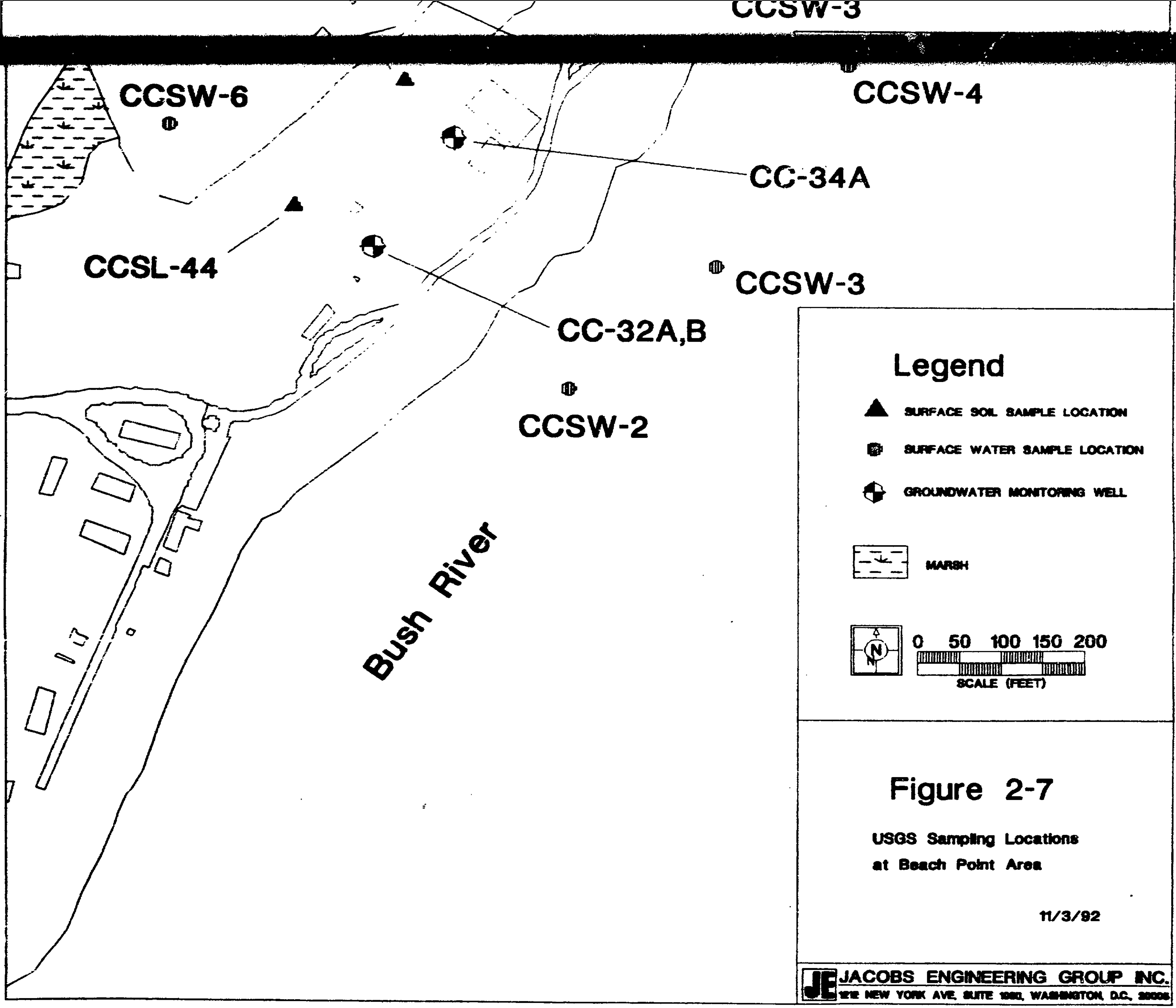


Figure 2-7

USGS Sampling Locations
at Beach Point Area

11/3/92

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Table 2-2. Inorganic Chemical Data for Soil Samples Collected in the Beach Point Area[1]

ANALYTE	CCSL-44	CCSL-45	CCSL-45R
Date Collected	9/26/89	9/26/89	9/26/89
Moisture % wet wt.	17.9	19.7	20.1
Calcium	480	1,500	2,700
Magnesium	1,200	1,800	1,900
Sodium	370	380	380
Silica	77	76	120
Nitrogen, Ammonia + Organic	—	—	—
Phosphorus	—	—	—
Iron	11,000	12,000	10,000
Manganese	81	160	190
Antimony	<3.8	<3.8	<3.8
Arsenic	3.7	3.0	2.5
Boron	<33	<33	<33
Cadmium	<3.0	<3.0	<3.0
Chromium	<13	<13	<13
Copper	<59	<59	<59
Lead	81	62	53
Mercury	<.050	<.050	<.050
Selenium	<.25	<.25	<.25
Zinc	<30	<.30	<30

1. [All units in micrograms per gram dry soil; R = replicate sample; and — = compounds not analyzed for.]

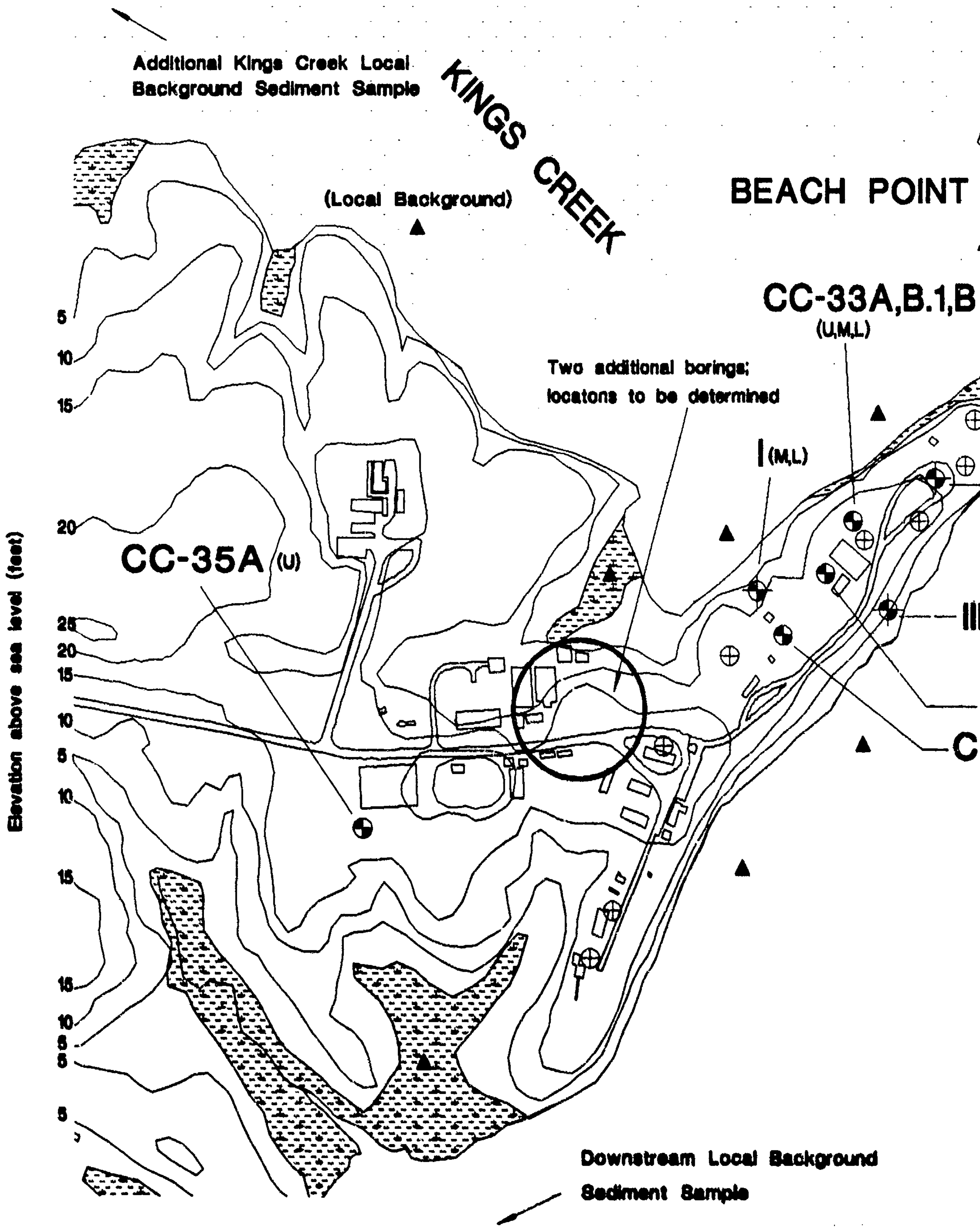
TABLE 2-3. Organic Chemical Data for Soil Samples Collected in the Canal Creek Area[2]

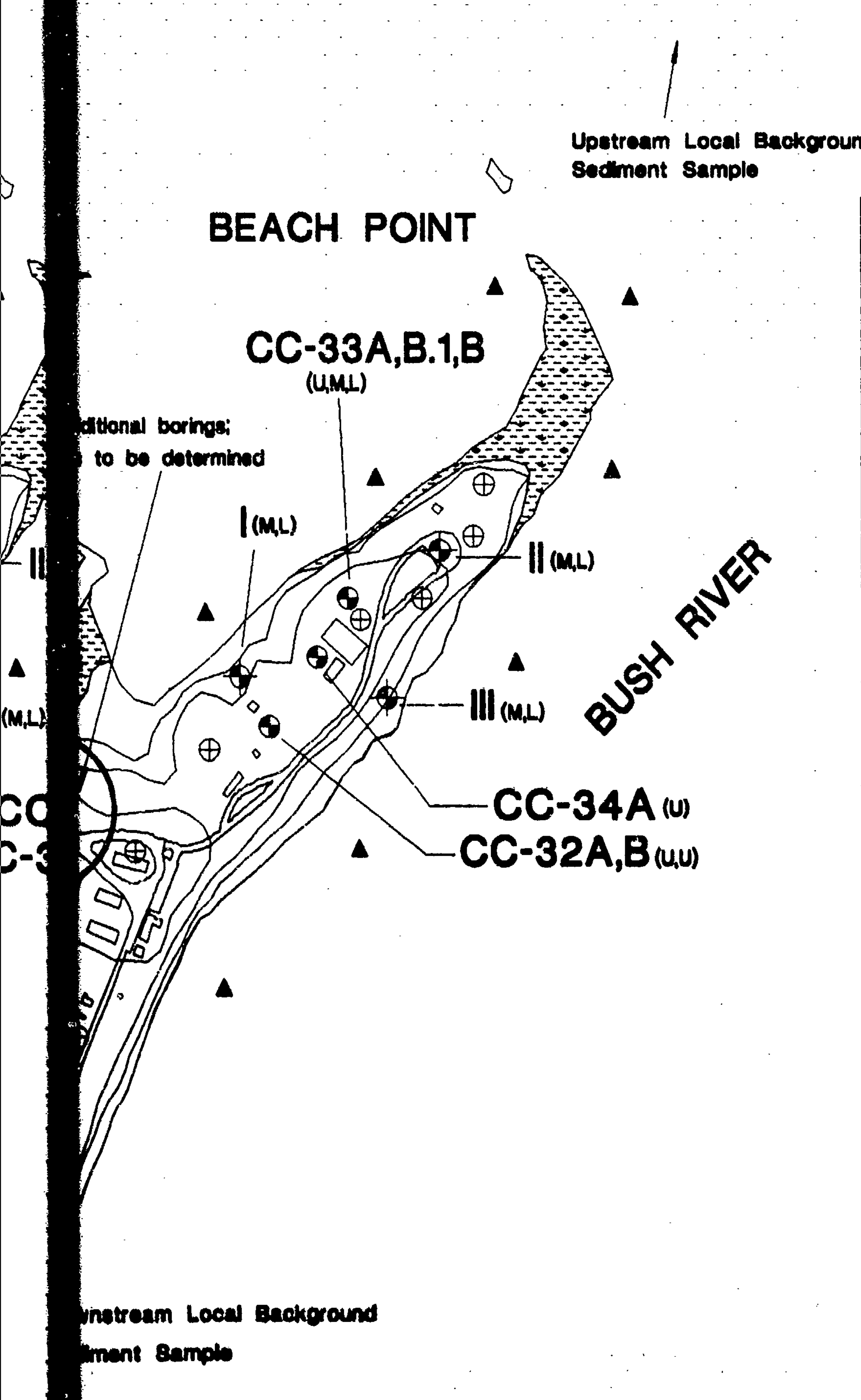
ANALYSIS	USATHAMA CODE	DETECTION LIMIT (mg/g)	CCSL-44	CCSL-45	CCSL-45R
Date Collected	—	—	9/26/89	9/26/89	9/26/89
Organic halides, total	—	200	.46	1.0	.39
Phenols, total	—	—	—	—	—
Organic carbon, total (g/kg)	TOC	—	—	—	—
Trichlorofluoromethane	CCL3F(V)	<.006	<.006	<.006	.01
Acenaphthylene	ANAPYL(S)	<.03	<.03	<.03	<.03
Anthracene	ANTRC(S)	<.03	<.03	<.03	<.03
Benzo(a)anthracene	BAANTR(S)	<.17	<.17	<.17	<.17
Benzo(b)fluoranthene	BBFANT(S)	<.21	<.21	<.21	<.21
Benzo(g,h,i)perylene	BGHIPY(S)	<.25	<.25	<.25	<.25
Benzo(a)pyrene	BAPYR(S)	<.25	<.25	<.25	<.25
Chrysene	CHYR(S)	<.12	<.12	<.12	<.12
Dibenzofuran	DBZFUR(S)	<.04	<.04	<.04	<.04
Di-n-butyl phthalate	DNBP(S)	<.06	<.06	<.06	<.06
Fluoranthene	FANT(S)	<.07	<.07	<.07	<.07
Fluorene	FLRENE(S)	<.03	<.03	<.03	<.03
Indeno(1,2,3-c,d)pyrene	ICDPYR(S)	<.29	<.29	<.29	<.29
Naphthalene	NAP(S)	<.04	<.04	<.04	<.04
Phenanthrene	PHANTR(S)	<.03	<.03	<.03	<.03
Pyrene	PYR(S)	<.03	<.03	<.03	<.03
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	PPDDE(S)	<.31	<.31	<.31	<.31
PCB 1260	PCB260(S)	<2.6	<2.6	<2.6	<2.6

Table 2-3 (Continued)

ANALYSIS	USATHAMA CODE	DETECTION LIMIT (mg/g)	CCSL-44	CCSL-45	CCSL-45R
Unknown 681	UNK681(SL)	—	.9	—	—
Unknown 641	UNK641(SL)	—	2	—	.6
Unknown 652	UNK652(SL)	—	1	—	—
Unknown 661	UNK661(SL)	—	.6	—	—
Unknown 691	UNK691(SL)	—	.7	—	—
Unknown 577	UNK577(SL)	—	1	2	3
Unknown 579	UNK579(SL)	—	1	2	3
Unknown 630	UNK630(SL)	—	.4	—	—
Unknown 651	UNK651(SL)	—	—	—	4

1. [All units in micrograms per gram dry soil, unless otherwise noted; R = replicate sample; (V) = quantitative analysis for volatile organics; (S) = quantitative analysis for semivolatile organics; (SL) = unknown or tentatively identified organic compounds with estimated concentrations detected by library search for semivolatile compounds; and — = compounds not analyzed for.]


Additional Kings Creek Local
Background Sediment Sample
KINGS CREEK
BEACH POINT
(Local Background)
CC-33A,B.1,B
(U,M,L)
Two additional borings;
locatons to be determined
(M,L)
CC-35A (U)
C
Elevation above sea level (feet)
5
10
15
20
25
20
15
10
5
10
15
15
10
5
5
5
Downstream Local Background
Sediment Sample



Legend

- ◐ Existing monitoring well - Surficial aquifer
- ⊕ Proposed monitoring well - Surficial aquifer

Letters in parentheses denote screen location in surficial aquifer

U Upper
M Middle
L Lower

- ⊕ Proposed soil boring location
- ▲ Proposed sediment sample location
- * All proposed sample locations approximate
- ☐ Open water
- ▨ Marsh

0 250 500
Scale (feet)

Figure 2-8

Locations of Existing Groundwater Monitoring Wells, Proposed Groundwater Monitoring Wells, Proposed Sediment Samples, and Proposed Soil Borings at Beach Point

[illegible]

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Groundwater data from these wells are summarized in Appendix A. Although the data represent a composite of several sampling events[1] and therefore must be evaluated with caution, it is apparent that groundwater quality at wells 33A and 33B has been impacted by the presence of several chlorinated VOCs, most notably 1,1,2,2-tetrachloroethane and trichloroethene (TCE). In addition, several metals, including zinc, manganese, copper, silver, and nickel, appear to be present at elevated concentrations. However, background data for metals in nearby areas of the surficial aquifer are not available for comparison. The following paragraphs summarize the chemical data for Beach Point groundwater:

- **Metals and Inorganics.** As noted previously, the surficial aquifer at Beach Point is high in TDS and shows a distinct sodium chloride major-ion chemistry that indicates its interconnection with the brackish surface waters (1 to 3 salinity units) at Kings Creek and the Bush River. Iron and manganese concentrations are highly variable depending upon sampling event and specific location within the aquifer. However, manganese concentrations (as well as historical iron levels) are higher at wells 33A and 33B, indicating low-oxygen (i.e., reducing) conditions possibly resulting from organic contamination. Other metals that have been detected at elevated concentrations include zinc, copper, nickel, and silver. The highest metal concentrations were observed in well 33B, which is screened at 62 to 67 feet below ground surface, in the lower portion of the surficial aquifer. Nitrate was also detected in groundwater at approximately 35 ug/L.
- **VOCs.** The predominant VOCs present in groundwater are 1,1,2,2-tetrachloroethane and TCE, with lower concentrations of perchloroethylene (PCE) also present. Chlorinated VOCs were detected at highest levels in wells 33A and 33B, and were present at significantly higher concentrations in the deeper well (33B), where a maximum concentration of 9480 ug/L was measured for 1,1,2,2-trichloroethane. Other chlorinated VOCs that have been detected at lower levels in wells 33A and 33B include 1,1,2-trichloroethane (112-TCA); chloroform; 1,1-dichloroethene (11-DCE); trans-1,2-dichloroethene (T12-DCE); vinyl chloride; chlorobenzene; and 1,3-dichlorobenzene. In addition, low levels of 1,4-dithiane (approximately 3 ug/l) were detected in well 33B, and chloroform was found at wells 32A and 32B (66 and 52 ug/L, respectively).

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[1] Appendix A presents combined data from several sampling rounds of Beach Point wells. Data for wells 32A, 32B, 34A, and 35A are from 1986 sampling; data for wells 33A and 33B include more recent sampling events (April and October 1989). Wells 32A, 32B, 34A, and 35A have not been sampled since 1986.

- **SVOCs.** The only SVOC detected in groundwater at Beach Point was 2-ethylhexanoic acid, a tentatively identified compound. This compound was detected at 8 ug/L in well 33B.

Although the available groundwater data are of variable quality (because of problems with detection limits, sample dilutions, and method blank contamination), several conclusions can be drawn regarding potential source areas and groundwater contamination at Beach Point. First, the predominant VOC detected in groundwater (1,1,2,2-tetrachloroethane) was known to have been used in the clothing-impregnating process, and it is suspected that as much as 100,000 pounds of this material may have been disposed at Beach Point during large-scale production activities from 1943 through 1947. Chlorobenzene was also known to have been used in clothing impregnating. TCE and PCE are widely used solvents and degreasing agents, and it is possible that these substances were used in clothing impregnation, pyrotechnic testing, or other operations at Beach Point. The other chlorinated VOCs (vinyl chloride, DCE, 112-TCA) are likely degradation products of 1,1,2,2-tetrachloroethane, TCE, and PCE. Dithiane is an organosulfur compound usually associated with the degradation of mustard.

Elevated levels of iron and manganese may be present as a result of dissolution of naturally occurring iron/manganese oxides under reducing (i.e., low-oxygen) conditions caused by organic degradation reactions. However, manganese concentrations (2700 ug/L at well 33B) appear quite high compared to typical aquifer conditions reported for the U.S. (100 ug/L average), suggesting that its presence may be the result of testing or manufacturing operations. Zinc is a major component of many pyrotechnic and smoke mixtures as well as the XXCC3 clothing-impregnating process; therefore, its presence appears site-related. As noted, copper, nickel, and silver also are present at well 33B at apparently elevated concentrations and are likely site-related, but definitive information linking these metals to site operations is not available.

2-Ethylhexanoic acid, the only SVOC detected in groundwater at Beach Point, may be associated with former rocket fuel testing activities. Hexanoic acids, hexanones, and related compounds are common components of propellant and rocket fuel mixtures.

2.4.3 Surface Water

The most recent surface water data for Beach Point and the Kings Creek area were collected during two rounds of sampling by USGS in 1988 and 1989. These sampling events included eight stations along the Kings Creek and Bush River shorelines of Beach Point, as well as five stations in the upper reaches of Kings Creek. Surface water samples collected in the area of Beach Point are depicted on Figure 2-7. Surface water data for the Beach Point sampling locations are presented for major ions and water quality parameters (Table 2-4), metals and inorganics (Table 2-5), and VOCs (Table 2-6).

Major ions and nutrients in surface water at Beach Point mostly appear to be within expected ranges based on overall water quality in the APG area (USAEHA, 1989). Major-ion chemistry is representative of a brackish water system, and phosphorus levels are well below reported concentration in Kings Creek from the late 1970s, when severe nutrient overloading problems were reported (USAEHA, 1977). However, relatively high levels of nitrate (300 to 500 ug/L) were observed at all Beach Point locations. Nitrate could plausibly be present as a result of rocket fuel testing activities involving red fuming nitric acid (RFNA), nitrogen tetroxide, or other oxidizers, explosives, or propellants containing nitrogen; however, data from other sampling stations in upstream areas of Kings Creek also appear elevated (especially at location CCSW-12). It is possible that observed concentrations of nitrate at Beach Point are at least partially related to an upstream source within the Kings Creek drainage basin.

Metals detected at elevated concentrations at Beach Point include aluminum, iron, manganese, cadmium, lead, zinc, and mercury. Although data are somewhat variable between 1988 and 1989 sampling events, iron, manganese, and lead were found at elevated concentrations at essentially all sampling locations. Zinc, mercury, and cadmium were detected at higher concentrations only in samples from the Kings Creek shoreline of Beach Point.

Table 2-4

Water Quality Parameters and Major Ion Concentrations Detected in Surface Water in the Beach Point Area, September 1988 and June 1989¹

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	CCSW 4U		CCSW 5U		CCSW 6U		CCSW 7U		CCSW 7UR	CCSW 7P	CCSW 8U		CCSW 9U	
Sampling Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6/19/89	9/15/88	6/19/89	9/15/88	6/19/89	9/15/88	6/19/89	6/19/89	6/19/89	9/15/88	6/19/89	9/15/88	6/19/89
Water Temperature (degrees C)	25.9	-	25.5	25.9	-	-	-	26.0	27.5	25.5	24.5	24.3	23.0	25.1	23.5	-	-	25.0	24.0	25.2	23.5
Oxygen	-	-	[illegible]	-	[illegible]	-	-	-	7.6	-	8.0	-	6.7		6.6	-	-	-	7.0	-	6.9
Specific conductance (µS/cm)	[illegible]	-	[illegible]	[illegible]	[illegible]	-	-	[illegible]	[illegible]	5,520	480	5,870	472	5,680	478	-	-	5,730	477	5,480	475
pH	[illegible]	-	[illegible]	[illegible]	[illegible]	-	-	5.53	8.07	5.54	8.83	5.72	8.88	5.72	8.90	-	-	5.72	7.04	5.54	7.70
Salinity (ppt)	-	-	[illegible]	-	[illegible]	[illegible]	[illegible]	-	30	-	24		-	-	21	-	-	-	27	-	
Solids residue at 180 C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	344	327	3,340	344	-	387	-	350	3,330	332	3,380	3,150	3,290	350	3,250	
Residue total at 105 degrees C suspended	-		[illegible]	-	[illegible]	9	5		14	-	31	-	35	-	17	-	-	-	25	-	-
Calcium	[illegible]	[illegible]	4.0	30	4.0	4.0	5.7	24	4.0	-	5.4	-	-	26	4.5	30	28	25	4.4	25	-
Magnesium	[illegible]	[illegible]	13	[illegible]	12	13	13	[illegible]	12	-	13	-	-	66	13	81	110	87	12	80	
Sodium	[illegible]	[illegible]	.51	[illegible]	54	54	.51	[illegible]	88	-	.54	-	-	890	100	900	1,300	950	.51	810	60
Potassium	[illegible]	[illegible]	-	37	-	-	-	30	-	-	-	-	-	34	-	37	40	35	-	35	-
Alkalinity (mg/L as CaCO3)	[illegible]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	[illegible]	[illegible]	30	[illegible]	29	30	28	280	28		28	-	-	320	29	300	280	310	28	300	28
Chloride	[illegible]	[illegible]	170	[illegible]	150	150	110	[illegible]	130	-	140	-	-	1,600	170	1,800	1,700	1,800	150	1,800	110
Iron (µg/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	57	[illegible]	[illegible]	-	1,800	-	-	1,300	1,800	1,300	40	870	3,400	1,000	-
Silica	[illegible]	[illegible]	-	[illegible]	-		-	4.6			-	-		1.1	-	3.6	2.8	3.1		3.4	

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Table 2-4

Water Quality Parameters and Major Ion Concentrations Detected in Surface Water in the Beach Point Area, September 1988 and June 1989 (continued)

[illegible]¹	CCSW 2U	CCSW 2F	CCSW [illegible]	CCSW 3U		CCSW 3UR	CCSW 3F	CCSW 4U		CCSW 5U		CCSW 6U		CCSW 7U		CCSW 7UR	CCSW 7F	CCSW 8U		CCSW 9U	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9/19/88	6/19/89	9/19/88	6/19/89	9/15/88	6/13/89	9/19/88	9/19/88	9/19/88	6/15/89	9/19/88	6/19/89
[illegible]	21	24	22	[illegible]	[illegible]	14	<.014	[illegible]	<.071	–	14	–	–	16	<.071	19	18	16	13	16	<.071
[illegible]	[illegible]	[illegible]		[illegible]	–	–	–	[illegible]	–	–	–	–	–	<.10	–	<.10	10	<.10	–	<.10	–
[illegible]	[illegible]	[illegible]	–	[illegible]	–	–	–	.17	–	–	–	–	–	.02	–	<.02	.09	<.02	–	<.02	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15	42	75	–	80	–	–	47	73	27	34	30	70	34	77
[illegible]	[illegible]	<.01	[illegible]	[illegible]	[illegible]	[illegible]	<.025	<.01	.058	–	.052	–	.001	.05	.017	.07	<.01	.06	.088	.06	.081
[illegible]	29	<.10	[illegible]	1.2	30	36	27	1.0	40	–	47	–	–	1.0	41	[illegible]	1.2	80	41	1.2	38
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	870	180	–	170	–	–	780	190	870	850	810	240	800	–
[illegible]	<.01	–	–	<.01	–	–	–	.08	–	–	–	–	–	<.01	–	<.01	.02	<.01	–	<.01	–

¹[µS/cm, microsiemens per centimeter at 25 degrees C, µg/l, micrograms per liter, U, unfiltered sample, F, filtered sample, R, replicate sample, <, less than, >, greater than, ppt parts per thousand —, compound not analyzed for.]

²[All results reported in milligrams per liter (mg/L) unless otherwise noted.]

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Table 2-5

Metal Concentrations Detected in Surface Water in the Beach Point Area, September 1988 and June 1989[1]

Analyte[2]	[illegible]	[illegible]	CCSW 2U	CCSW 3U		CCSW 3UR	CCSW 3F	CCSW 4U		CCSW 5U		CCSW 6U		CCSW 7U		CCSW 7UR	CCSW 7F	CCSW 8U		CCSW 9U	
Sampling Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9/15/88	6/15/89	9/15/88	6/15/89	9/15/88	6/15/89	9/15/88	6/15/89	9/15/88	9/15/88	9/15/88	6/15/89	9/15/88	6/15/89
Aluminum	-		[illegible]	-	[illegible]	[illegible]	[illegible]	-	2,300	-	3,300	-	-	-	2,500	-	-	-	2,300	-	-
Antimony	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<3	<72	-	<72	-	-	<3	<72	<3	<3	<3	<72	<3	-
Arsenic (total)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	<3	-	<3	-	-	<1	<3	<1	<1	<1	3	<1	-
Barium	-	-	[illegible]	-	[illegible]	[illegible]	[illegible]	-	[illegible]	-	13	-	-	-	11	-	-	-	12	-	-
Beryllium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<10	[illegible]	-	13	-	-	<10	12	<10	<10	<10	24	<10	-
Boron	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<27	-	26	-	-	440	<27	450	480	470	<27	470	-
Cadmium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	-	<3	-	-	1	<3	<1	<1	<1	4.7	<1	-
Chromium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	<50	-	<50	-	-	2	<55	1	<1	1	<50	2	-
Copper	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<22	-	<22	-	-	4	<22	4	2	3	<22	4	-
Lead	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	-	13	-	-	3	<8	4	<1	<1	7	2	-
Mercury	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<.5	<.6	-	<.6	-	-	<.5	<.6	<.5	<.5	<.5	1.7	5	
Nickel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<32	-	<32	-	-	8	<32	6	8	5	32	12	-
Selenium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<1	<4	-	<4	-	-	<1	<4	<1	<1	<1	<4	<1	-
Silver	-	-	[illegible]	-	[illegible]	[illegible]	[illegible]	-	<3	-	<3	-	-	-	<3	-	-	-	3	-	-
Thallium	-	-	[illegible]	-	[illegible]	[illegible]	[illegible]	-	<44	-	<44	-	-	-	<44	-	-	-	<44	-	<44
Zinc	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43	[illegible]	-	51	-	-	33	44	64	11	19	180	54	-

[1] [U, unfiltered sample, F, filtered sample, R, replicate sample, <, less than, —, compound not analyzed for.]

[2] [All results reported in micrograms per liter (µg/L).]

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Table 2-6

Concentrations of Volatile Organic Contaminants Detected in Surface Water in the Beach Point Area, September 1988 and June 1989[1]

Analyte[2]	CCSW-2		CCSW-3		CCSW-3B	CCSW-4		CCSW-5		CCSW-6		CCSW-7		CCSW-8		CCSW-9	
Sample Date	9/19/88	6/19/89	9/19/88	6/19/89	6/19/89	9/19/88	6/19/89	9/19/88	6/19/89	9/19/88	6/19/89	9/19/88	6/19/89	9/19/88	6/19/89	9/19/88	6/19/89
Date of Analysis	9/20/88	—	9/20/88	—	—	9/20/88	—	9/20/88	—	9/20/88	—	9/20/88	—	9/20/88	—	9/20/88	—
Carbon, total organic (mg/L)		30	—	30	33	—	30	—	38	—	30	—	30	—	36	—	—
Carbon, organic dissolved (mg/L)		32		32	31	—	32	—	31	—	30	—	32	—	32	—	—
Toluene	<5	<.61	<5	<.61	<.61	<5	<.61	<5	31	<5	<.61	<5	17	<5	<.61	<5	—
Benzene	<5	<.24	<5	<.24	<.24	<5	<.24	<5	38	<5	<.24	<5	16	<5	<.24	<5	—
Ethylbenzene	5	<.88	<5	<.88	<.88	<5	<.88	<5	30	<5	<.88	<5	10	<5	<.88	<5	—
Chlorobenzene	<5	<.14	<5	<.14	<.14	<5	<.14	<5	21	<5	<.14	<5	13	<5	<.14	<5	—
Carbon tetrachloride	5	<.58	<5	<.58	<.58	<5	<.58	5	31	<5	58	<5	38	<5	<.58	<5	—
Chloroform	5	<.84	<5	<.84	<.84	<5	<.84	5	73	<5	<.84	<5	15	<5	<.84	<5	—
Methylene chloride	8*	<.53	2*J	<.53	<.53	7*	<.53	13*	11	2*J	<.53	3*J	17	20*	<.53	3*J	—
1,1,2,2-Tetrachloroethane	<10	<.50	<10	<.50	<.50	<10	<.50	10	51	<10	<.50	<10	57	<10	<.50	<10	—
1,1,2-Trichloroethane	5	<.19	<5	<.19	<.19	<5	<.19	<5	<.19	<5	<.19	<5	<.19	<5	<.19	<5	—
1,2-Dichloroethane	<10	<.89	<10	<.89	<.89	<10	<.89	<10	37	<10	<.89	<10	20	<10	<.89	<10	—
1,1-Dichloroethane	5	<.11	<5	<.11	<.11	<5	<.12	5	71	<5	<.11	<5	33	<5	<.11	<5	—
Tetrachloroethylene	<5	<.27	<5	<.27	<.27	<5	<.27	<5	30	<5	<.27	<5	28	<5	<.27	<5	—
Trichloroethylene	<5	<.88	3J	<.88	10	<5	<.88	<5	37	<5	<.88	<5	19	<5	<.88	<5	—
1,1-Dichloroethylene	<5	<.19	<5	<.16	<.19	<5	<.16	<5	70	<5	<.18	<5	18	<5	<.18	<5	—
1,2-trans-Dichloroethylene	<5	<.11	<5	<.11	<.11	<5	<.11	<5	8.8	<5	<.11	<5	7.0	<5	<.11	<5	—
Vinyl chloride	<10	<.24	<10	<.24	<.24	<10	<.24	<10	30	<10	<.24	<10	33	<10	<.24	<10	—
1,3-cis-Dichloropropene	<5	<.50	<5	<.50	<.50	<5	<.50	<5	<.11	<5	<.50	<5	11	<5	<.50	<5	—

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Table 2-6

Concentrations of Volatile Organic Contaminants Detected in Surface Water in the Beach Point Area, September 1988 and June 1989 (continued)

ANALYTE[2]	CCSW-2		CCSW-3		CCSW-3R	CCSW-4		CCSW-5		CCSW-6		CCSW-7		CCSW-8		CCSW-9	
Sample Date	9/19/88	6/15/89	9/19/88	6/15/89	6/15/89	9/19/88	6/15/89	9/19/88	6/15/89	9/19/88	6/15/89	9/19/88	6/15/89	9/19/88	6/15/89	9/19/88	6/15/89
1,3-trans-Dichloropropene	—	38	—	<.50	<.50	—	<.50	—	57	—	50	—	62	—	<.50	—	—
Trichlorofluoromethane	<5	<.50	5	<.50	<.50	<5	<.50	<5	<.50	<5	<.50	<5	400	<5	<.50	<5	—
1,1,1-Trichloroethane	5	<.45	<5	<.45	<.45	<5	<.45	<5	42	<5	<.45	5	<.45	<5	<.45	<5	—
Bromodichloromethane	<5	<.75	<5	<.75	<.75	<5	<.75	<5	19	<5	<.75	5	64	<5	<.75	<5	—
1,2-Dichloropropane	<5	<.28	<5	<.28	<.28	<5	<.28	<5	140	<5	<.28	<5	110	<5	<.28	<5	—
Dibromochloromethane	<5	—	<5	—	—	<5	—	<5	—	<5	—	<5	—	<5	—	<5	—
Benzene	<10	<.87	<10	<.87	<.87	<10	<.87	<10	<.87	<10	<.87	<10	<.87	<10	<.87	<10	—
Vinyl chloride	—	<.11	—	<.11	<.11	—	<.11	—	31	—	<.11	—	24	—	<.11	—	—
cis-1,3-Dichloropropene	—	<.71	—	<.71	<.71	—	<.71	—	<.71	—	<.71	—	<.71	—	<.71	—	—
Chloroethane	—	<.40	—	<.40	<.40	—	<.40	—	32	—	<.40	—	22	—	<.40	—	—
1,2-Dichlorobenzene	—	<.10	—	<.10	<.10	—	<.10	—	14	—	<.10	—	<.10	—	<.10	—	—
1,3-Dichlorobenzene	—	<.98	—	<.98	<.98	—	<.98	—	<.98	—	<.98	—	<.98	—	<.98	—	—
1,4-Dichlorobenzene	—	<.91	—	<.91	<.91	—	<.91	—	15	—	<.91	—	<.91	—	<.91	—	—
2-Chloroethyl vinyl ether	—	<.86	—	<.86	<.86	—	<.86	—	<.86	—	<.86	—	<.86	—	<.86	—	—
Phenols, total	—	<.21	—	<.21	<.21	—	<.21	—	<.21	—	<.21	—	<.21	—	<.21	—	—

[1] [R, replicate sample, mg/L, milligrams per liter, *, compound detected in method blank, #, indicates an estimated value because peak was present but concentration was below detection limit; <, less than, —, compound not analyzed for.]

[2] [All results reported in micrograms per liter (µg/L) unless otherwise indicated.]

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It is important to note that several of the detected metals (especially zinc, aluminum, and lead) are major components of many pyrotechnic and smoke mixtures. Therefore, their presence at elevated concentrations in surface water may be related to past pyrotechnic/smoke testing activities at the point. Also, as noted previously, zinc oxide was a major component of the XXCC3 clothing-impregnating process, and it is possible that some zinc contamination in surface water may have resulted from this operation.[2]

As presented in Table 2-6, numerous VOC compounds were detected at low levels (approximately 10 to 70 ug/L) in several surface water samples collected in September 1989. VOCs were detected primarily at locations CCSW-5 (on the Bush River shoreline) and CCSW-7 (on the Kings Creek shoreline). Predominant contaminants included 1,1,2,2-tetrachlorethane, TCE, and PCE. However, detectable levels of many other chlorinated VOCs were also found, including 11-DCE, TCFM, chloroform, and carbon tetrachloride. Aromatic VOCs, including ethylbenzene and toluene, were also detected. An earlier sampling round conducted by USGS in September 1988 detected no VOC contamination in surface water at Beach Point with the exception of 10 ug/L of 1,1,2,2-tetrachloroethane at sampling station CCSW-3, located on the Bush River. SVOCs were analyzed in selected samples from both 1988 and 1989 sampling events but were not detected, with the exception of very low levels of tentatively identified compounds related to hexanoic acid.

VOCs such as 1,1,2,2-tetrachloroethane and PCE were known to have been associated with clothing-impregnating operations, and it is possible that other solvents such as TCE, DCE, chloroform, and carbon tetrachloride may also have been used on an experimental or pilot-scale basis. Many of the chlorinated VOCS that were detected in the 1989 sampling event may also be present as a result of degradation reactions involving the more highly chlorinated compounds (e.g., vinyl chloride may be present resulting from the degradation of PCE, TCE, or DCE). In addition, several of these compounds have been identified in

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[2] Records indicate that activities on Beach Point primarily involved the CC2 clothing-impregnating process (USAEHA, 1989), but it is possible that some pilot-scale testing or full-scale production work involving the XXCC3 process was also performed.

groundwater at Beach Point. Thus, these compounds appear to be site-related. Because of the differences between the 1988 and 1989 sampling efforts, particularly with regard to the VOCs, the data from those efforts must be treated with caution. Laboratory contamination or analytical problems might also explain the presence of these compounds.

Background data for VOCs from other sampling locations within Kings Creek are available. However, no VOCS were detected at any upstream stations with the exception of chloroform at CCSW-10 (58 ug/L). Because VOCs typically persist in surface water for only a short time period because of volatilization, they are likely to be present only in the immediate vicinity of source areas (e.g., groundwater plumes). Thus, background data for VOCs is not as significant as for the previously discussed metals and inorganic compounds.

Table 2-7 presents the current chemicals of concern (COCs) for the Beach Point Test Site.

2.5 CONCEPTUAL SITE MODEL

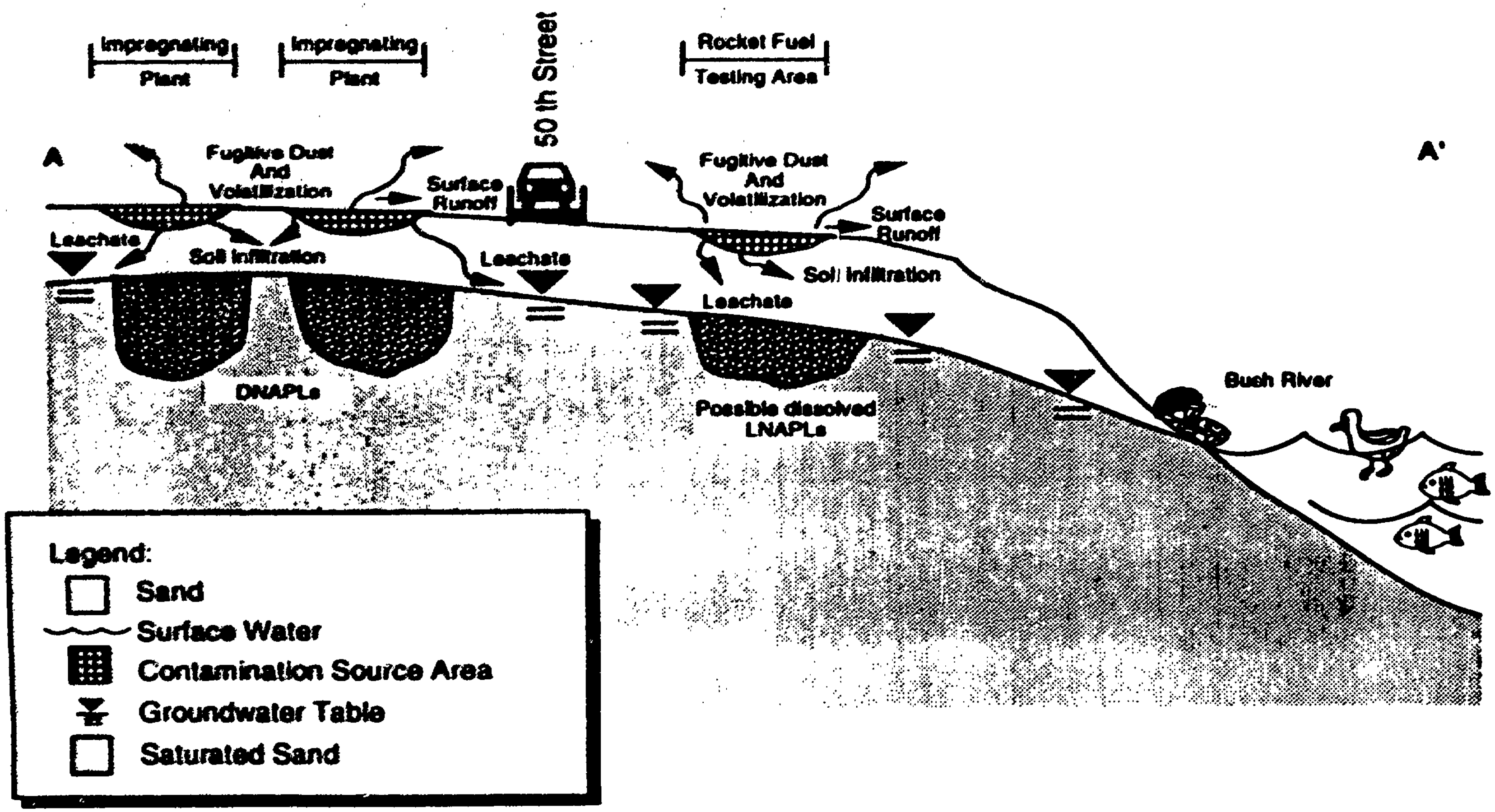
The scope of this task addresses only groundwater and sediments which are the major pathways of concern for the Beach Point site (see Figures 2-9 and 2-10). The primary release mechanism for the Beach Point site is infiltration and percolation of contaminants through subsurface soil. This release mechanism allows contaminants to migrate either vertically and/or horizontally through subsurface soil eventually reaching groundwater and/or surface water/sediments. Storm water runoff and dust/volatile emission release mechanisms transport contaminants present in the surface soil to either air or surface water bodies. Although the scope of this work addresses only aquatic biota receptors, a qualitative risk assessment for human receptors will be done for limited scenarios and pathways.

Table 2-7. Chemical of Concern at Beach Point: Maximum Detected Surface Water Concentrations and Fresh Water Aquatic Toxicity Criteria

Chemical	Maximum Detected Surface Water Concentration (µg/L)	Acute Toxicity Value (µg/L)	Chronic Toxicity Value (µg/L)	Toxicity Values Exceeded
1,1,2,2-Tetrachloroethane	10	9300[1]	6900[2]	None
Trichloroethene	37	18,000[1]	--	None
Aluminum	3300	750[3]	87[3]	Acute and Chronic
Cadmium	6.7	3.9[4]	1.1[4]	Acute and Chronic
Lead	13	83[4]	3.2[4]	Chronic
Mercury	2.2	2.4[4]	0.012 (AWQC)[4] 0.26 (LOEC)[5]	Chronic
Nitrate	800	--	90,000[6]	None
Zinc	182	120[4]	110[4]	Acute and Chronic

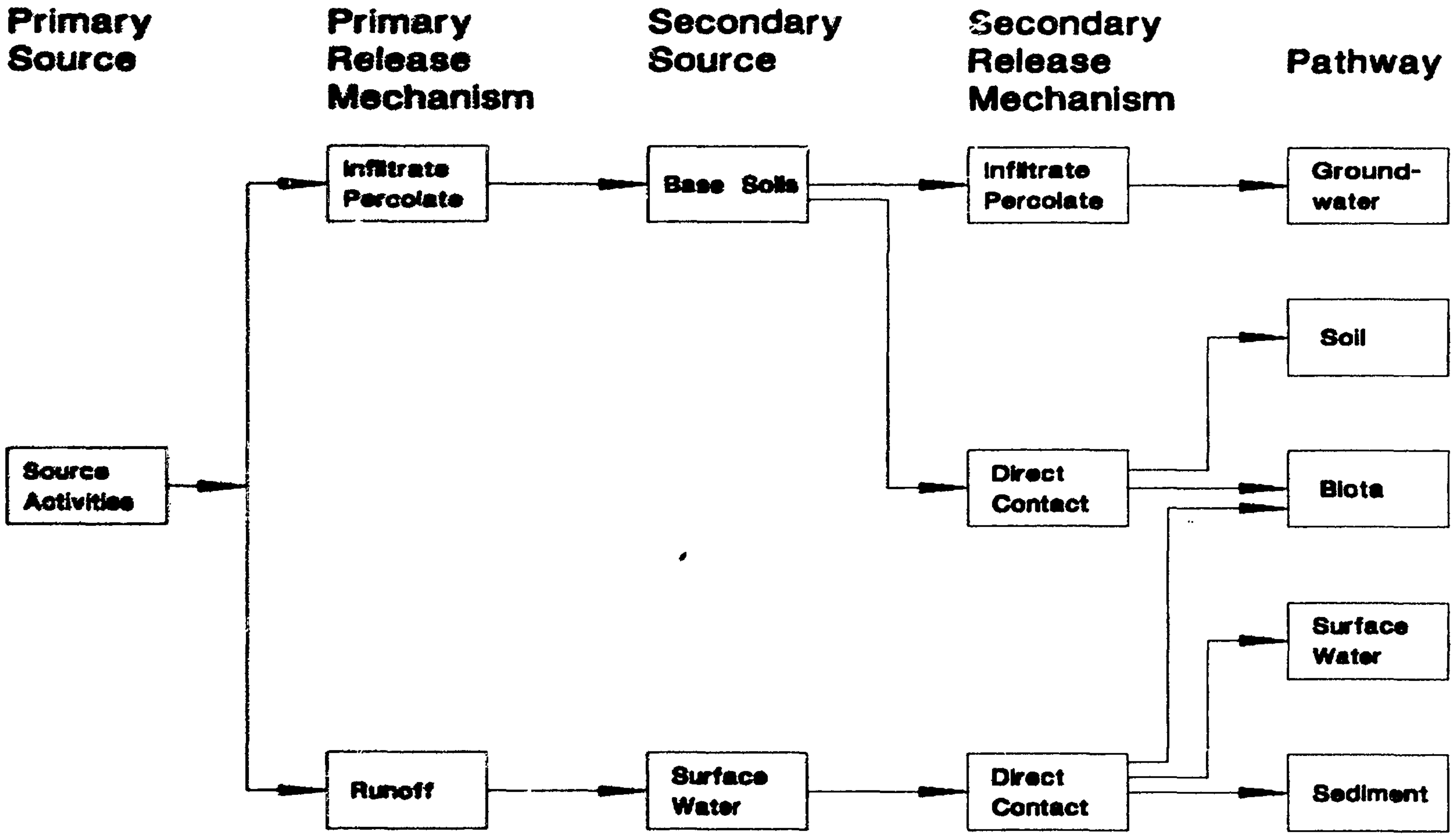
[1] 48-hour LC50 in Daphnia (LeBlanc 1980)
[2] 28-day LOEC [lowest observed effect concentration] in Daphnia (AQUIRE 1990)
[3] AWQC [Ambient water quality criteria] (EPA 1988a)
[4] AWQC (1986)
[5] Chronic LOEC (EPA 1986)
[6] Estimated protective concentration (EPA 1986)

Figure 2-9
Beach Point Test Site
Conceptual Model Cross Section



[illegible]
[illegible]

Figure 2-[illegible] Beach Point
Contaminant Migration Pathways Analysis



2.6 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQO) process is a Total Quality Management tool developed by EPA to facilitate the planning of data collection activities. The DQO process used here will focus data collection activities to ensure that results from the FFS produce the right type and quality of information. By following the DQO process, it will be possible to reduce the overall costs of sampling and analytical activities and accelerate project planning and implementation. The DQO process includes the following steps:

- Stating the problem to be resolved,
- Identifying the decision to be made,
- Identifying inputs to the decision,
- Defining the boundaries of the study,
- Developing decision rules,
- Specifying limits on uncertainty, and
- Optimizing design for obtaining data.

The DQO process allows data users to evaluate the potential consequences of uncertainty before the data is collected, and to specify limits on the amount of uncertainty that can be tolerated in the decision that will be based on the study results. The DQO process is dynamic and the decisions, inputs, boundaries and uncertainty limits may be modified as the investigation proceeds.

This work plan has been designed to address the seven steps of the DQO process. The objective of the FFS is to assess potential environmental risks, evaluate contaminant remediation alternatives, and provide a basis to select a cost effective remedial action. The site investigation will focus on potential risk to biological receptors from known contaminants in Kings Creek and Bush River, evaluate the fate and transport of contamination attributable to the site, and determine source areas of contamination. For example, the degree to which groundwater contamination impacts surface water and sediments will be assessed.

This data will be utilized to develop the ecological risk assessment and provide input for selection of possible remedial alternatives. Analytical data quality levels appropriate to these objectives will be specified. During the planning phase of the FFS, existing information for each potential source area or groundwater volume that has been identified for remediation will be evaluated in terms of potential remedial actions and cleanup levels on the basis of potential risks and ARARs. Data for each source area will be assessed to determine if they are sufficient to evaluate remedial alternatives and prepare accurate risk estimates. If existing data are not sufficient, data collection activities to address data gaps will be planned.

The current investigation will be conducted using a phased approach. In the initial phase of the FFS, source areas will be identified, the extent to which the ecology of Beach Point is effected from contaminants will be defined, and background levels in the Beach Point Test Site will be established. The scope of the subsequent phases of the investigation will include collection of additional data for characterization of chemistry and geometry of groundwater contamination and an evaluation of engineering alternatives that may be applied to remediate contaminant sources or contaminated groundwater.

2.6.1 Data Uses

2.6.1.1 **Site Characterization**. Data will be collected to determine the nature and extent of contamination at the site. Site characterization usually requires the most data collection. Site characterization data are generated through the sampling and analysis of waste sources and environmental media. Data will be collected to determine the presence or absence of contaminants above background concentrations in groundwater, soil, soil gas, sediment, and sediment porewater at the site. The specific data quality objectives for field activities to further characterize the site are presented in Table 2-8. DQO are also addressed in Section 4.0 of the Quality Assurance/Quality Control Plan.

TABLE 2-8 DATA QUALITY OBJECTIVES FOR FIELD ACTIVITIES

DQO	Surveying and Establishing Grid System	Soil Gas and Geophysical Investigation	Hydrogeologic Investigation	Sediment Investigation	Surface Soil and Soil Boring Investigation	Biological/Ecological Investigation
Objective	Surveying and establishing a grid system will provide location information for geophysical surveys, soil gas surveys, and subsequent soil sampling and monitoring well installation activities within the Beach Point Test Site.	Soil gas (active and passive) and geophysical surveys (seismic and EMI) will be performed to locate buried metal and other geophysical anomalies, estimate the depth to groundwater and presence of confining layers in areas where empirical data are not available, and identify areas containing elevated levels of contaminants within the soil gas phase. The final determination of monitoring well and surface soil sampling locations will be made.	New monitoring wells will be installed at shallow and intermediate depth clusters so that the vertical and horizontal profile of DNAPL distribution in the groundwater may be determined. Logging of new wells will provide a characterization of the stratigraphy and lithology of the Beach Point Test Site. Subsurface soil samples and groundwater samples will be collected and analyzed to determine the nature and extent of contamination. A water level elevation survey will be performed in order to construct a groundwater elevation map. Flow meter will be performed to determine the in-situ hydraulic conductivity and groundwater flow direction within the underlying aquifers.	Sediment data will be collected in Bush River to determine the extent to which past disposal practices have impacted pore water and sediment quality.	Surface and subsurface soil samples will be collected in areas to determine if contaminant transport is occurring from suspected source locations.	Chemical residue analysis to assess bioaccumulation of contaminants. Human exposure will be discussed qualitatively, not quantitatively
Chemical Data	None	If soil gas samples are collected: Samples will be analyzed for a variety of analytes. Active soil gas samples will be analyzed for VOCs. Analyses for passive soil gas samples are still to be determined.	Groundwater and subsurface soil samples will be analyzed for TCL VOCs and BNAs, TAL inorganics (dissolved and total for groundwater), CSM breakdown products, explosives, pesticides/PCBs, herbicides, dioxins/furans, and total phosphorus.	• Sediment samples will be analyzed for TCL VOCs, TCL BNAs, TAL inorganics, CSM breakdown products, explosives, pesticides/PCBs, herbicides, dioxins/furans, total organic carbon and total phosphorus. • Well point samples will be analyzed for TCL VOCs and TAL inorganics.	Surface soil samples will be analyzed for TCL VOCs and BNAs, TAL inorganics, CSM breakdown products. Refer to Hydrogeologic Investigation for discussion of soil boring chemical data.	None

Table 2-3 (Continued)

DQO	Surveying and Establishing Grid System	Soil Gas and Geophysics Investigation	Hydrogeologic Investigation	Sediment Investigation	Surface Soil and Soil Boring Investigation	Biological/Ecological Investigation
Physical Data	• Three permanent reference markers will be established at Beach Point surveyed to an accuracy of 1 foot in lateral coordinates and 0.01 foot in elevation. • Grids with 20-foot cells, reproducible to 2 feet, will be established in the Beach Point Test Site for geophysical and soil gas surveys. • All new and existing monitoring wells will be surveyed in elevation and coordinates. Accuracy-0.05 foot in National Vertical Datum and using an UTM (meters) or STP (feet) grid.	• Seismic data will include reflected radar signals for interpretation. • EMI data- subsurface conductivities will be interpreted.	• Visual logging of 6 new wells. • Natural gamma ray logging of all new wells for stratigraphic control and correlation. • Temperature, Eh, pH, DO, turbidity, and conductivity measurements before, during, and after pre-sample purging. • Flow meter logs will be performed in each of the current wells and the 6 new well installations. • Water level measurements will be taken within a 24-hour period from all wells, accurate to 0.01 feet. • Map coordinates for the sampling locations will be generated using GPS.	• Temperature, pH, and conductivity measurements will be collected prior to sampling. • Grain size distribution will be determined on all sediment samples • Map coordinates for the sampling locations will be generated using GPS.	• Visual characterization of soil types. • Map coordinates for the sampling locations will be generated.	• None.
Sampling Method	***Chemical Data*:** No sampling to be performed. ***Physical Data*:** Biased, non-intrusive	***Chemical Data*:** Field analysis of soil gas samples. ***Physical Data*:** Environmental, biased, non-intrusive	***Chemical Data*:** Environmental, biased, grab, composite (subsurface soil from shallow borings only), and intrusive. ***Physical Data*:** Environmental, biased, grab, intrusive	***Chemical Data*:** Environmental, biased, grab, and intrusive. ***Physical Data*:** Environmental, biased, grab and intrusive	***Chemical Data*:** Environmental, biased, intrusive, composite (subsurface soil from shallow borings only) ***Physical Data*:** Environmental, biased, intrusive	***Chemical Data*:** Environmental, biased, grab, and intrusive. ***Physical Data*:** Environmental, biased, grab, and intrusive.
Data Use	Site Characterization	Site Characterization/Source Identification	Site Characterization Risk Assessment	Site Characterization Risk Assessment	Site Characterization Risk Assessment	Site Characterization Risk Assessment

Table 2-3 (Continued)

DQO	Surveying and Establishing Grid System	Soil Gas and Geophysical Investigation	Hydrogeologic Investigation	Sediment Investigation	Surface Soil and Soil Boring Investigation	Biological/Ecological Investigation
Analytical Data Level	All data will be equivalent to EPA Level I	• Seismic and EMI data will be equivalent to EPA Level I. • Soil gas data will be equivalent to EPA Level II.	• CLP-certified analyses will be equivalent to EPA Level IV • USAEC- and EPA-certified analyses will be equivalent to EPA Level III. • Physical testing of soils will be equivalent to EPA Level V. • Field screening physical data and logs will be equivalent to Level I.	• CLP-certified analyses will be equivalent to EPA Level IV • USAEC- and EPA-certified analyses will be equivalent to EPA Level III. • Physical testing of soils will be equivalent to EPA Level V. • Field screening physical data and logs will be equivalent to Level I.	• CLP-certified analyses will be equivalent to EPA Level IV • USAEC- and EPA-certified analyses will be equivalent to EPA Level III. • Visual logging will be equivalent to EPA Level I.	• CLP-certified analyses will be equivalent to EPA Level IV • USAEC- and EPA-certified analyses will be equivalent to EPA Level III. • Taxonomic classification will be equivalent to Level I.
Analytical Method CLP, USAEC, EPA, and ASTM	No chemical or physical analytical data is required for surveying and grid establishment.	• No chemical or physical analytical data is required for geophysical data. • Soil gas samples will be analyzed by non-certified, chemical specific USAEC, EPA, or ASTM methods.	***Chemical testing:*** CLP Methods-(OLM01.8, ILM02.0, DFLM01.0) 8280, 200.7M, 206.2M, 239.2M, 270.2M, 245.2M, 245.5M, 335.2M, 335.3M, GC/MS, and GC/ECD. USAEC Methods- Aqueous samples- Method numbers are laboratory specific. Solid samples- Method numbers are laboratory specific. ***Physical Testing:*** ASTM Methods for soil samples- D-422, D-2216, D-2487, D-2974, D-4318, and EPA method 9100.	***Chemical testing:*** CLP Methods--(OLM01.8, ILM02.0, DFLM01.0) 8280, 200.7M, 206.2M, 239.2M, 270.2M, 245.2M, 245.5M, 335.2M, 225.3M, GC/MS, and GC-ECD. USAEC Methods- For solid samples- Method numbers are laboratory specific. ***Physical Testing:*** ASTM-certified methods for soil samples- D-422, D-2216, D-2487, D-2974, D-4318, and EPA Method 9100.	***Chemical testing:*** CLP Methods-(ILM02.0, OLM01.8, DFLM01.0) 8280, 200.7M, 206.2M, 239.2M, 270.2M, 245.5M, 335.3M, GC/MS, and GC-ECD. USAEC Methods- For solid samples- Method numbers are laboratory specific.	**Chemical testing:** CLP Methods-(ILM02.0, OLM01.8, DFLM01.0) 8280, 200.7M, 206.2M, 239.2M, 270.2M, 245.5M, 335.3M, GC/MS, and GC-ECD. USAEC Methods- For solid samples- Method numbers are laboratory specific. **Bioassay Endpoints:** Mysid Shrimp (*Mysidopsis bahia*)- survival after 48 hours. Sheepshead Minnow (*Cyprinodon variegates*)- survival after 48 hours.
Typical Detection Limit	None	Typically 1 ppb for VOCs in soil gas samples.	Typically 1 ppb for water and 1 ppm for soil.	Typically 1 ppm.	Typically 1 ppm.	Typically 1 ppm.
Quality Control Samples	None	Soil gas: Performance evaluation samples, matrix spikes, and blanks. Geophysical: None.	Trip Blanks, Rinse Blanks, Duplicates, Filter Blanks, Ambient Blanks, Method Blanks, Internal Laboratory Standards	Trip Blanks, Rinse Blanks, Duplicates, Ambient Samples, Method Blanks, Internal Laboratory Standards	Rinse Blanks, Duplicates, Method Blanks, Ambient Samples, Internal Laboratory Standards	Rinse Blanks, Duplicates, Method Blanks, Ambient Samples, Internal Laboratory Standards Bioassays: Control Group- must be 90% or greater. Three replicates per test concentration.

Table 2-3 (Continued)

DQO	Surveying and Establishing Grid System	Soil Gas and Geophysical Investigation	Hydrogeologic Investigation	Sediment Investigation	Surface Soil and Soil Boring Investigation	Biological/Ecological Investigation
Local Background Samples	None	None	Groundwater sample from well CC35A.	Two sediment samples each from Kings Creek and Bush River will be taken at locations upstream and downstream from Beach Point. Data must be evaluated carefully, taking into account tidal/storm influences on sediment.	Select soil sampling from boring program.	None

Note: DQO's from Phase III will be developed during Phase I and/or Phase II.

2.6.1.2 **Ecological Risk Assessment and ARAR Evaluation**. Data will be collected in support of an ecological risk assessment that will be prepared by UM/ICF in accordance with EPA Risk Assessment Guidance. Preliminary cleanup levels for contaminants in soil, soil gas, sediment porewater, sediment and groundwater will be developed in part from the risk assessment results. Potential receptors and exposure pathways will be evaluated.

Contaminant concentrations in all media will be evaluated in terms of ARARs. All promulgated requirements that affect contaminants and remedial activities will be evaluated. When preliminary cleanup levels for media have been identified, remedial alternatives that will attain the cleanup levels will be selected and evaluated. Background information and site specific data concerning bioavailability and mobility; and physical characteristics such as pH, oil and grease, and total organic carbon that impact toxicity and mobility will be utilized.

2.6.1.3 **Remedial Alternatives**. Specific data requirements for the development of remedial alternatives include determination of the volumes or areas of waste or media that must be addressed, the chemical-specific information on waste constituents, and information necessary to identify those remedial action alternatives that would be effective for the contaminants and media of concern. Treatability studies are conducted to provide sufficient data to allow treatment alternatives to be fully developed and evaluated and to reduce the cost and performance uncertainties for treatment alternatives to acceptable levels. A data gathering procedure closely related to treatability studies is aquifer testing. To evaluate the velocity of contaminant migration and to determine the design of remedial action, aquifer testing may be required.

2.6.2 Analytical Data Quality Levels

The following are associated analytical data quality levels and broad use categories:

- Level I (Field Screening) - Provides the lowest quality data but with immediate field results. Results are often not compound specific and results are typically qualitative. Data uses for Level I data include:

—site characterization
—monitoring
—implementation

- Level II (Field Analysis) - Provides a tentative identification of compounds through analyte specific analysis. Yields immediate field results with more sophisticated equipment than Level I. Data generated may have highly variable quality. Acceptable uses of Level II data include:

  —site characterization
  —evaluation of alternatives
  —engineering design
  —monitoring during implementation

- Level III (Non-CLP Methods/RCRA Characteristic Testing) - Provides analyte specific analytical results. Data is often comparable to Level IV (CLP) data. Laboratory QA/QC may be less vigorous than Level IV. Acceptable uses of Level III data include:

  —risk assessment
  —site characterization
  —evaluation of alternatives
  —engineering design
  —monitoring during implementation

- Level IV (CLP analytical methods) - Provides data of known quality using CLP methods, rigorous QA/QC, and data validation. Data is used for:

  —risk assessment,
  —engineering design
  —evaluation of alternatives.

- Level V (Modified Analytical methods) - Provides data of known quality using modified methods, or analysis for nonconventional parameters. Data is used for:

  —risk assessment.

2.6.3 Data Quality Indicators (DQIs)

Data quality is defined as the degree of uncertainty with respect to precision, accuracy, representativeness, completeness, and comparability of a data set. These characteristics will be used to develop sampling protocols and identify applicable documentation, sample handling procedures, and measurement system procedures. These objectives are established based on site conditions, objectives of the project, and knowledge of available measurement systems. USATHAMA sets minimum data quality standards for analytical methods which will be followed.

Precision — Precision is a measure of how well repeated measurements of the same parameter on the same sample or a duplicate sample agree with one another. Precision will be measured by the relative percent difference between duplicate samples. Precision limits are specified by USATHAMA for specific analytes and methods.

Accuracy — Accuracy is a measure of the degree that a sampling protocol can produce analytical results which match known standards. Accuracy will be measured against the percent recovery of an analyte. Accuracy limits are specified by USATHAMA for specific analytes and methods.

Representativeness — Measurements will be made to ensure that results are representative of the media. Sampling and sample handling protocols will be developed to protect the representativeness of the collected samples.

Completeness — Completeness is the amount of valid data obtained compared to the amount of data collected.

Comparability — The characteristic of comparability reflects both internal consistency of data and consistency of data to previously collected information.

DQIs are discussed in greater detail in Section 4.2 of the Quality Assurance/Quality Control Plan.

2.6.4 Specifying Limits of Uncertainty and Optimizing Design for Obtaining Data

Limits on uncertainty will be based on careful consideration of the consequences of incorrect conclusions during design of the field sampling and quality assurance plans. Statistical methodology will be utilized to establish an acceptable probability for decision errors, i.e. false positives or false negatives. Based on the acceptable level of uncertainty, the field sampling effort will utilize the most cost effective design to achieve project goals. Table 2-8, illustrates the type of information which will be included during planning of field sampling activities at each suspected source area and at sites requiring remediation.

2.7 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

The Superfund Amendments and Reauthorization Act of 1986 (SARA) amended the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Prior to the SARA amendments, CERCLA on-site actions were not required to be in compliance with other laws although other federal environmental laws were required to be considered in the remedial alternative selection process. The National Oil and Hazardous Substance Contingency Plan (NCP) was created to effectuate the response powers of CERCLA. The United States Environmental Protection Agency (EPA) stated in NCP Section 300.68(i)(1) that CERCLA response actions would attain or exceed applicable or relevant and appropriate environmental and public health standards unless one of five specifically enumerated situations were present. CERCLA Section 121 requires all applicable, relevant and appropriate federal standards and any more stringent state standards to be considered for all on-site remedial actions initiated by the EPA or performed under EPA guidance.

2.7.1 Purpose

A preliminary identification and screening of federal and state environmental regulatory requirements that may be applicable or relevant and appropriate to potential remedial actions that may be conducted at the Beach Point site is presented to assist in the selection and implementation of an appropriate remedial methodology for the site. CERCLA Section 121(d) lists specific federal environmental laws that must be considered as part of an applicable, or relevant and appropriate requirements (ARARs) analysis. This list includes:

- Toxic Substances Control Act (TSCA).
- Safe Drinking Water Act (SDWA).
- Clean Air Act (CAA).
- Clean Water Act (CWA).
- Marine Protection, Research and Sanctuaries Act (MPRSA).
- Solid Waste Disposal Act (SWDA)/Resource Conservation and Recovery Act (RCRA).

Section 121(d) also states that remedial actions must meet the applicable or relevant and appropriate requirements of any promulgated standard, requirement, criteria, or limitation under a state environmental or facility-siting law that is more stringent than any federal standard, requirement, criteria, or limitation. Criteria, advisories, and guidances that are not law may be used to ensure protectiveness of human health or the environment in the absence of ARARs, or when ARARs are not sufficient to accomplish this. These criteria, advisories, and guidances fall in the "to be considered" (TBC) category and can be used to ensure protection.

Applicable or relevant and appropriate requirements are defined as:

> "Applicable requirements are those clean-up standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site."
>
> "Relevant and appropriate requirements are those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site." (EPA, 1988)

It should be noted that:

> "a requirement that is judged to be relevant and appropriate must be complied with to the same degree as if it were applicable." (EPA, 1988)

Other non-promulgated advisories or guidance issued by State or Federal governments are not legally binding and do not have the legal status of potential ARARs. These "to-be-considered" (TBC) requirements will be evaluated along with ARARs in determining site risks.

The identification and screening of ARARs for a site is best achieved by examining the body of Federal, State, and local environmental laws, regulations, standards, etc. relative to three general categories:

- Chemical-specific ARARs - health or environmentally based numerical values limiting the amount of a contaminant that may be released to, or allowed to remain in the environment. These include, for example, maximum contaminant levels (MCLs) established under the Safe Drinking Water Act.
- Location-specific ARARs - are those requirements that may restrict remedial action because a site is in a special location such as an urban setting, a floodplain, wetland, or historical area.
- Action-specific ARARs - technology or activity based requirements that may include, for example, National Pollutant Discharge Elimination System (NPDES) effluent standards or incinerator contaminant destruction standards.

2.7.2 Chemical-Specific ARARs and TBCs

"Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which when applied to site specific conditions, result in establishment of numerical value. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment" (EPA, 1988).

The media of potential concern at the site include groundwater, sediment and soil. Based on previous site investigations (USGS 1986 to 1989; ICF; Darda and others, 1991), the potential contaminants of concern at the site include:

- 1,1,2,2-tetrachloroethane (1,1,2,2-TCA)
- trichloroethene (TCE)
- aluminum

- cadmium
- lead
- mercury
- nitrate
- zinc

The following are common chemical-specific standards or references that are used to establish chemical-specific ARARs. Potential chemical specific ARARs for these contaminants of concern are presented in Tables 2-9 and 2-10.

- Federal Safe Drinking Water Act Maximum Contaminant Levels. Maximum contaminant levels (MCLs) for toxic compounds have been established under the Safe Drinking Water Act (SDWA). MCLs are enforceable standards for public drinking water systems that are set as close to MCL goals as feasible when considering the best available technology and treatment techniques. MCLs have been established for mercury, nitrates, lead, cadmium, and TCE. The contaminated aquifer is classified as brackish and is not used as a drinking water source; therefore the SDWA MCLs are probably neither applicable or relevant and appropriate.
- Clean Air Act National Primary/Secondary Ambient Air Quality Standards (NAAQS) and National Emission Standards for Hazardous Air Pollutants (NESHAPs).
- Resource Conservation and Recovery Act (RCRA) regulations.
- Federal Ambient Water Quality Criteria (AWQC) are non-enforceable guidelines that set concentrations of pollutants that may be relevant and appropriate depending on the uses of the surface water body, the media affected, purposes of the criteria and current information.
- Federal Regulatory Standards EPA Risk Reference Doses and EPA Carcinogen Assessment Group (CAG) Potency Factors are used to characterize current and potential site risks.
- Maryland Drinking Water Law (ACOM, Env. Article, Title 9). The purpose of this regulation is to establish that the state has primary enforcement responsibility for drinking water standards under the federal SDWA. Again, drinking water standards are not applicable or appropriate and relevant in this case.

Table 2-9. Chemical-Specific ARARs for Protection of Aquatic Life

Compound	**AWQC for Protection of Aquatic life Freshwater Acute (ug/l)**	**AWQC for Protection of Aquatic life Freshwater Chronic (ug/l)**	**AWQC for Protection of Aquatic life Marine Acute (ug/l)**	**AWQC for Protection of Aquatic life Marine Chronic (ug/l)**	**Sediment Quality Criteria (ug/kg)**
Inorganic Mercury	2.4	1.2E-02	2.1	2.5E-02	
Alkyl Mercury	2.4	1.2E-02	2.14	2.5E-02	-
Zinc	130	110	96	86	-
Nitrate	-	-	-	-	-
Lead (inorganic)	80 +	3.2 +	100	5.6	-
Cadmium	3.9 +	1.1 +	43	93	-
Aluminum	-	-	-	-	-
TCE	4.5E04 *	2.1E04 *	2.0E03 *	-	-
1,1,2,2-tetrachloro-ethane	2.4E03 *	-	9.0E03 *	-	-

+ Harness-dependent
* LOEL

Table 2-10. Chemical-Specific ARARs for Protection of Human Health

Compound	**Proposed RCRA Action Levels for soils (mg/kg)**	**Proposed RCRA Action Levels for Air (ug/m³)**	**SDWA MCLs April 1991 (ug/l)***	**SDWA MCLGs (ug/l)**	**RCRA MCLs (ug/l)**	**Maryland Hazardous Waste regulation Limit for Groundwater that may impact Surface Water**	**AWQC human health water only (ug/l)**	**AWQC human health fish and water ingestion (ug/l)**	**HAL (ug/l)**	**10-4 cancer risk (ug/l)**	**Carcinogen Class**
Mercury	20	-	2(F)	2(F)	2	2	0.14	0.15	2(F)	-	D
Zinc Zinc Cyanide Zinc Phosphide	- 4E03 2E03	-	-	-	-	-	-	-	20(D)	-	D
Nitrate	-	-	10,000 as N (F)	10,000 (F)	-	-	10,000	-	-	-	D
Lead	-	-	5 at source (P)	0 (P)	50	50	50	-	-	-	B2
Cadmium	4E01	6E-04	5 (F)	5 (F)	10	10	10	-	5 (F)	-	D(SDWA) B1(RCRA)
Aluminum	-	-	-	-	-	-	-	-	-	-	D
TCE	6E01	-	5(F)	0(F)	-	-	0.6	42	-	300 (F)	B2
1,1,2,2-tetrachloro-ethane	3E02	1	-	-	-	-	-	-	70 (F)	100 (F)	C

(F) = Final
(P) = Proposed
(D) = Draft

- Maryland Air Quality Control Act (ACOM, EA, Title 2 chapter 240 and amendments). The purpose of this act is "to maintain the degree of purity of the air necessary to protect the health, the general welfare, and property of the people of the state." It includes "regulations that require a permit or registration before a person constructs, modifies or uses a source that may cause or control emissions in the air".
- Maryland Hazardous Waste Regulations concern the disposal of controlled hazardous substances and the impact of groundwater quality on wildlife crops and vegetation. They also protect against potential adverse effects on surface water that is hydraulically connected to groundwater.
- Maryland Environmental Service Act of 1970 (ACOM Natural resource Article, Title 3). The act is designed to "assist with the preservation, improvement and management of the quality of air, land, and water resources... and to provide for dependable, effective, and efficient water supply and purification and disposal of liquid and soil wastes and to encourage reduction in the amount of waste generated and discharged to the environment."
- Maryland Water Pollution Control Law (ACOM, EA, Title 9, Chapter 240 and amendments). The purpose of the law is "to establish effective programs and to provide additional and cumulative remedies to prevent, abate, and control pollution of the waters of the state". This includes maximum permissible long term and short term concentration of pollutants in water and issuance of discharge permits.

2.7.3 Location-specific ARARs

Restrictions placed on the concentration of hazardous substances or the conduct of activities because they are in specific locations are location-specific ARARs. Some sensitive locations for which there are ARARs include floodplains, wetlands, historic places, and sensitive ecosystems and habitats.

> "A site's location is a fundamental determinant of its impact on human health and the environment. Location-specific ARARs are restrictions placed on concentrations of hazardous substances or the conduct of activities solely because they are in specific locations." (EPA, 1988)

The following are location-specific standards or references that are used to establish location-specific ARARs:

- National Historic Preservation Act.
- Archaeological and Historic Preservation Act.
- Historic Sites, Buildings and Antiquities Act.
- Fish and Wildlife Coordination Act.
- Endangered Species Act.
- Coastal Zone Management Act.
- Wild and Scenic Rivers Act.
- Clean Water Act.
- Antidegradation Policy.
- Rivers and Harbor Act of 1899.
- Maryland Wetland Regulations
- Maryland Coastal Facilities Review Act and Rules
- Maryland Wetlands Law
- Maryland Hazardous Waste Facilities Siting Rules
- Maryland Hazardous Waste Facility Siting Law
- Maryland Hazardous Substance Spill Response Law
- Maryland Solid Waste Management Regulations
- Maryland Hazardous Waste Regulations
- Maryland Regulations reflecting Chesapeake Bay Critical Area Commission Criteria for Local Critical Area Program Development
- Maryland Threatened and Endangered Species
- Maryland Water Appropriation or Use

2.7.4 Action-specific ARARs

Action-specific ARARs are technology or activity based requirements or actions taken with respect to hazardous wastes. Action-specific ARARs do not determine the remedial alternative but indicate how a selected alternative must be achieved. Action-specific ARARs may establish performance levels, actions or technologies as well as specific levels for discharged or residual contaminants.

"Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy." (EPA, 1988)

The following are action-specific standards or references that are used to establish action-specific ARARs:

- Solid Waste Disposal Act.
- Resource Conservation and Recovery Act/Land Disposal Restrictions, Minimum Technology Requirements, Land Treatment Requirements, TCLP. To determine the applicability of RCRA requirements, the definition of solid and hazardous waste, the types of activities covered and time periods covered should be analyzed. In general, Subtitle C requirements are applicable if:
  (1) the waste is a listed or characteristic waste under RCRA, and
  (2) the waste was treated, stored, or disposed after the effective date of RCRA requirements, or
  (3) the activity at the CERCLA site constitutes treatment, storage or disposal as defined by RCRA.
- Hazardous Materials Transportation Act. Department of Transportation (DOT) Regulations for Hazardous Material Transport. DOT Regulations for hazardous waste transport will apply for off site transport of such wastes.
- Occupational Safety and Health Administration (OSHA). Federal OSHA requirements that regulate worker safety and employee records will be applicable during all site activities.
- Marine Protection, Research and Sanctuaries Act
- Clean Air Act, National Emission Standards for Hazardous Air Pollutants
- Hazardous Waste Permit Program
- National Pollutant Discharge Elimination System Program
- Maryland Wastewater Treatment Law. This law covers discharge to waters of the state including surface and underground waters of Chesapeake Bay, the Atlantic Ocean, ponds, lakes, rivers and streams.
- Maryland Well Construction Regulations
- Maryland Solid Waste Management Regulations
- Maryland Board of Well Drillers Regulations

- Maryland Erosion and Sediment Control Regulations
- Maryland Storm Water Management Regulations
- Maryland Oil Pollution Regulations

2.7.5 Other Potential Requirements

2.7.5.1 **Superfund Offsite Policy**. The Federal Register dated November 5, 1985 mandates that selection of an appropriate facility for offsite management of hazardous substances from CERCLA response actions, meet the following requirements:

- The hazardous waste management facility must have applicable RCRA permit or interim status.
- A RCRA compliance inspection must be performed not more than six months prior to the hazardous waste management facility's receipt of hazardous substances.
- If land disposal of the hazardous substance occurs, the landfill or surface impoundment must meet the minimum technology requirements of a double liner and a leachate collection system.
- If land disposal is proposed at a facility with interim status, adequate groundwater monitoring data are required to identify whether or not contamination exists.
- The hazardous waste management facility must be free of significant RCRA violations or adverse environmental impacts unless the owner/operator has committed to correcting the problems through an enforceable agreement that disposal will occur only within a new or existing unit that is in compliance with RCRA requirements and is not contributing to the adverse conditions at the facility.

Finally, it is noted that a remedial action may be selected that does not meet ARARs according to CERCLA Section 121(d)(4) if:

(a) "the remedial action selected is only part of a total remedial action that will attain such level or standard of control when completed";

(b) "compliance with such requirements at the facility will result in greater risk to human health and the environment than alternative options";

(c) "compliance with such requirements is technically impracticable from an engineering perspective";

(d) "the remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation, through use of another method or approach";

(e) "with respect to a State standard, requirements, criteria, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criteria, or limitation in similar circumstances at other remedial actions with the State"; or

(f) "in case of a remedial action to be undertaken solely under section 104 (42 USC 9604) using the Fund, selection of a remedial action that attains such level or standard of control will not provide a balance between the need for protection of public health and welfare and the environment at the facility under consideration, and the availability of amounts from the Fund to respond to other sites which present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats..."

3.1 SITE OBJECTIVES

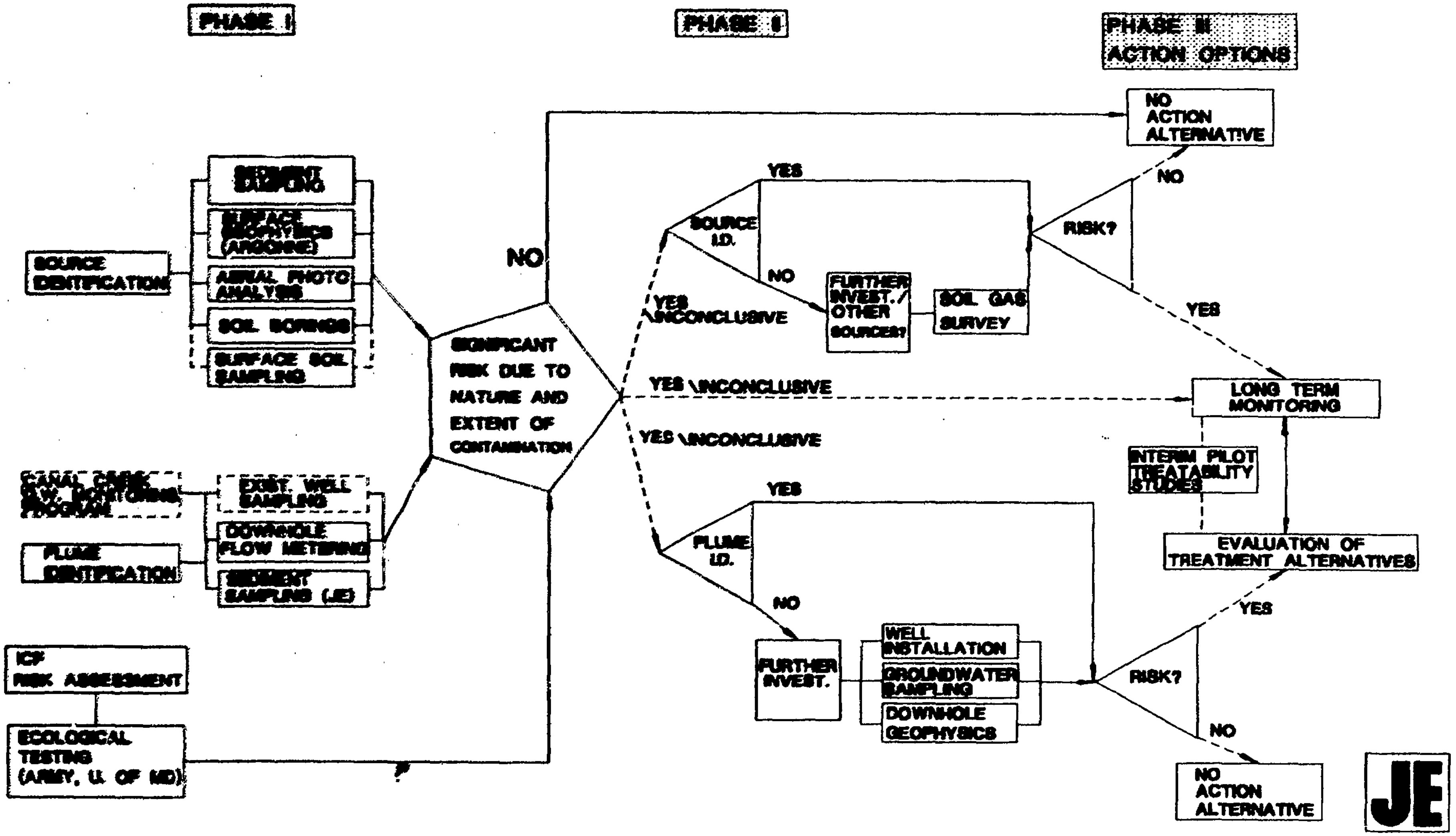
The Beach Point Focused Feasibility Study will be conducted in a three phase approach that is comprised of the phases listed below.

- Phase I: Evaluate potential on-site sources, define morphology and limited flow patterns of the surficial aquifer (JEG) and perform biological assessments (UM) and a risk assessment at Beach Point (ICF).
- Phase II: Evaluate and define the lateral extent of the DNAPL plume that exists and establish flow patterns above the clay aquitard at Beach Point.
- Phase III: Evaluate treatment options as each applies to the site conditions at Beach Point.

A flow diagram detailing the phases and integration of the activities is found in Figure 3-1.

Initially, Phase I will include an evaluation of any existing on-site sources. From historical records, past site activities that occurred at Beach Point were examined including pyrotechnic testing, clothing impregnation testing, rocket fuel testing, and assorted trenching activities. From these records, it was concluded, based on historical groundwater and soil chemical data, that activities associated with the clothing impregnating operations potentially impacted the site soils and groundwater more extensively than the activities associated with the other two site operations. Therefore, the likelihood of adverse impact to the site soils and groundwater at Beach Point caused by the pyrotechnic and rocket fuel testing is minimal, but will be addressed. The source evaluation conducted in Phase I will focus primarily at characterizing the areas located near the mobile clothing impregnating units, the burn pit and old trenching areas. Soil borings will be drilled and discrete soil samples will be collected during Phase I to help define the source areas, if they exist. In addition, groundwater sampling will be conducted from all monitoring wells that currently exist at Beach Point. The purpose for the groundwater monitoring is to continue to build the chemical data base that will be used in the risk assessment.

FIGURE 3-1
BEACH POINT - FFS ACTIVITIES



Source identification and control is dependent on groundwater velocity and direction at Beach Point. These measurements will be collected during Phase I using downhole vertical and horizontal flow meters. These instruments will attempt to partially define groundwater movement, directions, and velocities at Beach Point.

Based on historical groundwater chemical data, the predominant contaminants of concern at Beach Point are volatile organic compounds that belong to a class of constituents known as Dense Non-aqueous Phase Liquids (DNAPLs). The behavior of these contaminants of concern are not well understood within the groundwater system due primarily to their physical-chemical nature. As the name of these compounds suggest, each exhibits a density greater than water. As such, DNAPLs tend to behave as "sinkers" and will migrate downward through the vadose zone into the groundwater system and rest upon an impermeable stratum such as bedrock or clay. Therefore, it is critical to understand, to the fullest extent possible, the physical geomorphology of the surficial aquifer. Part of the task in Phase I will be to define the shape and structure of the upper confining clay aquitard at Beach Point.

Assessing the impact to the environment from past site activities conducted at Beach Point is difficult without studying the effects that these past activities have on the living biota in the area. During Phase I, a risk assessment will be conducted to assess the influence of past site activities on living biota in the area of Beach Point and to qualitatively determine human health risk from limited pathways. Depending on the Phase I risk assessment analysis, a decision will be made whether to implement Phase II and Phase III. If, as a result of the analysis, no risk to human health or the environment has been determined, the need for subsequent phases will be determined.

Phase II of the FFS at Beach Point will entail defining the lateral extent of the DNAPL plume above the clay aquitard. The Phase II scope of work will be dependent on the results of the Risk Assessment. To accomplish the tasks of identifying the DNAPL plume will require invasive activities including monitoring well installation and soil gas surveys (if relevant sources are identified). Phase II will be implemented to serve as the core of the

Beach Point FFS defining the nature and extent of the contamination, its fate and transport, and the potential for remedy. The hydrogeologic work incorporated in this phase will help to define the lateral extent of the DNAPL plume that exists above the clay aquitard. With the installation of new monitoring well clusters during Phase II, it is expected that the groundwater flow patterns, and the structural and stratigraphic components of the aquifer which affect groundwater movement at Beach Point will be better defined. Phase II will also establish a short term groundwater monitoring program of the existing and newly installed monitoring wells to ascertain the persistence of contaminants of concern in groundwater and determine whether treatment is appropriate.

Phase III is the section of the Beach Point Focus Feasibility Study technical work plan in which the treatment options will be considered based on the findings obtained during the Phase I and II portions of the technical plan. There are three categories of options that will be considered for Phase III and each is presented below:

(1) No treatment.

(2) Limited action — Long-term groundwater monitoring to measure the natural biodegradation of the contaminant plume and determine its long-term persistence in the groundwater system.

(3) Pilot/treatability study/remedial alternatives for the contaminants of concern.

3.2 FIELD INVESTIGATION/SAMPLING AND ANALYSIS ACTIVITIES

3.2.1 Phase I Investigations

Phase I investigations are intended to provide a baseline data base for determining the nature of groundwater contamination, identifying possible source areas, and performing a risk assessment in the Beach Point Test Site of APG-EA. This study only addresses the surficial aquifer at Beach Point. A schedule depicting the integration of Phase I activities is found in Figure 3-2. Table 3-1 summarizes the Phase I sampling regime.

Table 3-1. Phase I Sampling Regime

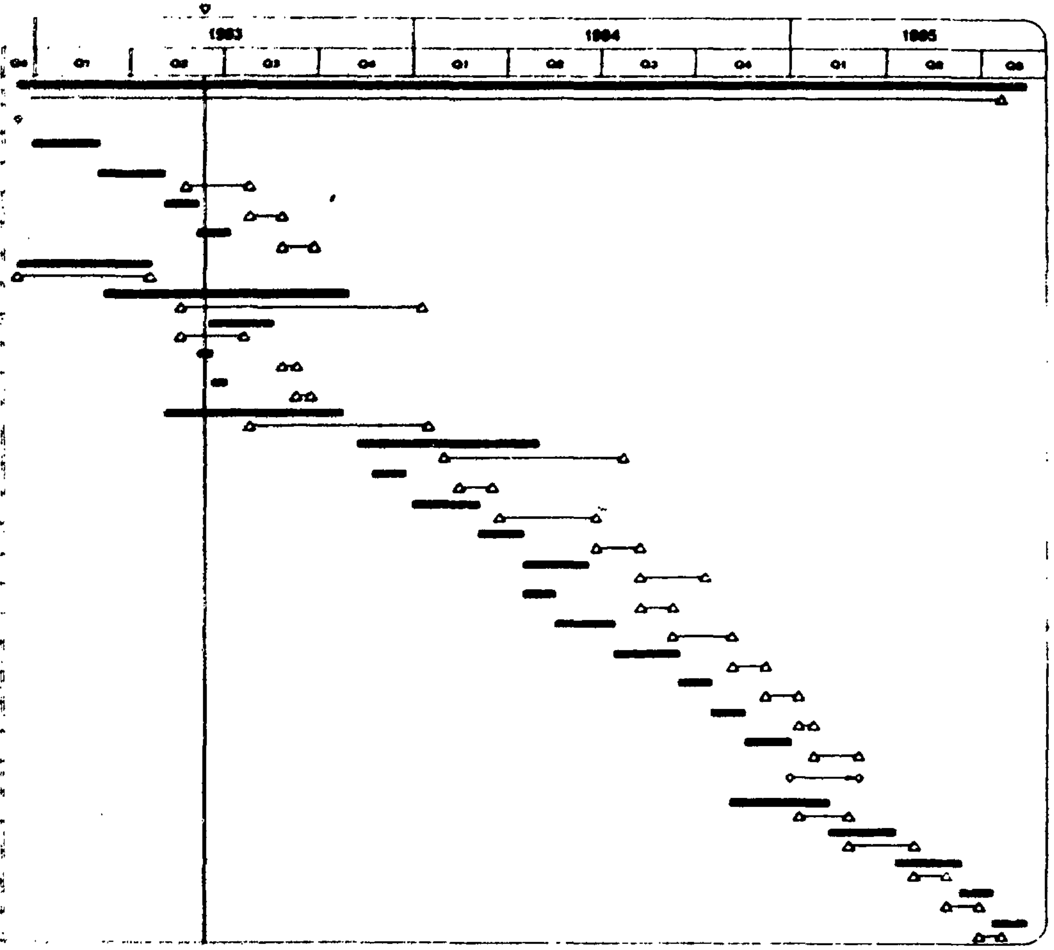
MEDIA SAMPLED	NUMBER OF SAMPLES	LOCATION OF SAMPLES**
Sediment*	10	Proximate to site
Sediment (local background)	4	Bush River, Kings Creek
Groundwater	7	Existing wells
Subsurface Soil	10	Source locations
Surface soil	20	Suspected source locations

*University of Maryland will be conducting bioassays and biotoxicity studies on groundwater and on porewater from sediment samples.

**Figure 2-6 shows sampling locations.

Figure 3-2
PROJECT SCHEDULE

Task Name	Start Date	Duration	End Date
Focused Feasibility Study OU	15-Dec-92	662.0 days	20-Jul-95
Draft FFS Work Plan	13-Dec-92	0.0	13-Dec-92
Regulatory Review	30-Dec-92	105.0 days	28-May-93
Draft Final FFS Work Plan	24-May-93	2.0 mons	26-Jul-93
Regulatory Review	27-Jul-93	1.0 mons	25-Aug-93
Final FFS Work Plan	26-Aug-93	1.0 mons	27-Sep-93
Develop FFS Goals	15-Dec-92	4.0 mons	15-Apr-93
Phase I FFS	18-May-93	7.5 mons	11-Jan-94
Geophysics	18-May-93	2.0 mons	20-Jul-93
Sediment Sampling	26-Aug-93	2.0 wks	9-Sep-93
Groundwater Sampling	10-Sep-93	2.0 wks	23-Sep-93
Risk Assessment	27-Jul-93	5.5 mons	17-Jan-94
Phase II FFS	1-Feb-94	5.5 mons	21-Jul-94
Well Installation	15-Feb-94	1.0 mons	16-Mar-94
Field Investigation	24-Mar-94	3.0 mons	24-Jun-94
Final FFS Report	27-Jun-94	6.0 wks	8-Aug-94
Regulatory Review	9-Aug-94	2.0 mons	10-Oct-94
Draft Proposed Plan	8-Aug-94	1.0 mons	6-Sep-94
Regulatory Review	9-Sep-94	8.0 wks	3-Nov-94
Draft Final Proposed Plan	4-Nov-94	1.0 mons	6-Dec-94
Regulatory Review	7-Dec-94	1.0 mons	9-Jan-95
Final Proposed Plan	10-Jan-95	2.0 wks	23-Jan-95
Public Comments	24-Jan-95	6.0 wks	6-Mar-95
Public Meeting	7-Mar-95	0.0	7-Mar-95
Draft ROD	10-Jan-95	1.5 mons	23-Feb-95
Regulatory Review	24-Feb-95	2.0 mons	26-Apr-95
Draft Final ROD	27-Apr-95	1.0 mons	26-May-95
Regulatory Review	30-May-95	1.0 mons	28-Jun-95
Final ROD	29-Jun-95	3.0 wks	20-Jul-95



3.2.1.1 **Aerial Photography**. Sections 1.0 and 2.0 of this work plan discuss known previous operations and investigations performed in the Beach Point Test Site. This information is inadequate for determining the exact locations of suspected contaminant source areas. In order to provide more specific spatial information concerning the previous activities in the Beach Point Test Site, a search for, and analysis of available historical aerial photographs will be conducted.

All available aerial photographs presently at DSHE will be reviewed. In addition, photographs will be acquired from the United States Department of Agriculture (USDA) and other sources, which cover time frames not available at DSHE.

Photographs will be obtained at an appropriate scale allowing for fine analysis of activities and conditions in the Beach Point Test Site and vicinity. The photographs will entail a minimum 10% coverage overlap allowing for stereoscopic photo-interpretation.

The stereo pairs will be examined to define operations and conditions noted for each time frame. Suspect hazardous waste activities will be plotted on a base-map and used as a guide to direct surface geophysical, soil gas sampling, surface soil sampling, and soil boring activities.

3.2.1.2 **Surface Geophysics**. Surface geophysical surveys have been conducted by Argonne National Laboratory in order to better define the hydrostratigraphy and geomorphology of Beach Point, to locate magnetic bodies, and to identify potential contaminant source areas. The geophysical techniques employed include:

1. Seismic Reflection
2. Seismic Refraction
3. Electrical Depth Sounding
4. Conductivity and Resistivity Profiling
5. Ground Penetrating Radar Survey
6. Magnetometer Survey

The field data was gathered starting May 25 and was completed by June 24, 1993. The data is now being compiled and interpreted by Argonne, Appendix B will contain the geophysical grids area. Ground truthing of shallow geophysics will be done in conjunction with Section 3.2.1.5 (Soil Borings).

3.2.1.3 Flowmeter Logging Program. A flowmeter logging program will be performed for six existing wells in the Beach Point Test Site. Measurements will be made of the lateral and vertical components of groundwater flow in the surficial aquifer. Detail of the work to be performed is presented as Appendix C.

3.2.1.4 Groundwater Analysis. Historical data indicates the contaminants of concern (COCs) in groundwater at Beach Point are 1,1,2,2-tetrachloroethane, trichloroethane, aluminum, cadmium, lead, mercury, and zinc. In order to better define the contaminant plume, seven existing wells in the Beach Point Test Site will be sampled as part of the Canal Creek Groundwater Monitoring Program. Before sample purging begins, a discrete bottom sample shall be taken from Well 33B for analysis for DNAPL.

The existing wells labeled CC-32A, CC-32B, CC-33A, CC-33B.1, CC-33B, CC-34A and CC-35A (see Figure 2-6) will be sampled for volatile organic compounds, semivolatile organic compounds, pesticides/aroclors, total metals, dissolved metals, cyanide, total phosphorous, explosives, CSM degradation products including thiodiglycol 1,4 dithane, IMPA, AND MPA; organophophorous and organosulfer compounds, dioxins/furans, herbicides, nitrate, chlorides, and fluorides.

The results from the full suite analysis of the groundwater sampling for existing monitoring wells conducted during the Canal Creek Groundwater Monitoring Program will be evaluated to determine the need to modify to the current group of contaminants of concern (COCs). The new suite of COCs will serve as an analyte list for future chemical groundwater testing in the Beach Point Test Site.

3.2.1.5 **Surface Soil Sampling**. Surface soil samples will be collected in areas determined to be "hot areas", that is, potential source areas, based on surface geophysics, aerial photographs and visual soil inspections. Samples will be collected from a number of yet to be determined locations at a depth of 1 foot below ground surface (BGS) using a cleaned stainless steel bucket auger. Sampling procedures and quality assurance procedures for surface soil sampling are presented in Sections 3.5.1 of the FSP and SOP 025 of the QAPP.

Surface soil samples will be analyzed for volatile organic compounds, semivolatile organic compounds, pesticides/aroclors, TCLP metals, cyanide, total phosphorous, explosives, thiodiglycol, dioxins/furans, organophophorous and organosulfer compounds, CSM degradation products including, 4 dithane, IMPA, and MPA, herbicides and nitrate/nitrites.

3.2.1.6 **Soil Borings**. Based upon the results of the aerial photography and surface geophysical programs, approximately (10) soil borings (see Figure 2-6) will be performed in suspect contaminant source areas. The purpose of the borings will be to collect subsurface soil samples in the vadose zone for chemical soil analyses and to ground Truth Shallow. The chemical soil analyses will identify contaminant sources, types of contaminants associated with this source, and geophysical surveys whether the contaminants are near or in contact with the groundwater surface.

Prior to soil boring activities, all locations will be screened for the presence of UXO. UXO screening will be performed during the drilling operations as described in Section 3.5.2 of the FSP. Soil borings will be performed using a standard truck-mounted drill rig and hollow-stem augers. Decontamination procedures will be followed as described in SOP 005 of the QAPP. Sampling will be performed using a 5' direct-push type sampler or 24" split spoon sampler. The soil samples will be collected from the sampler and placed in appropriate laboratory certified clean glass containers (see Sections 3.10.3 of the FSP and 5 of the QAPP). One sample will be acquired from each continuous core. Sampling will continue until the first occurrence of groundwater (approximately 15') or when the photoionization monitoring detects a hot spot. The sample will then be taken at this point and the boring terminated. One sample from each well boring is anticipated, totaling ten (10) chemical soil boring samples to be sent for analysis.

Contaminants of concern selected for chemical analysis are volatile organic compounds, semivolatile organic compounds, pesticides/aroclors, TCLP metals, cyanide, total phosphorous, explosives, thiodiglycol, dioxins/furans, organophophorous and organosulfer compounds, CSM degradation products including 1,4 2, dithane IMPA, MPA, herbicides, nitrate, chlorides, and fluorides.

3.2.1.7 Sediment Sampling. Four sediment samples are to be collected on the Kings Creek side and six are to be collected on the Bush River side of the Beach Point peninsula (see figure 2-6 for approximate sampling locations). These samples are intended to supplement information generated by the risk assessment and provide detailed chemical analysis sediments. Two pairs of local background sediment samples will also be collected, one pair from Kings Creek upstream from the Beach Point peninsula, the other pair from the Bush River. All sediment samples will be collected proximate to shore below the low-tide elevation.

3.2.1.8 Risk Assessment. A Risk Assessment will be performed by ICF Kaiser Engineers for the Kings Creek/Beach Point Test Site. The scope of work includes toxicological studies to assess the impact on aquatic life due to the presence of contaminants in surface water and sediment in the Beach Point Test Site. A general work plan for this phase of work is provided as Appendix D of this FFS Work Plan. Groundwater biomonitoring will be performed by the University of Maryland, in collaboration the US Army Biomedical Research and Development Laboratory. A detailed work plan for this activity is provided in Appendix E.

3.2.2 Phase II Investigations

Phase II investigations will be performed as required following Phase I regulatory review. Specifically, if it is determined that unacceptable risks exist at the site, or if information generated during Phase I activities is insufficient to determine the fate and transport of groundwater contamination in the Beach Point Test Site, Phase II will be undertaken.

Current well installations mainly monitor the upper portion of the surficial aquifer (4 of 6 wells). Only two wells in (Cluster 33) monitor the mid- and deep portion of the surficial aquifer (see Figure 2-5).

3.2.2.1 Well Installations/Groundwater Monitoring. Under Phase II, an additional six (6) groundwater wells will be installed in three clusters in the Beach Point Test Site (figure 2-6). The new well installations will allow JEG to obtain more detailed information concerning the groundwater quality in the mid to lower portion of the surficial aquifer in the Beach Point Test Site and allow definition of the vertical and horizontal extent of the plume.

The approximate locations of the new well clusters are presented in Figure 2-6. These cluster locations may be repositioned by the United States Geological Survey (USGS) and JEG based upon flow logs and geophysical interpretation.

The wells will be installed in clusters of two wells, one well screened at the bottom of the surficial aquifer (approximately 60-75 feet BGS) and the second well in the cluster screened at the mid-level of the surficial aquifer (approximately 45-55 feet BGS). Borings for the wells will be performed using hollow stem auger (HSA) drilling techniques. Continuous soil sampling will be performed throughout the boring to:

1. Identify soil stratigraphy and moisture content.
2. Screen the soils for VOC contamination.
3. Identify the top of the clay aquitard.

The borings will be drilled and wells installed as detailed in Section 3.5.3 of the FSP and Section SOP 019 of the QAPP. In addition, UXO screening will be performed prior to, and during the drilling operations as described in SOP 044 of the QAPP.

Groundwater sampling will be performed at the seven existing wells in the Beach Point Test Site in addition to newly installed well locations after the wells have been properly developed (see Section 3.3.1 of the FSP and Section SOP 019 of the QAPP). The analytes chosen for sampling will be the COCs determined from the results of the Canal Creek Groundwater Monitoring Program. This second phase of sampling will be performed monthly for a total of three (3) months and will include weekly groundwater level measurements in order to provide more groundwater gradient information.

3.2.2.2 **Flowmeter Logging Program**. A flowmeter logging program will be performed on wells installed in Phase II as discussed in Section 3.2.1.3.

3.2.2.3 **Downhole Geophysics**. Gamma ray logging of newly installed wells will be performed on the Phase II wells and older USGS well 33B to provide geologic correlation. Downhole geophysics will be performed by a JEG subcontractor.

3.2.2.4 **Soil Gas Survey(s)**. Approximately 50 soil gas samples will be collected and analyzed for the presence of VOCs and/other contaminants of concern.

Objectives of the soil gas sampling program are to:

- Identify vadose zone areas of source contamination.
- Outline the surficial extent of source contamination.

Figure 2-2 illustrates the general study area for the soil surveys at Beach Point.

Prior to initiation of any soil gas sampling, a APG-DSHE approved, UXO contractor assisted by the APG Explosive Ordnance Disposal (EOD) team members will coordinate the field work effort with APG-EA Safety Office. An MK-26 Ordnance Locator and/or similar metallic material detector will screen the subsurface to a depth of four feet. If suspicious anomalies are encountered, the sampling point will be abandoned and moved to a safe location.

- The location of all identified or suspected UXO will be marked and reported to EOD. The UXO contractor will assist in developing a "render safe" plan for all UXO.
- Additional steps to ensure the safety of site personnel will be followed as described in the Unexploded Ordnance Clearance Scope of Work (see Sections 3.2.4 in the Work Plan, and SOP 044 in the QAPP and Section 4.1 in the HASP).

The soil gas sampling will be performed using active soil gas withdrawal. Passive soil gas sampling equipment will be used if it is not possible to penetrate the subsurface due to the presence of a large amount of potential UXO. Several off-site background soil gas samples will be collected as baseline correlations for non-source points. The background areas will be determined by Army personnel.

Soil gas surveys will be completed within six weeks. Following the completion of the soil gas surveys, possible additional soil boring locations (if needed) will be selected in areas of suspected significant subsurface soil contamination to identify sources.

3.2.3 Phase III — Development and Screening of Alternatives

If Phase II is implemented, the analysis of the results of this phase will determine the development of alternatives in Phase III.

An FFS Report will be prepared which will evaluate potential groundwater waste management options applicable to the site and waste characteristics (e.g., the extent of DNAPL contamination) as identified in Phase I and Phase II. ICF will conduct a risk assessment which will provide an evaluation of the potential ecological risk and threat to human health in the absence of any remedial action. Appropriate waste management options will be developed that will minimize or eliminate such risk. Depending on site-specific circumstances, this may involve the complete elimination or destruction of hazardous substance at the site, the reduction of concentrations of hazardous substances to acceptable health and aquatic-based levels, and prevention of exposure to hazardous substances via engineering or institutional controls, or some combination of the above.

3.2.3.1 **No Action Alternative**. As required by CERCLA and the NCP, the no action alternative will be evaluated as a potential remedy. The no action alternative will serve as a baseline for comparison of other alternatives. This alternative will be selected, if the results of Phase I, Phase II, and previous sampling programs indicate compliance with ARARS and no existing ecological risk or threat to human health and the environment.

3.2.3.2 **Limited Action Alternative**. A limited action alternative will include ongoing monitoring and sampling of groundwater to detect any changes in contaminants concentrations. Due to the DNAPL characteristics at Beach Point, extreme caution will be taken when drilling in DNAPL areas in order to avoid creating new vertical pathways.

3.2.3.3 **Alternative Development Process**. Potential alternatives will be developed concurrently with Phase I and/or II contaminant characterization activities, with the results of one influencing the other in an iterative fashion (i.e., Phase II characterization data will be used to develop alternatives and screen technologies in Phase III).

If pilot treatability studies are deemed necessary, a work plan will be prepared which will constitute an amendment to the overall FFS work plan. A pilot test will be omitted in the event that screening feasibility studies are sufficiently conclusive. Table 3-2 outlines the general content of such a plan.

Table 3-2. Format for Pilot-scale Work Plan

1. Remedial technology
2. Test Objectives
3. Pilot plant installation and start-up
4. Pilot plant operation and maintenance procedures
5. Parameters to be tested
6. Sampling plan
7. Analytical methods
8. Data Management
9. Data analysis and interpretation
10. Health and safety
11. Residuals management

Pilot plant systems will be designed as small as possible to minimize cost, yet large enough to get the data required for scaling up. Pilot units will be operated in a manner as similar as possible to the operation of a full-scale system. Any waste generated will be handled and stored in a manner responsive to CERCLA requirements.

Testing procedures will be well documented, in bound notebooks. Backup copies will be made of critical items of data. In addition, data sheets will be prepared to facilitate the collection of complete data.

Alternatives for remediation will be developed by an initial screening of remedial technologies and process options based on technology development, site and waste characteristics. The retained options will undergo secondary screening based on effectiveness, implementability and relative cost. A combination of the retained technologies would be assembled into alternatives that address contamination in the accelerated groundwater operable unit. This process would follow six general steps:

(1) Develop remedial action objectives specifying the contaminants and media of concern, exposure pathways, and preliminary remediation goals that permit a range of treatment and containment alternatives to be developed. The preliminary remediation goals are developed on the basis of chemical-specific ARARS and site-specific risk-related factors.

(2) Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the remedial objectives for Beach Point.

(3) Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characterization of the site.

(4) Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site. The general response actions will be further defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include physical/chemical or thermal destruction technology types).

(5) Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

(6) Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

3.2.3.4 Detailed Analysis of Alternatives. JEG will conduct a detailed analysis to provide the basis for identifying a preferred alternative. Upon completion of the detailed analysis, the FFS report will be submitted for public review and comment. The results of the detailed analysis will support the final selection of a remedial action and will be the foundation of the Record of Decision.

The detailed analysis of alternatives will address the following components:

- Further definition of each alternative, if necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.
- Assessment and summary profile of each alternative against the evaluation criteria.
- Comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

Two statutory requirements of CERCLA constitute threshold criteria to be met by each alternative of the FFS:

- Overall protection of human health and the environment.
- Compliance with ARARs.

Evaluation of the overall protectiveness of an alternative during the FFS will focus on whether that alternative achieves adequate protection. The evaluation will also describe how site risks posed through each pathway being addressed by the FFS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. Evaluation also allows for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

The detailed analysis will summarize which ARARs are pertinent to each alternative and describe how the alternative meets these requirements. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA will be discussed. Specifics to be included are:

- Compliance with chemical-specific ARARs (e.g., maximum contaminant levels) — This factor addresses whether the ARARs can be met, and if not, whether a waiver is appropriate.

- Compliance with location-specific ARARs (e.g., preservation of historic sites) — As with other ARAR-related factors, this involves a consideration of whether the ARARs can be met or whether a waiver is appropriate.
- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards) — It must be determined whether ARARs can be met or will be waived.

All ARARs will be listed and a determination will be made of whether each will be satisfied by the specific remedial alternative.

Several criteria are largely technical in nature and as such distinguish engineering refinement in remedial design. These criteria represent the primary factors upon which the detailed analysis is based. The overall approach for analyzing technological and engineering aspects will focus first on long-term effectiveness and permanence, specifically:

- Magnitude of residual risk.
- Adequacy and reliability of controls.

With respect to effectiveness in reducing toxicity, mobility, and volume through treatment, JEG will study the following factors:

- Treatment process used and material treated.
- Amount of hazardous materials destroyed or treated.
- Degree of expected reductions in toxicity, mobility, and volume.
- Degree to which treatment is irreversible.
- Type and quantity of residuals remaining after treatment.

With respect to short-term effectiveness the factors to be studied will be:

- Protection of community during remedial actions.
- Protection of workers during remedial actions.

- Environmental impacts.
- Time until remedial action objectives are achieved.

Aspects of the implementability of the remedial alternatives which will be analyzed are:

- Ability to construct and operate the technology.
- Reliability of the technology.
- Ease of undertaking additional remedial actions, if necessary.
- Ability to monitor effectiveness of remedy.
- Ability to obtain approvals from other agencies.
- Coordination with other agencies.
- Availability of treatment, storage, and disposal services and capacity.
- Availability of necessary equipment and specialists.
- Availability of prospective technologies.

Cost aspects to be evaluated during detailed analysis will be:

- Capital costs.
- Operating and maintenance costs.
- Present worth cost.

3.2.3.5 **Acceptability**. Preliminary evaluations will be made on the acceptability of the remedial alternatives to the State of Maryland and to the community in vicinity of Beach Point. Acceptability is finally determined later on the basis of the comments made in review of the FFS report.

3.2.3.6 **Comparative Analysis**. A comparative analysis will be conducted to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. This is in contrast to the preceding analysis in which each alternative was analyzed independently without a consideration of other alternatives.

The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that the key tradeoffs the decisionmaker must balance can be identified.

3.2.3.7 **Potential Remedial Alternatives**. Some potential remedial alternatives for the groundwater operable unit that may result from a thorough screening and combining of general response actions, technologies and process options include the following:

- No Action
- Limited Action - Continue to Monitor
- Pump, Treat and Discharge to King's Creek
- Pump and Transport Off-Site
- Pump and Discharge to POTW
- Pump, Treat and Discharge to POTW
- Insitu-Bioremediation

Where removal of DNAPL by excavation is not viable, remediation using in-situ removal methods is typically considered. In addition to bioremediation, other potential in-situ options will be evaluated including:

- Induced Volatilization
- Chemically-Enhanced Displacement
- Steam Displacement
- Chemically-Enhanced Dissolution

Induced volatilization or soil vapor extraction is currently the only in-situ method being applied DNAPL at sites with success; however, even this method has limited applicability and effectiveness. Consequently, at present, most DNAPL sites are using conventional engineering approaches, such as aquifer pumping wells or combinations of cut-off walls and source area groundwater pumping, to control offsite migration dissolved contaminants. It is important to note that the remediation strategy becomes one of long-term control versus actual site clean-up.

4.0 FOCUSED FEASIBILITY STUDY REPORT

4.1 PHASE I

At the conclusion of Phase I of the project, JEG will prepare a report. The report will be submitted to EMO within 90 calendar days of the collection of the final media sample and conclusion of all other activities. The format of the report will be as follows:

- Introduction
  - Report objective and criteria
  - Governing documents and regulations
  - Summary of report contents
- Field Activities and Sampling Methodology
  - Field measurements
  - Sample collection
  - Sampling handling, documentation, and custody
  - Laboratory analytical procedures
- Observations and Summary
  - Aerial Photography Investigation
  - Surface Geophysical Investigation
  - Physical Soil Boring Data, Geology, and Down—hole Geophysics
  - Water level data
  - Chemical Data
  - Data validation summaries
  - Recommendations
  - Groundwater levels and field parameter measurements
  - Summary of laboratory analytical data
  - Summary of recommended actions
- Appendix
  - Maps
  - Surface geophysics survey location map and EM and Seismic maps
  - Water level contour maps
  - Contaminant plume map or cross-section/source(s) map; shaded map of contaminated areas defined by chemical data, more than one map may be constructed if spacial and graphic constraints are encountered.

Results of the sampling program will be presented in the groundwater monitoring report. The report will contain descriptions of sampling procedures and methods used to accomplish the task in addition to laboratory methods employed for chemical analyses of groundwater samples. Summaries and recommendations will be supported with tabulated data and associated maps.

5.1 PROJECT STAFFING

Figure 5-1 shows the overall FFS project organization, the principal lines of communication for implementation, and the functional relationships within the contractor organization.

5.1.1 Key Roles

Designated key roles for the APG-DSHE work at APG-EA are described below:

- **DSHE Project Officer**. The Project Officer will be responsible for coordinating and monitoring DSHE activities at APG. Responsibilities will include technical management of the investigations and review and approval of all deliverables for technical content and compliance with DSHE guidelines and requirements.
- **Battelle-EMO Program Manager**. The Program Manager will be responsible for overall direction, coordination, technical consistency, and review of the entire effort. Responsibilities include:
  - — Formal communications with the Project Officer;
  - — Final approval and review of work plans, all project deliverables, schedules, contract changes, and labor allocations; and
  - — Guiding the approach to particularly difficult problems which may arise.
- **JEG Project Manager**. The Project Manager is vested with the authority to select personnel assigned to the project. He or she may also alter personnel assigned to the project team and approve or disapprove all submissions and modifications to budgets and schedules. In addition, the Project Manager will interact with the EMO Program Manager, Task Managers, and the Project Team to ensure consistency of work products.

The Project Manager will be responsible for directing coordination among support personnel to ensure consistency of performance. Responsibilities include:

- Technical and project management interactions with DSHE;
- Effective day-to-day management of all task operations;
- Preparation of cost and performance reports with the assistance of key support personnel;
- Management of all funds for labor and materials procurement;
- Management of the team toward unified, productive project accomplishment; and
- Technical review of all task deliverables and integration of all work elements.

Figure 5-1. Project Management Organization

To supervise the day-to-day operations of the project, including the preparation and technical review of all project deliverables, and management of funds, he or she has the authority to allocate budgets among the work elements required for the project, and to establish and enforce milestones to ensure timely completion of the investigation. He, or she, may also approve or disapprove any labor or material charges and contributions to any technical deliverable.

- **Task Manager.** The Task Manager will direct all field studies and investigations and the development of assigned reports. He or she will be responsible for the completeness of data gathered during the field program.

5.1.2 Support Roles

Important support roles to the project are:

- **Site Health and Safety Coordinator (SHSC).** The SHSC will be responsible for:
  - — Preparing and reviewing the project Health and Safety Plan. He, or she, will ensure that all elements addressed in the Plan are consistent with the field sampling requirements.
  - — To fulfill these responsibilities, the SHSC has the authority to recommend and require safety systems and procedures commensurate with defined hazards at a site, and to demand compliance with all safety-related SOPs and plans, and dismiss from the site any personnel not acting in a safe manner. In addition, he or she can directly intercede to stop any activities deemed to be a threat to personal health or property, and recommend/implement procedures for correcting safety problems. Responsibilities will also include identifying the required level of protection for personnel for any field procedures, requiring the utilization of qualified personnel trained in necessary safety procedures, and ensuring that adequate emergency procedures and response capabilities are available.
- **QA Coordinator (QAC).** The Quality Assurance Coordinator is responsible for all quality assurance and data/documentation control activities. The role of the QAC will be to:
  - — Assure that all final project deliverables are based on defensible, documented data for which uncertainties can be quantified;
  - — Assure that adequate QC documentation is provided for all project deliverables; and

- — Assure that all QC problems are resolved in an expeditious manner and brought to the attention of the technical managers.
- — To fulfill these responsibilities, the QAC has the authority to demand quality performance from all project participants and recommend solutions to observed quality problems to the Task Manager.

5.2 PROJECT MONITORING AND CONTROL

The Project Manager and appropriate technical management support staff will provide oversight and control of project progress, schedule. and budget in accordance with the approved Work Plan. Their efforts will ensure that the Battelle-EMO Program Manager remains aware of work assignment status.

5.2.1 Monthly Progress Reports

Monthly technical and financial progress/status reports will be submitted to Battelle-EMO.

5.2.2 Monitor Quality Assurance

All technical review and oversight activities will be monitored under the Jacobs Quality Assurance/Quality Control Plan for DSHE. The plan is based on the premise that the quality control process is more than review of deliverables. It starts as soon as a work assignment or task order is received and continues through the planning, execution, documentation and close-out of the project. Although the primary responsibility for quality work rests with the project manager, appropriate management and technical personnel will assist in meeting this requirement. The management and technical personnel will review deliverables and participate in critical decisions on an as needed basis. Ongoing monitoring by Jacobs management is designed to identify potential problems, to promote their solution and to prevent their reoccurrence. The deliverable review process will ensure that documents are technically sound, complete, and understandable. For budgeting purposes, it has been assumed that a field quality assurance audit will also be conducted by a senior Jacobs employee during the field investigation.

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Acronyms

1,1-DCE	1,1-Dichloroethene
1,2-DCA	1,2-Dichloroethane
ACOM	Annotated Code of Maryland
ANL	Argonne National Laboratory
APG-EA	Aberdeen Proving Ground - Edgewood Area
BGS	Below Ground Surface
BNAS	Base Neutral Acids
CAG	Carcinogen Assessment Group
CC2	(N,N-dichloro-bis(2,4,6-trichlorophenyl)urea)
CFC	Chlorofluorocarbon
COC	Contaminant of Concern
CLP	Contract of Laboratory Program
CRDE	Chemical Research Development Engineering
CSM	Chemical Surety Material
DCE	Dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquids
DQI	Data Center Quality Indicator
DQO	Data Quality Objective
DSHE	Directorate of Safety, Health,and Environment
EMI	Electromagnetic Induction
EMO	Environmental Management Operations
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
FFS	Focused Feasibility Study
FS	Feasibility Study
HC	Hydrocarbon
HGA	Hydrogeological Assessment
HMX	Cyclotetramethylenetetranitramine [Explosive]
HSA	Hollow Stem Auger
ICF	ICF Kaiser Engineers
IMPA	Isopropylmethylphoshonic Acid
IRP	Installation Restoration Program
JEG	Jacobs Engineering Group
M1	Solvent Based Process Used In Clothing Impregnating Operations
M2	Water Based Process Used in ClothingImpregnating Operations
MCL	Maximim Contaminant Level
MPA	Methylphosphonic Acid
MGD	Million Gallons Per Day
MNRC	Maryland National Resource Code
MPRSA	Marine Protection, Research, and Sanctuaries Act
NESHAPs	National Emission Standards for Hazardous Air Pilutants
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

PCB	Polychlorinated Biphenyl
PCE	Perchloroethene
POTW	Publicly Owned Treatment Works
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,4-triazine [Explosive]
RFA	RCRA Facility Assessment
RFNA	Red Fuming Nitric Acid
SAP	Sampling and Analysis Plan
SDWA	Safe Drifting Water Act
SED	Sediment
STP	Standard Temperature & Pressure
SVOC	Semivolatile Organic Compound
SWDA	Solid Waste Disposal Act
SWMU	Solid Waste Management Unit
T-1,2-DCE	Trans-1,2-dichloroethene
TAL	Target Analyte List
TBC	To Be Considered
TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TCFM	Trichlorofluoromethane
TCPU	N-chloro-bis (2,4,6-trichlorophenyl) Urea
TDS	Total Dissolved Solids
TIC	Tentatively Identified Compounds
TNT	Trinitrotoluene
TOC	Total Organic Carbon
UDMH	Unsymmetrical Dimethylhydrazine
UM	University of Maryland
UTM	Universal Transverse Mercator
USAEHA	United States Army Environmental Health Agency
USATHAMA	United States Army Toxic and Hazardous Material Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WP	White Phosphorus
WWI	World War I
WWII	World War II
WWTP	Wastewater Treatment Plant
XXCC3	Micronized Impregnite [N,N'-dichloro-bis (2,4,6-trichlorophenyl) Urea] with 10% Zinc Oxide

Appendix A — Data from Groundwater Monitoring Wells in Beach Point Area*

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*Data derived from the USGS HGA

Table A-1

Water Quality Parameters and Major Ion Concentrations Detected in Groundwater Monitoring Wells in the Beach Point Area[1]

WELL	CC-32A				CC-32B				CC-33A			
PHASE[a]	1	2	3	4	1	2	3	4	1	2	3(H)	4
ANALYSES[b]												
Water Temperature (degrees C)	14.0	15.3	–	–	14.0	16.0	–	–	14.0	15.0	13.6	13.6
Oxygen	4	3.4	–	–	6	< .10	–	–	6	2.0	0.5	2.6
Specific conductance (µS/cm)	1200	670	–	–	1610	1000	–	–	617	301	400	376
pH	5.68	5.38	–	–	6.12	5.60	–	–	6.56	6.37	6.26	6.23
Solids, residue at 180 degrees C	770	614	–	–	1000	640	–	–	370	200	262	–
Calcium	31	11	–	–	27	20	–	–	30	6.6	3.3	4.6
Magnesium	16	11	–	–	20	27	–	–	12	7.6	6.3	6.2
Sodium	160	200	–	–	200	270	–	–	80	66	41	60
Potassium	1.5	88	–	–	6.1	3.0	–	–	3.6	3.1	–	2.1
Alkalinity, (mg/L as $CaCO_3$)	37	16	–	–	7	6	–	–	50	30	16	13
Sulfate	170	70	–	–	150	86	–	–	74	68	75	66
Chloride	270	200	–	–	430	400	–	–	160	60	60	60
Iron (µg/L)	340	110	–	–	180	480	–	–	2000	200	< 30	310

WELL	CC-33B.1				CC-33B						CC-34A				CC-35A			
PHASE[a]	1	2	3	4	1	2	3(H)	3(HR)	4	4(R)	1	2	3	4	1	2	3	4
ANALYSES[b]																		
Water Temperature (degrees C)	–	14.0	–	–	13.2	14.0	13.6	–	14.8	–	14.6	16.0	-	–	13.6	–	–	–
Oxygen	–	< .10	–	–	< .1	< .10	6	–	.4	–	1.3	3.1	–	–	2	–	–	–
Specific conductance (µS/cm)	–	670	–	–	2400	2100	2400	–	2310	–	3700	4400	–	–	364	–	–	–
pH	–	4.37	–	–	4.44	4.14	3.87	–	4.00	–	10.06	6.18	–	–	6.66	–	–	–
Solids, residue at 180 degrees C	–	610	–	–	1140	1100	1400	1400	–	–	2110	2770	–	–	–	–	–	–
Calcium	–	13	–	–	20	23	23	22	27	24	20	61	–	–	–	–	–	–
Magnesium	–	16	–	–	40	48	40	40	44	46	30	72	–	–	–	–	–	–
Sodium	–	280	–	–	330	360	230	220	370	320	600	880	–	–	–	–	–	–
Potassium	–	2.6	–	–	4.0	4.1	–	–	4.0	4.7	60	32	–	–	–	–	–	–
Alkalinity, (mg/L as $CaCO_3$)	–	< 1	–	–	< 1	< 1	< 1	–	0	–	87	83	–	–	–	–	–	–
Sulfate	–	18	–	–	66	75	66	63	66	100	160	210	–	–	–	–	–	–
Chloride	–	280	–	–	600	630	660	780	> 240	240	1000	1400	–	–	–	–	–	–
Iron (µg/L)	–	14,000	–	–	7400	8300	< 30	< 30	4800	4300	60	80	–	–	–	–	–	–

Table A-1

Water Quality Parameters and Major Ion Concentrations Detected in Groundwater Monitoring Wells in the Beach Point Area
(continued)

WELL	CC-32A				CC-32B				CC-33A				CC-33B.1				CC-33B						CC-34A				CC-38A			
PHASE[2]	1	2	3	4	1	2	3	4	1	2	3(H)	4	1	2	3	4	1	2	3(H)	3(HR)	4	4(R)	1	2	3	4	1	2	3	4
ANALYSES[3]																														
Silica	[illegible]	[illegible]	–	–	[illegible]	17	–	–	1.4	21	10	10	–	11	–	–	14	14	11	12	12	12	3.0	8.3	–	–	–	–	–	–
Fluoride	[illegible]	[illegible]	–	–	[illegible]	17	–	–	[illegible]	< 10	< 071	20	–	< 10	–	–	30	23	< 071	< 071	1.3	1.4	24	14	–	–	–	–	–	–
Nitrogen, ammonia (as N)	< 20	< 10	–	–	[illegible]	< 10	–	–	< 20	< 10	–	–	–	< 10	–	–	< 20	< 10	–	–	–	–	< 20	< 10	–	–	–	–	–	–
Nitrogen, nitrite (as N)	[illegible]	< 02	–	–	< 01	< 02	–	–	[illegible]	< 02	–	< 10	–	< 02	–	–	01	< 02	–	–	< 10	< 10	32	< 02	–	–	–	–	–	–
Nitrogen, nitrite + nitrate (as N)	[illegible]	10	–	–	20	[illegible]	–	–	16	[illegible]	033	–	–	[illegible]	–	–	13	< 05	< 031	046	–	–	53	10	–	–	–	–	–	–
Nitrogen, ammonia + organic (as N)	[illegible]	20	–	–	77	< 20	–	–	07	< 20	–	10	–	< 20	–	–	01	< 20	–	–	20	[illegible]	[illegible]	< 20	–	–	–	–	–	–
Phosphorus	[illegible]	< 10	–	–	[illegible]	01	–	–	17	.01	–	–	–	< 01	–	–	02	< 01	–	–	–	–	.02	02	–	–	–	–	–	–
Sulfide	–	–	–	–	–	–	–	–	< 1.0	–	–	–	–	–	–	–	< 1.0	–	–	–	–	–	–	–	–	–	< 1 0	–	–	–
Bromide	–	1.2	–	–	–	1.4	–	–	–	37	15	23	–	< 10	–	–	–	1.1	1.7	1.7	2.0	3.1	–	.01	–	–	–	–	–	–
Cyanide	< 01	–	–	–	< 01	–	–	–	< 01	–	–	–	–	–	–	–	< 01	–	–	–	–	[illegible]	< 01	–	–	–	–	–	–	–
Manganese (µg/L)	[illegible]	[illegible]	–	–	[illegible]	[illegible]	–	–	[illegible]	[illegible]	[illegible]	140	–	1400	–	–	3300	3100	2700	2700	3000	4300	< 2	[illegible]	–	–	–	–	–	–

[1] [illegible] at 25 degrees C; µg/L, micrograms per liter; R, replicate sample; H, [illegible] analysis performed; <, less than; >, greater than; –, compound not analyzed for.]

[2] [Sample collection dates: Phase 1, 12/17/88; Phase 2, 6/7/89; Phase 3, 4/20/89; Phase 4, 10/11/89.]

[3] [All results reported in mg/L (milligrams per liter), unless otherwise noted.]

Table A-2

Metal Concentrations Detected in Groundwater Monitoring Wells in the Beach Point Area[1]

WELL	CC-32A				CC-32B				CC-33A				CC-33B.1				CC-33B						CC-34A				CC-35A			
PHASE[2]	1	2	3	4	1	2	3	4	1	2	3(H)	4	1	2	3	4	1	2	3(H)	3(HR)	4	4(R)	1	2	3	4	1	2	3	4
ANALYSES[3]																														
Aluminum	–	–	–	–	–	–	–	–	–	–	<100	300	–	–	–	–	–	–	<100	<100	4000	4200	–	–	–	–	–	–	–	–
Antimony	<24	<3	–	–	<24	<3	–	–	<24	<3	<70	<72	–	<3	–	–	<24	<3	<70	<70	<72	<72	<24	<3	–	–	–	–	–	–
Arsenic (total)	<5	<1	–	–	<5	<1	–	–	<5	<1	<1	<3	–	<1	–	–	<5	<1	<1	<1	<3	<3	<5	<1	–	–	–	–	–	–
Barium	–	–	–	–	–	–	–	–	–	–	30	24	–	–	–	–	–	–	77	74	88	88	–	–	–	–	–	–	–	–
Beryllium	<1	<10	–	–	<1	<10	–	–	<1	<10	–	–	–	<10	–	–	4	<10	–	–	–	–	<1	<10	–	–	–	–	–	–
Boron	60	30	–	–	130	70	–	–	60	<30	<270	<270	–	<30	–	–	80	50	<270	<270	<270	<270	220	370	–	–	–	–	–	–
Cadmium	<2	3	–	–	<2	<1	–	–	<2	<1	<3	5	–	4	–	–	<2	3	<3	<3	<3	<3	<2	<1	–	–	–	–	–	–
Chromium	7	4	–	–	10	3	–	–	<6	<1	<80	<80	–	<1	–	–	14	<1	<30	<80	<80	<80	14	<1	–	–	–	–	–	–
Copper	<3	10	–	–	13	3	–	–	7	1	<20	<22	–	10	–	–	10	10	100	80	<22	<22	10	2	–	–	–	–	–	–
Lead	<30	<1	–	–	<30	3	–	–	<30	<1	<6	<6	–	8	–	–	<30	8	15	12	12	<6	<30	<1	–	–	–	–	–	–
Mercury	<.2	<.5	–	–	<.2	<.5	–	–	<.2	<.5	<.6	–	–	<.6	–	–	<.2	<.5	<.6	<.6	–	–	<.2	<.5	–	–	–	–	–	–
Nickel	10	15	–	–	63	40	–	–	<6	11	<22	40	–	180	–	–	180	140	220	210	170	150	<6	10	–	–	–	–	–	–
Selenium	<2	<1	–	–	<2	<1	–	–	<2	<1	<4	[illegible]	–	<1	–	–	<2	<1	<4	<4	<4	<4	<2	<1	–	–	–	–	–	–
Silver	–	–	–	–	–	–	–	–	–	–	<3	3	–	–	–	–	–	–	26	<3	<3	<3	–	–	–	–	–	–	–	–
Thallium	–	–	–	–	–	–	–	–	–	–	<40	<44	–	–	–	–	–	–	<40	<40	<44	<44	–	–	–	–	–	–	–	–
Zinc	60	32	–	–	180	73	–	–	40	10	<42	<42	–	370	–	–	430	480	570	510	440	430	40	610	–	–	–	–	–	–

[1] (R) replicate sample, H, [illegible] analysis performed, < less than, –, compound not analyzed for.)

[2] (Sample collection dates: Phase 1, 12/11/88, Phase 2, 6/7/89, Phase 3, 4/30/90, Phase 4, 10/11/90.)

[3] (All results reported in ug/L (micrograms per liter).)

Table A-3

Concentrations of Volatile Organic Constituents Detected in Groundwater Monitoring Wells CC-32A, CC-32B, CC-33A, and CC-33B.1 in the Beach Point Area[1]

WELL	CC-32A				CC-32B				CC-33A				CC-33B.1			
PHASE	1	2	3	4	1	2	3	4	1	2	3(R)	4	1	2	3	4
SAMPLING DATE	12/17/86	9/7/88	Not	Not	12/17/86	9/7/88	Not	Not	12/17/86	9/7/88	4/26/89	10/11/89	Not	9/7/88	Not	Not
ANALYSIS DATE	1/9/87	9/29/88	Sampled	Sampled	1/8/87	9/20/88	Sampled	Sampled	1/8/87	9/21/88	—	—	Sampled	9/21/88	Sampled	Sampled
ANALYTES[2]																
Carbon, total organic (mg/L)	—	—	—	—	—	—	—	—	—	—	61	30	—	—	—	—
Carbon, organic, dissolved (mg/L)	—	—	—	—	—	—	—	—				—	—	—		—
Organic halogen, total (µg/L)	210	—	—	—	190	—	—	—	1000	—	720	870	—	—	—	—
Organic halogen, total (µg/L), lab duplicate	380	—	—	—	200	—	—	—	1000	—	—	—	—	—	—	—
Organic halogen, total (µg/L), [illegible]	60	30	—	—	40	<5	—	—	1300	—	—	—	—	43	—	—
Toluene	<4	<50	—	—	<4	<50	—	—	<60J	<50	—	<81	—	<50	—	—
Benzene	<6	<50	—	—	<6	<50	—	—	<10J	<50	—	<24	—	<50	—	—
Ethylbenzene	<4	<50	—	—	<4	<50	—	—	<60J	<50	—	<88	—	<50	—	—
Chlorobenzene	<6	<50	—	—	<6	<50	—	—	<17J	<50	<10	<14	—	<50	—	—
Carbon tetrachloride	<10	<50	—	—	<10	<50	—	—	<20J	<50	<15	<50	—	<50	—	—
Chloroform	60	30	—	—	52	<50	—	—	<16J	70	<73	60	—	20	—	—
Methylene chloride	3100	4000J	—	—	3100	80	—	—	<22J	14	<20	<53	—	10	—	—
1,1,2,2-Tetrachloroethane	<14	<10	—	—	<14	<10	—	—	1300	—	730	840	—	38	—	—
1,1,2-Trichloroethane	<10	<50	—	—	<10	<50	—	—	<37J	80	40	<10	—	<50	—	—
1,2-Dichloroethane	<10	<10	—	—	<10	<10	—	—	<30J	<10	<28	<80	—	<10	—	—
1,1-Dichloroethane	<10	<50	—	—	<10	<50	—	—	<20J	<50	<17	<11	—	<50	—	—

C:\BEACHPOINT\A-1 [illegible]

Table A-3

Concentrations of Volatile Organic Constituents Detected in Groundwater Monitoring Wells CC-32A, CC-32B, CC-33A, and CC-33B.1 in the Beach Point Area

(continued)

WELL	CC-32A				CC-32B				CC-33A				CC-33B.1			
PHASE	1	2	3	4	1	2	3	4	1	2	3(H)	4	1	2	3	4
SAMPLING DATE	12/17/86	6/7/88	Not	Not	12/17/86	6/7/88	Not	Not	12/17/86	6/7/88	4/26/89	10/11/89	Not	6/7/88	Not	Not
ANALYSIS DATE	1/5/87	6/21/88	Sampled	Sampled	1/5/87	6/20/88	Sampled	Sampled	1/8/87	6/21/88	—	—	Sampled	6/21/88	Sampled	Sampled
ANALYTES[b]																
Tetrachloroethylene	<1.0	<5.0	—	—	<1.0	<5.0	—	—	84	28	11	19	—	<5.0	—	—
Trichloroethylene	1.7	<5.0	—	—	3.1	<5.0	—	—	250	—	200	100	—	8.0		—
1,1 Dichloroethylene	<1.0	<5.0	—	—	<1.0	<5.0	—	—	<.38d	<5.0	<.30	<10	—	<5.0	—	—
1,2 trans Dichloroethylene	<1.0	<5.0	—	—	<1.0	<5.0	—	—	<.32d	3.0J	<.67	<11	—	<5.0	—	—
Vinyl chloride	<1.3	<10	—	—	<1.3	<10	—	—	<.28d	<10	<.48	<2.4	—	<10	—	—
1,3 cis Dichloropropene	—	—	—	—	—	—	—	—	—	—	<.10	<5.0	—	—	—	—
1,3 trans Dichloropropene	—	—	—	—	—	—	—	—	—	—	<.71	<8.0	—	—	—	—
1,1,2 Trichloroethane	—	—	—	—	—	—	—	—	—	—	<.30	<4.5	—	—	—	—
Bromodichloromethane	—	—	—	—	—	—	—	—	—	—	<.13	<7.5	—	—	—	—
1,2 Dichloropropane	—	—	—	—	—	—	—	—	—	—	<.13	<2.8	—	—	—	—
Bromoform	—	—	—	—	—	—	—	—	—	—	<.73	<8.7	—	—	—	—
Methyl chloride	—	—	—	—	—	—	—	—	—	—	<.65	<1.1	—	—	—	—
Chlorodibromomethane	—	—	—	—	—	—	—	—	—	—	<.30	<7.1	—	—	—	—
Chloroethane	—	—	—	—	—	—	—	—	—	—	<.60	<4.0	—	—	—	—
1,2 Dichlorobenzene	—	—	—	—	—	—	—	—	—	—	<.50	<10	—	—	—	—
1,3 Dichlorobenzene	—	—	—	—	—	—	—	—	—	—	30	<9.0	—	—	—	—
1,4 Dichlorobenzene	—	—	—	—	—	—	—	—	—	—	<.35	<8.1	—	—	—	—

Table A-3

Concentrations of Volatile Organic Constituents Detected in Groundwater Monitoring Wells CC-32A, CC-32B, CC-33A, and CC-33B.1 in the Beach Point Area

(continued)

WELL	CC-32A				CC-32B				CC-33A				CC-33B.1			
ROUND	1	2	3	4	1	2	3	4	1	2	3(R)	4	1	2	3	4
SAMPLING DATE	12/17/86	6/7/88	Not	Not	12/17/86	6/7/88	Not	Not	12/17/86	6/7/88	6/29/88	10/11/88	Not	6/7/88	Not	Not
ANALYSIS DATE	1/6/87	6/21/88	Sampled	Sampled	1/6/87	6/20/88	Sampled	Sampled	1/5/87	6/21/88	—	—	Sampled	6/21/88	Sampled	Sampled
ANALYTES²																
Phenols, total	–	–	–	–	–	–	–	–	–	–	<1	–	–	–	–	–

¹(R), replicate sample; (-), no detection; analysis performed; mg/l, milligrams per liter; (B), compound detected in the method blank; J, estimated value because peak present but below detection limit; #, sample was diluted; <, less than; >, greater than,
*, compound not analyzed for.

²(All results in µg/l (micrograms per liter) unless otherwise noted.)

Table A-4

Concentrations of Volatile Organic Constituents Detected in Groundwater
Monitoring Wells CC-33B, CC-34A, and CC-35A
in the Beach Point Area¹

WELL	CC-33B								CC-34A				CC-35A			
ROUND	1	2ᶜ	[illegible]	[illegible]ᶜ³	[illegible]ᶜ³	4	[illegible]	[illegible]	1	2	3	4	1	2	3	4
SAMPLING DATE	10/17/86	6/7/88	6/7/88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12/17/86	9/7/88	Not	Not	12/17/86	Not	Not	Not
ANALYSIS DATE	1/8/87	[illegible]	[illegible]	—	—	—	—	—	1/8/87	9/21/88	Sampled	Sampled	1/7/87	Sampled	Sampled	Sampled
ANALYSES²																
Carbon, total organic (mg/L)	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—	—	—	—	—
Organic halogen, total (µg/L)	[illegible]	—	—	[illegible]	[illegible]	[illegible]	[illegible]	—	400	—	—	—	27	—	—	—
Organic halogen, total (µg/L), lab duplicate	[illegible]	—	—	—	—				400	—	—	—	[illegible]	—	—	—
Organic halogen, total (µg/L), calculated	[illegible]	[illegible]	[illegible]	—	—				310	250	—	—	9	—	—	—
Toluene	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]		[illegible]	[illegible]	—	—	<4	—	—	—
Benzene	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]	—	[illegible]	[illegible]	—	—	<8	—	—	—
Ethylbenzene	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]	—	[illegible]	[illegible]	—	—	<4	—	—	—
Chlorobenzene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<8	—	—	—
Carbon tetrachloride	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<10	—	—	—
Chloroform	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	14	—	—	—
Methylene chloride	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	4	—	—	—
1,1,2,2-Tetrachloroethane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<14	—	—	—
1,1,2-Trichloroethane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<10	—	—	—
1,2-Dichloroethane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<18	—	—	—
1,1-Dichloroethane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<10	—	—	—
Tetrachloroethylene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	<18	—	—	—

[illegible]

Table A-4

Concentrations of Volatile Organic Constituents Detected in Groundwater
Monitoring Wells CC-33B, CC 34A, and CC-35A
in the Beach Point Area
(continued)

WELL	[illegible]								CC 34A				CC 35A			
PHASE	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	2	3	4	1	2	3	4
SAMPLING DATE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12/17/86	6/2/88	Not	Not	12/17/86	Not	Not	Not
ANALYSIS DATE	[illegible]	[illegible]	[illegible]	–	–	–	–	–	1/2/87	[illegible]	Sampled	Sampled	1/7/87	Sampled	Sampled	Sampled
ANALYTES[a]																
Trichloroethene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	[illegible]	–	–	–
1,1-Dichloroethylene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	[illegible]	–	–	–
1,2-trans-Dichloroethylene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	[illegible]	–	–	–
Vinyl chloride	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	[illegible]	–	–	–
1,3-cis-Dichloropropene	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		–	–	–	–	–	–	–
1,3-trans-Dichloropropene	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		–	–	–	–	–	–	–
1,1,1-Trichloroethane	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–
Bromodichloromethane	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–
1,2-Dichloropropane	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		–	–	–	–	–	–	–
Benzene	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		–	–	–	–	–	–	–
[illegible]	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–
Chlorodibromomethane	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–
[illegible]	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–
1,2-Dichlorobenzene	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–		–
1,3-Dichlorobenzene	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–
1,4-Dichlorobenzene	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	–	–

Table A-4

Concentrations of Volatile Organic Constituents Detected in Groundwater Monitoring Wells CC-33B, CC-34A, and CC-35A in the Beach Point Area
(continued)

WELL	CC-33B								CC-34A				CC-35A			
PHASE	1	2*	3(R)	3(H)*†	3(H,R)*†	4	4(R)	4(H,R)	1	2	3	4	1	2	3	4
SAMPLING DATE	12/17/86	9/7/88	9/7/88	4/28/88	4/25/88	10/11/88	10/11/88	10/11/88	12/17/86	9/7/88	Not	Not	12/17/86	Not	Not	Not
ANALYSIS DATE	1/8/87	9/21/88	9/21/88	—	—	—	—	—	1/6/87	9/21/88	Sampled	Sampled	1/7/87	Sampled	Sampled	Sampled
ANALYTES[2]																
Phenols, total	—	—	—	<1	<1	—	—	—	—	—	—	—	—	—	—	—

[1] (R, replicate sample, H, halocarbon analysis performed, *, analysis for semivolatile organics performed (see Table A-5), † analysis for organosulfur compounds performed (see Table A-5), #, sample was diluted, <, less than, >, greater than, —, compound not analyzed for.)

[2] (All results reported in µg/L (micrograms per liter) unless otherwise noted.)

TABLE A-5

CONCENTRATIONS OF SEMIVOLATILE ORGANIC CONSTITUANTS AND ORGANOSULFUR COMPOUNDS DETECTED IN GROUNDWATER MONITORING WELL CC-33B IN THE BEACH POINT AREA[1]

Phase	2	3(H)	3(HR)
Sampling Date	9/7/88	4/26/89	4/26/89
Analyses[2]			
Bis (2-ethylhexyl) phthalate	72	—	—
Butyrolactone#	71	—	—
1-Methyl-2-pyrrolidinone	6	—	—
2-Ethylhexanoic acid#	6	8	4
Ethenyl cyclobutane#	3	—	—
Diethylborinic acid, methyl ester#	5	—	—
Hexanedioic acid, dioctyl ester#	450	—	—
1,1,2,2-Tetrachloroethane#	—	600	800
Unknown (4.61 min.)*	8	—	—
Unknown (5.63 min)*	10	—	—
Unknown (5.69 min.)*	2	—	—
Unknown (5.77 min.)*	3	—	—
Unknown (6.42 min.)*	39	—	—
Unknown (6.50 min.)*	12	—	—
Unknown (7.64 min.)*	9	—	—
Unknown (13.4 min.)*	6	—	—
Dithiane†	—	3.0	3.2

[1] [H, halocarbon analysis performed; R, replicate sample; #, tentatively identified organic compound with estimated concentration; *, unknown compound identified by peak retention time with estimated concentration; †, compound detected by organosulfur analysis (performed in Phase 3 only).]

[2] [All results reported in mg/L (milligrams per liter).]

Appendix B — Argonne National Laboratory Draft Geophysics Work Plan**

ARGONNE
NATIONAL
LABORATORY

INTRA-LABORATORY MEMO

October 29, 1992

TO: Francine Gordon
Jacobs Engineering Group, Inc.

FROM: L.D. McGinnis ES-372

SUBJECT: **Attached Draft Point Geophysics**

This is a draft geophysics workplan. We are exploring SOP's for seismic and electrical geophysics with EPA and ASTM. Please get back to me on Workplan modifications.

LDM/ma
Attachment

cc: D.E. Edgar/ANL
K.L. Brubaker/ANL

Beach Point Geophysics Workplan for FFS October 29, 1992

Background

A Geophysical Workplan designed to assist a sampling and data collection program in the Beach Point area of Aberdeen Proving Ground is described. The Work Plan objective is based upon discussions with Jacobs Engineering personnel. Recommendations on how the objective is to be resolved are based on experience of the ANL geophysics team in the Canal Creek and Westwood areas, geologic logs for USGS boreholes 32, 33, and 34, and a literature search. It is assumed that geophysical properties of sediment in the Canal Creek and Westwood areas are similar to those at Beach Point.

Objective

- Objective - Determine hydrostratigraphy from geophysical measurements down to the base of the surficial aquifer beneath Beach Point.

Approach

No geophysical technique has been tried on [illegible] at Beach Point. In order to determine the hydrostratigraphy down to the base of the surficial aquifer lying at a depth of approximately 60 ft, it is proposed that a geophysical calibration profile is run down the axis of Beach Point using geophysical technologies that are known to provide subsurface hydrostratigraphic control beneath Gunpowder Neck and adjacent waters. [illegible] staff have conducted electrical sounding and profiling and seismic refraction sounding in the Canal Creek area of the Edgewood section of Aberdeen Proving Grounds. The USGS has successfully profiled the surficial aquifer using marine, single channel seismic m[illegible] offshore [illegible] Field.

Following completion of the calibration profile, short profiles will be run to areas of concern in the time frame provided in the attached schedule (Figure 1).

Four techniques will be applied, namely:

1. Seismic Reflection
2. Seismic Refraction
3. Electrical [illegible] Sounding
4. Resistivity Profiling

Because of the success achieved with high-resolution seismic reflection profiling offshore, a non-intrusive land reflection profile will be shot along the axis of Beach Point along with several profiles orthogonal to the axis. Profiles will be tied to existing boreholes to establish subsurface correlation. It is expected that reflectors will be seen at lithologic boundaries, the Pleistocene/Cretaceous unconformity, base of the surficial aquifer, and at the basement unconformity. The seismic array will be optimally designed to provide information between the surface and 100 ft. However, data will be recorded to times adequate to map basement which is expected to lie at depths of approximately 500 ft.

A continuous seismic refraction profile will be run along the axis of Beach Point. Shallow seismic refraction soundings over the Building 103 Dump indicate velocities in the soils above water table average about 300 m/s (i.e., near that in air). Below the water table, velocities increase to 1870 m/s at the base of the surficial aquifer (Figure 2). From the work of Hughes (1991), a refractor was anticipated at the boundary between the surficial aquifer and the upper confining layer. Velocity data provided by the refraction profile will aid in the conversion of reflection times to depths.

Electrical depth soundings will be taken at 50 ft intervals along the axis of Beach Point. Four experimental electrical depth soundings were made by the ANL team during building decommissioning studies. Soundings were made too far apart to attempt correlations between them or with borehole data. However, extremely large variations in resistivities were observed which suggests that electrical techniques will be very useful in characterizing subsurface lithologies and hydrogeochemistry beneath Beach Point. A prominent electrical boundary was observed at the unconformity separating the lower Cretaceous sediments from crystalline basement at a depth of 50 m in the Westwood area (Figure 3).

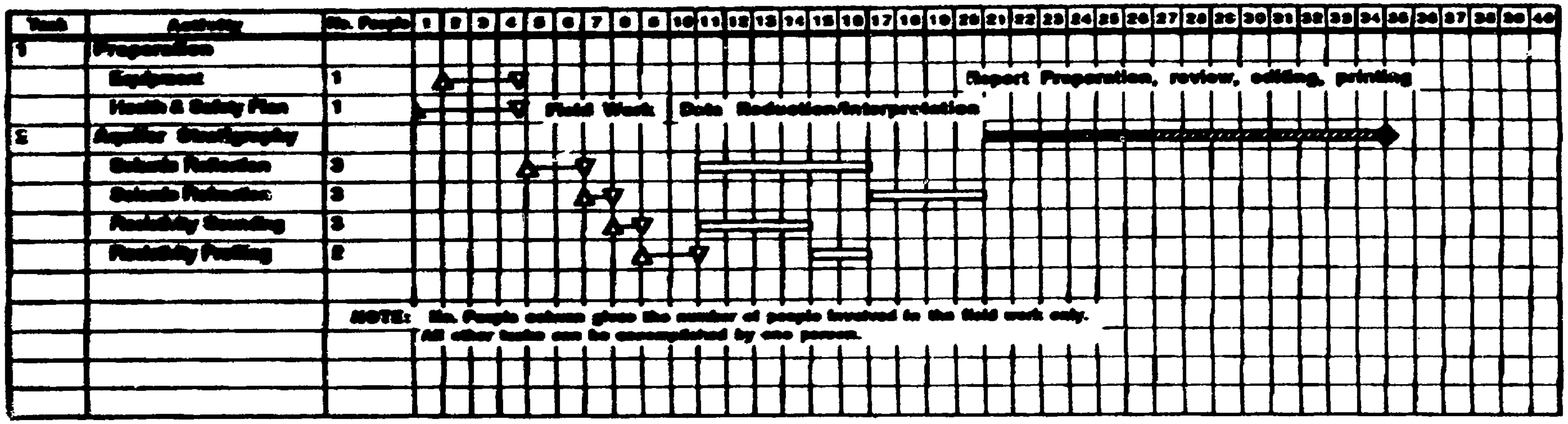
A continuous, horizontal electrical profile will be run along the axis of Beach Point. Horizontal and vertical gradients in salinities and contaminant concentrations beneath Beach Point may also produce electrical gradients. Electrical profiling of the subsurface may therefore provide information on subtle changes in hydrogeochemical properties. Horizontal electrical gradients were measured by ANL staff using resistivity methods in the Canal Creek area. Argonne has developed a variation of the resistivity method using a device we call the Octapod. The Octapod is favored over the GEONICS EM-34 for horizontal measurements because traverses can be made at equivalent speeds, it can be operated by one or two technicians, depending on the length of the Octapod array, versus three for the EM-34, and is immune to interference caused by extraneous radio-wave frequencies. Although the EM-34 can be operated over more rugged terrain than the Octapod, this poses no advantage at Beach Point because the surface is a cut-grass, estuarine spit of land with little relief.

It is expected that in a brackish, estuarine environment like that at Beach Point, natural soil and water salinities will play a more dominant role in resistivity and conductivity of the subsurface than contaminants. However, natural salinities due to the proximity of Chesapeake Bay will produce an electrical halo sub-parallel to the shoreline. It is probable that differentiation of natural conditions, from those artifically induced by contaminants, is possible.

Task Schedule

A tentative estimate of time required for geophysical measurements is given in Figure 1. Following testing of the four techniques listed, the time committed to a specific task may change in order to optimize the program objective.

Estimated Beach Point Geophysics Schedule (Weeks)



NOTE: No. People column gives the number of people involved in the field work only.
All other tasks can be accomplished by one person.

	Layer 1	Layer 2	Layer 3	Layer 4
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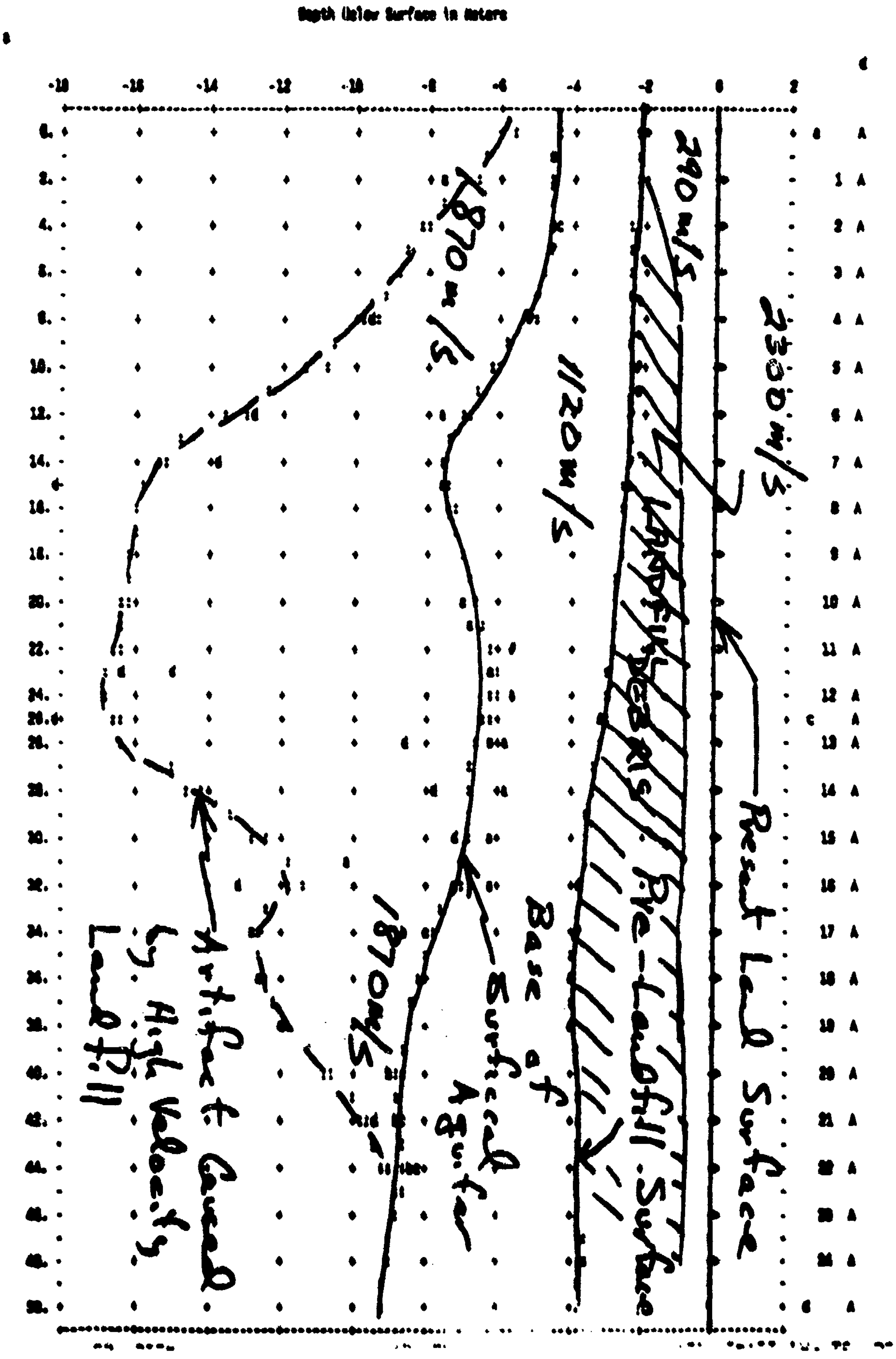
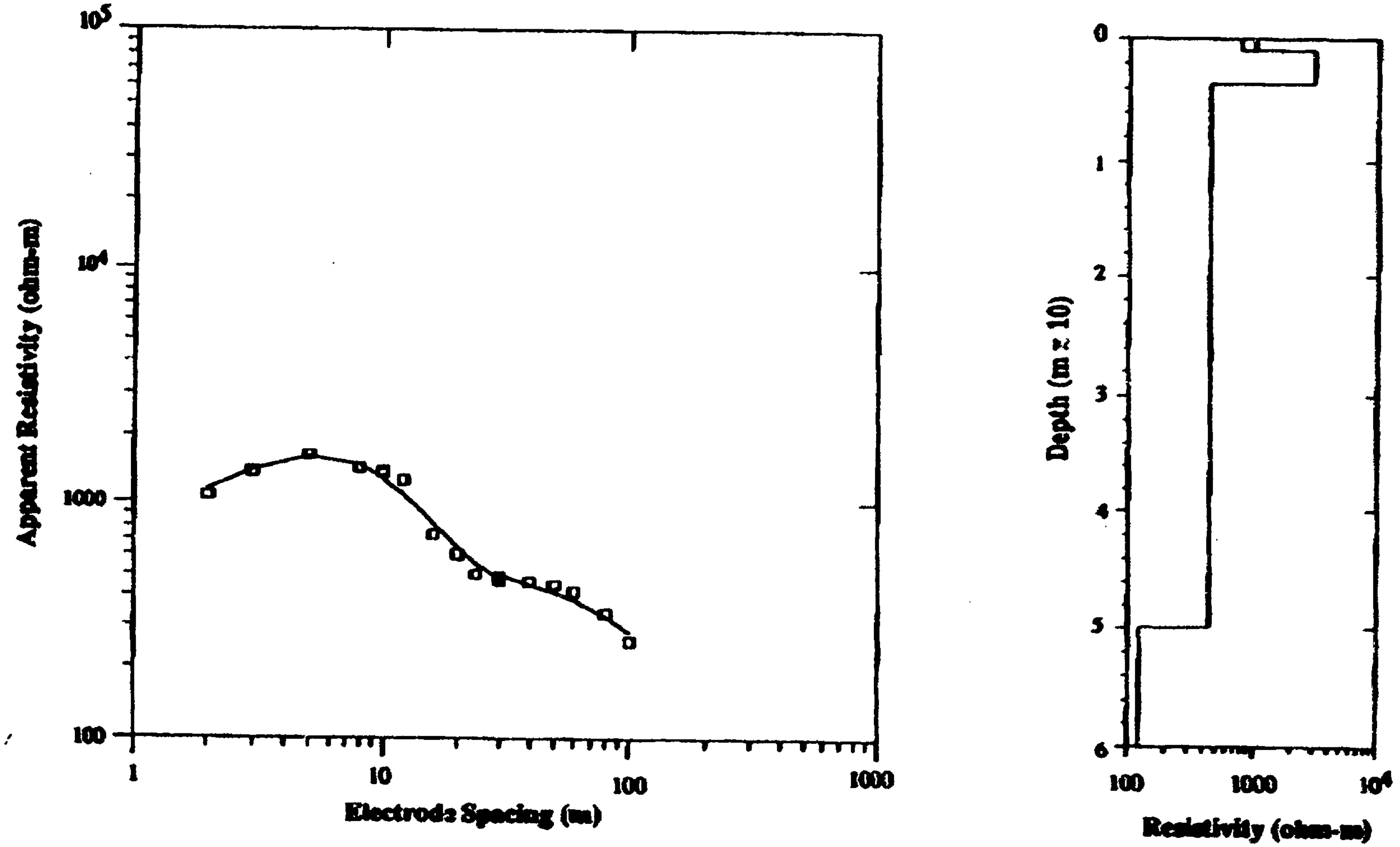
Vertical	291.	1120.	1868.	
Horizontal		1120.	1868.	2301.





ELECTRICAL DEPTH SOUNDING CURVE NEAR E5974

Appendix C — K-V Associates Flowmeter Logging Program.

KV

K-V ASSOCIATES, INC.
ANALYTICAL SYSTEMS

281 MAIN STREET • P.O. BOX 574 • FALMOUTH, MASSACHUSETTS 02541 • (508) 540-0561 • FAX (508) 457-[illegible]

October 27, 1992

Mr. Wayne Mandell
Mr. Dave Stein
Jacobs Engineering
1212 N.Y. Avenue, NW
Suite 1050
Washington, D.C. 20005
FAX: (202) 371-2241

RE: Groundwater Flow Metering, Aberdeen Proving Grounds, MD

K-V Associates, Inc. is pleased to present this proposal for services associated with conducting a groundwater flow metering program at the Aberdeen Proving Grounds site in Aberdeen, MD.

This project will require measurements of groundwater flow rates and directions using a KVA Geoflow, Model 40 flowmeter and horizontal flow measurements in one well using the KVA Model 90 Borehole Flowmeter. From our telephone conversation of October 27, 1992, K-V Associates, Inc. (KVA) understands that the project will require horizontal flow and velocity measurements in six (6) existing 4-inch diameter PVC monitoring wells and the possibility for similar flow measurements in an additional ten wells. The existing wells are installed into an upper aquifer of sandy deposits (both well sorted and poorly sorted sands) extending below the surface to approximately 60 feet. An aquitard (confining unit) exists below the 60 foot depth. The average depth to groundwater at the site is 13 to 14 ft.

The existing wells are completed with 10-foot screens. A well cluster (triplet) in which one well is screened at 55 -65 feet, an intermediate well is screened at approximately 40 -50 feet and an upper well is screened from 10 -20 feet will be flowmetered as a part of this study. The deep well (existing) will be flowmetered in the cased, upper zone to determined vertical flow characteristics. The remaining three existing wells are all screened in the upper water table zone, from 10 -20 feet. The contaminants of concern at the site include VOCs, SVOCs and TCLP Metals. The groundwater gradient at the site is estimated to be very shallow.

Appendix D — ICF Risk Assessment Plan.

ICF KAISER ENGINEERS

ICF KAISER ENGINEERS INC
9300 LEE HIGHWAY
FAIRFAX, VIRGINIA 22031-1207
703-934-3300

November 11, 1992

Francine Gordon
Jacobs Engineering
1212 New York Avenue, NW
Suite 1050
Washington, D.C. 20005

Francine:

Enclosed is a hard copy and disk copy (Wordperfect 5.1) of our risk assessment plan to be included in the Beach Point groundwater Focussed Feasibility Study Workplan. At the request of Wayne Mandell, I have prepared the risk assessment plan as a stand-alone document that can be incorporated as an appendix to your workplan. Please give me call if you need anything else. Also, could you please send me a draft copy of the full workplan once it is available for distribution? Thanks.

Sincerely,

Judi Durda

cc

John Wrobel (APG-DSHE)
John Paul (APG-DSHE)
Larry Thebeau (ICF KE)

PROPOSED PLAN FOR CONDUCTING A RISK ASSESSMENT FOR BEACH POINT GROUNDWATER

ABERDEEN PROVING GROUND, MARYLAND

Prepared for:

Jacobs Engineering Group Inc.
1212 New York Avenue
Washington, D.C.

Prepared by:

ICF Kaiser Engineers
Clement Division
9300 Lee Highway
Fairfax, Virginia

November 1992

TABLE OF CONTENTS

1.0 INTRODUCTION

This workplan has been prepared by ICF Kaiser Engineers (ICF KE) to address potential risks associated with known groundwater contamination at Beach Point, located in the Edgewood Area of Aberdeen Proving Ground, Maryland. The workplan has been prepared at the request of the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) and Aberdeen Proving Ground Directorate of Safety, Health, and Environment (APG-DSHE) under Task Order Number 4 of Contract DAAA15-91-D-0014. The approaches outlined in this workplan are consistent with the overall approaches outlined in the general Technical Plan (ICF KE 1992) for risk and biological impact assessment at APG.

Beach Point is a peninsula located immediately adjacent to the mouth of Kings Creek, a major tributary to the Bush River that drains a large number of the chemical storage and research and development areas at APG. As the former location of propellant, smoke, and pyrotechnic testing activities, as wells as chemical protective clothing-impregnating operations, the Beach Point site is known or suspected to be contaminated with various industrial solvents and military-related compounds, and may be impacting the aquatic environment in nearby Kings Creek and the near-shore areas of the Bush River.

This workplan outlines the approach to be used to evaluate potential risks associated with chemical contamination in groundwater at the Beach Point site. The risk assessment will focus on potential impacts in aquatic life inhabiting nearby areas in Kings Creek and the Bush River, because aquatic species are the receptors potentially at greatest risk from exposure to chemicals released from groundwater. Potential human health risks associated with exposures to chemicals released to surface water from groundwater will be evaluated qualitatively.

The risk assessment will consist of five principal steps: (1) identification of chemicals of potential concern; (2) receptor characterization; (3) exposure assessment; (4) toxicity assessment; and (5) risk characterization. The basic components of each of these steps and the proposed approach for conducting the Beach Point groundwater risk assessment are outlined below.

2.0 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The first step of the risk assessment will be to review the results of available environmental sampling, as well as other site-specific information to identify chemicals of potential concern for detailed study in the risk assessment. Factors to be considered in selecting a chemical of potential concern include the chemical's relatedness to the suspected source or to past activities at Beach Point and the relationship of the sample chemical concentrations to the background levels of the chemical (i.e., principally for inorganic chemicals). Data collected by USGS (1989a,b) as part of a hydrogeological study of the Canal Creek area will be used along with data to be collected by Jacobs Engineering Group Inc. (Jacobs) as part of the current study to select chemicals of concern. Based on the information collected to date, the principal chemicals of concern in groundwater at Beach Point are volatile organic chemicals and some metals.

3.0 RECEPTOR CHARACTERIZATION

After the chemicals of potential concern have been selected, the populations (receptors) that could be exposed to chemicals in groundwater will be identified.

3.1 Ecological Receptors

For this assessment, it will be assumed that the primary receptors of concern in the Beach Point area are aquatic species that could be exposed to chemicals released from groundwater to surface water and sediment.

The principal aquatic receptors for this assessment are assumed to be those occupying groundwater discharge areas near Beach Point. Benthic and water-column invertebrates, including clams, isopods, and insects, are probably common in the area. A variety of freshwater and estuarine fish also occur in the area. Fish species that have been caught in Kings Creek include carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), menhaden (*Brevoortia tyrannus*), drum (*Sciaenidae*), minnows (*Cyprinidae*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), and gizzard shad (*Dorosoma cepedianum*). Other fish species likely include blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), bay anchovy (*Anchoa mitchilli*), atlantic silverside (*Menidia menidia*), and hogchoaker (*Trinectes maculatus*). Most of these species probably use Kings Creek and the Bush River near Beach Point as a nursery area.

3.2 Human Receptors

Human use of the Beach Point area is limited. The closest human receptors occupying the area on regular basis are workers at the sewage treatment plant, located near the southern portion of the Beach Point peninsula. Commercial and recreational fishing from boats occurs in the Bush River (no fishing occurs in Kings Creek). The nearest residents are in the Canal Creek area, located one to two miles west of Beach Point. There are no water supply wells located on Beach Point.

4.0 EXPOSURE ASSESSMENT

After the potential receptors have been identified, the pathways by which they may be exposed to chemicals of potential concern will be identified. All complete exposure pathways will be evaluated quantitatively or qualitatively in the risk assessment.

4.1 Ecological Exposures

The principal exposure pathway of concern in the Beach Point area is release of chemicals in groundwater to surface water with subsequent exposure of aquatic life. Aquatic life living along and adjacent to the Beach Point shoreline in the groundwater discharge zone could be exposed to chemicals present in surface water via respiration (i.e., uptake over the gills) or via direct ingestion of surface water, although the latter route is not likely to result in significant exposure relative to respiration. Sessile and less mobile benthic species are susceptible to the greatest impacts as these species cannot move out of the contaminated area to reduce exposures. Fish are less susceptible to large exposures as these species can move out of the contaminated area. Further, because they generally range over a much larger area than benthic species, fish are likely to spend a much smaller proportion of their total time near the Beach Point shoreline.

Aquatic life also may be exposed to chemicals released from groundwater that sorb to sediments. The primary pathways by which sediment exposures can occur is via direct contact and ingestion of sediment. Exposure via respiration can occur as chemicals are released (desorbed) from sediments. Benthic species are most susceptible to exposures as these species live in sediment and thus, can be in constant contact with contaminants.

4.2 Human Exposures

No pathways exist by which human populations could be exposed directly to chemicals in groundwater or to groundwater chemicals released to surface water or sediment. As discussed above, There are no water supply wells at Beach Point. Additionally, neither Kings Creek nor the Bush River downgradient of Beach Point are used for drinking water supplies. Further, no swimming or wading occurs in the area.

Persons in the area could be exposed to chemicals that have volatilized to air as most of the organic chemicals detected in groundwater to date will partition to air once released to surface water. Persons fishing in the Bush River near Beach Point and persons working at the sewage treatment plant could be exposed via inhalation to chemicals that have volatilized from surface water and dispersed to these receptors. Based on the groundwater and surface water sampling data collected to date, such exposures are not likely to be large, given the relatively low concentrations of most volatile organic chemicals and the distance to potential receptor points. However, these exposures will be evaluated qualitatively in the risk assessment.

Chemicals present in surface water could accumulate in aquatic life, resulting in exposures of humans ingesting aquatic life from the area. Food-chain exposures are expected to be of minimal concern in the assessment because volatile organic chemicals (the principal chemicals of concern in the groundwater) do not accumulate to any appreciable degree in aquatic life. Exposures via this pathway will be evaluated qualitatively in the risk assessment.

5.0 TOXICITY ASSESSMENT

Chemicals of potential concern will be characterized with respect to their toxic effects in the selected receptor species.

5.1 Aquatic Toxicity

The results of bioassays conducted on-site with Beach Point groundwater will be used to assess the potential aquatic toxicity of chemicals of potential concern. The principal data to be used will be those obtained from the following groundwater assays: (1) *Selenastrum capricornutum* growth assay; (2) *Ceriodaphnia dubia* survival and reproduction assay; (3) *Pimephales promelas* survival and growth assay; and (4) Microtox assay. These data will be supplemented by the results of the Microtox assays conducted on sediment pore water collected from the groundwater discharge zone in Kings Creek to estimate potential toxic effects in aquatic species inhabiting nearby surface waters.

Bioassays conducted with 100% groundwater and sediment pore water will be used to evaluate potential aquatic toxicity directly in the area of groundwater discharge. This will represent an evaluation of the "worst-case" scenario. Bioassays conducted with diluted groundwater will be used to evaluate potential toxicity in areas of Kings Creek and Bush River that are outside of the immediate groundwater discharge area.

5.2 Human Toxicity

The potential human toxicity of the chemicals of concern will be discussed qualitatively in the risk assessment. Therefore, no quantitative criteria will be presented. General EPA reference documents (e.g., IRIS, health assessment documents) will be used as the source of qualitative toxicity information.

6.0 RISK CHARACTERIZATION

Potential aquatic life impacts will be characterized based on the results of the site-specific bioassays, as well as information (or estimates) on the size and location of the groundwater discharge zone and the likely fate, transport, and dilution of chemicals discharged from groundwater to Kings Creek and Bush River. These results will be used along with chemical analytical data to identify (to the extent possible) the particular chemicals or chemical groups that are driving the toxic response. The focus of the risk characterization will be potential impacts on the aquatic populations and communities of Kings Creek and Bush River, rather than on localized impacts on individuals inhabiting the discharge zone. This approach is consistent with EPA's general guidance regarding the scope and objectives of ecological assessments (see EPA 1989a,b).

Potential human health impacts will be evaluated by qualitatively comparing estimates of exposure with toxicity information.

7.0 REFERENCES

Environmental Protection Agency (EPA). 1989a. Risk Assessment Guidance for Superfund. Volume II. Environmental Evaluation Manual. Interim Final. EPA/540/1-89-001. Washington, D.C. March

Environmental Protection Agency (EPA). 1989b. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. EPA/600/3-89/013. Corvallis, Oregon. March.

ICF Kaiser Engineers (ICF KE). 1992. Risk and Biological Impact Assessment at U.S. Army Aberdeen Proving Ground, Maryland. Technical Plan. Volume I. Draft Final. July.

United States Geological Survey (USGS). 1989a. Hydrogeology of the Canal Creek Area, Aberdeen Proving Ground, Maryland. Water Resources Investigations Report 89-4021.

United States Geological Survey (USGS). 1989b. Inorganic and Organic Ground-water Chemistry in the Canal Creek Area of Aberdeen Proving Ground, Maryland. Water Resources Investigations Report 89-4022.

Appendix E — University of Maryland Correspondence*

THE UNIVERSITY OF MARYLAND SYSTEM
1807

MARYLAND INSTITUTE FOR AGRICULTURE AND NATURAL RESOURCES
AGRICULTURAL EXPERIMENT STATION
Wye Research and Education Center

November 2, 1992

Ms. Francine J. Gordon
Jacobs Engineering Group Inc.
1212 New York Avenue, N.W., Suite 1050
Washington, DC 20005

Dear Francine:

Enclosed in a copy of ASTM Designation E 1391-90 which is a standard guide for working with sediments. To my knowledge, there is no EPA SOP for isolating pore waters. Section 11 describes several methods for collecting pore water. We use the centrifugation method described in the second paragraph on page 1144. The standard guide also contains recommendations for sediment holding times (Table 2; page 1142).

I recommend that you consider running EPA 7-day chronic toxicity tests with both an invertebrate and fish for the 10 samples at Beach Point. It appears that estuarine organisms should be used since the Bush River and the lower part of Kings Creek are low salinity areas. It is also my understanding that the groundwater is high in dissolved solids. The two EPA recommended species that probably should be considered are the mysid and a silverside. As I discussed, if estuarine species are used, it will be necessary to add salt to the test medium.

If we have a little time, we could consider two freshwater organisms which can tolerate low salinities. This would avoid having to add large amounts of salt. I will look into the species issue and get back to you.

If you need more information, please let me know.

Sincerely yours,

Dennis

Dennis T. Burton, Ph.D.
Senior Research Scientist

Enclosure

(410) 827-8056 • FAX (410) 827-9039

PO BOX 169 • QUEENSTOWN MARYLAND 21658

356

THE UNIVERSITY OF MARYLAND SYSTEM
1807

MARYLAND INSTITUTE FOR AGRICULTURE AND NATURAL RESOURCES
AGRICULTURAL EXPERIMENT STATION
Wye Research and Education Center

September 28, 1992

U.S. Army Aberdeen Proving Ground
Directorate of Safety, Health, and Environment
STEAP-SH-EE
ATTN: Michael Kanowitz
Aberdeen Proving Ground, MD 21005

RE: Information for Beach Point Biomonitoring Study

Dear Mr. Kanowitz:

Enclosed in a brief statement of work which explains the study we will be conducting for USARBDL this GFY93 at Beach Point. As discussed in our meeting on September 14, 1992, with Vicky Cwiertnie, we would like to explore the possibility of discharging a maximum of ≈1 gallon of groundwater (well 33b) mixed with ≈2 gallons of dechlorinated APG tap water to the APG-EA Wastewater Treatment Plant. The enclosed document shows the concentrations of contaminants that are expected to be present in the groundwater from well 33b at Beach Point.

Please call me after you have considered my request so that I will know how to proceed. I appreciate your help

Sincerely yours,

Dennis T. Burton

Dennis T. Burton, Ph.D
Senior Research Scientist

cc: T.R. Shedd
V. Cwiertnie

Enclosure

(410) 827-[illegible] • FAX (410) 827-[illegible]

P.O. BOX [illegible] • QUEENSTOWN, MARYLAND [illegible]

2. Chronic toxicity tests

a. Green algal growth test- The potential toxicity (96-h EC50 for growth) of the groundwater to Selenastrum capricornutum) will be determined three times at 2-month intervals by the procedure EPA/600/4-89/001.

b. Daphnid survival and reproduction test- The chronic toxicity of the groundwater to Ceriodaphnia dubia will be determined three times at 2-month intervals using the procedure EPA/600/4-89/001. All tests will be started with neonates <24 h old.

c. Fathead minnow survival and growth test- The chronic toxicity of the groundwater to fathead minnow (Pimephales promelas) will be determined three times at 2-month intervals using the procedure EPA/600/4-89/001. All tests will be started with larvae <24 h old at the start of the test.

3. Mutagenicity

Genotoxicity potential will be determined using the Salmonella/mammalian-microsome reverse mutation assay (Ames test). The assay will be performed three times at 2-month intervals on both raw groundwater and diluent water. The assays will be conducted by Hazelton Washington, Vienna, VA, on both unconcentrated and concentrated (10X via XAD-2 resin extracts) samples of the groundwater and diluent water.

4. Teratogenicity

Developmental toxicity will be determined by the 96-h frog embryo teratogenesis assay-Xenopus (FETAX) using ASTM Designation E 1439-91. FETAX will be performed three times at 2-month intervals under flow through conditions using Xenopus laevis stage 8 blastulae to normal stage 11 gastrulae at the initiation of the test.

5. Carcinogenicity

The Japanese medaka (Oryzias latipes) will be used in a 6-month continuous assay to test for environmental pollutants in the groundwater which may induce neoplasms. Both unexposed and embryos initiated with diethylnitrosamine will be used. Procedures developed by USABRDL will be followed for all phases of the study.

6. Chemical analyses

Comprehensive chemical analyses including the priority pollutants will be performed before the biomonitoring studies are initiated on both the groundwater and dechlorinated tap water. Since it is anticipated that the majority of groundwater contaminants are volatile organic compounds (see attached list), the comprehensive chemical analysis of the groundwater may be modified to focus on the VOCs for the 6-month study. This would allow us to make more frequent analyses of the VOCs during the study.

The following routine water quality analyses will be taken daily on all carcinogen and diluent water tanks: dissolved oxygen, pH, and temperature. In addition, alkalinity, total ammonia-nitrogen, hardness, and conductivity will be measured twice a week in all tanks. Total residual and free available chlorine will also be measured two times per week in the dechlorinated diluent water tanks.

Additional Tasks

Dr. Dennis T. Burton, Principal Investigator, will be responsible for project coordination, writing of reports, and quality assurance. USABRDL approved SOPs will be used for all phases of the study conducted both on-site and off-site. Quarterly technical progress reports will be submitted to USABRDL during the project.

TABLE 2.2*

ANALYTICAL RESULTS FROM USGS GROUNDWATER TESTING

BEACH POINT SITE - ABERDEEN PROVING GROUND

Check MD MCL's

RESULTS (µg/l)

CHEMICAL	RANGE OF CONCENTRATIONS	ARITHMETIC MEAN CONC.*	NO. OF TIMES DETECTED PER NO. OF SAMPLES	
Toluene	<.4 - 2	0.2	1/12	SDWA [illegible]
Benzene	<.5 - <25**	0	0/12	⑤ ?
Ethylbenzene	<.4 - <20**	0	0/12	700 SDWA
Chlorobenzene	<.6 - 2***	0.25	2/12	5?
Carbon Tetrachloride	<1.5 - <75**	0	0/12	5?
Chloroform	2.0*** - 66	16.9	9/12	?
Methylene Chloride	3.5 - 14	5.9	9/12	?
1,1,2,2-Tetrachloroethane	<1.4 - 9,030	2,244	7/11	?
1,1,2-Trichloroethane	2.0*** - 80	18.8	5/12	
1,2-Dichloroethane	<1.5 - <75**	0	0/12	
1,1-Dichloroethane	<1.0 - <50**	0	0/12	
Tetrachloroethylene	<1.5 - 64	43.6	5/12	
Trichloroethylene	1.7 - 935	345.5	9/11	
1,1-Dichloroethylene	<1.9 - <95**	0	0/12	
1,2-Trans-Dichloroethylene	<1.6 - 610	347.0	4/12	
Vinyl Chloride	<1.3 - <65**	0	0/12	

* Samples with results below detection limit assumed to have 0 concentration.

** Sample was diluted.

*** Estimated concentration, peak present, but concentration below reported detection limit.

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* Table 2.2 was taken from the following report: Proposed plan for Beach Point Site Aberdeen Proving Ground, Maryland. July 1990. R&R International, Inc., Aberdeen, MD.

Designation: E 1391 - 90

U N:
D. Zu...

Standard Guide for
Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing[1]

This standard is issued under the fixed designation E 1391; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers procedures for obtaining, storing, characterizing, and manipulating saltwater and freshwater sediments, for use in laboratory sediment toxicity evaluations. It is not meant to provide guidance for all aspects of sediment assessments, such as chemical analyses or monitoring, geophysical characterization, or extractable phase/fractionation analyses. Some of this information might, however, have applications for some of these activities. Methodological considerations which affect toxicity studies will be reviewed and the apparent consensus approach for test methods discussed. Currently, the state-of-the-art is in its infancy, and the development of standard methods is not feasible; however, it is crucial that there be an understanding of the significant effect which these test methods have on sediment quality evaluations. It is anticipated that recommended test methods and this guide will be routinely updated to reflect progress in our understanding of sediments and how to best study them.

1.2 There are several regulatory guidance documents (1-16)[2] concerned with sediment collection and characterization procedures, which might be important for individuals performing Federal or State agency-related work. Discussion of some of the principles and current thoughts on these approaches can be found in Dickson et al., 1987 (17).

1.3 This guide is arranged as follows:

1.4 Field collected sediments might contain potentially toxic materials and thus should be treated with caution to minimize occupational exposure to workers. Worker safety must also be considered when working with spiked sediments containing various organic or inorganic contaminants, or both, and those that are radio-labeled. Careful consideration should be given to those chemicals which might biodegrade, volatilize, oxidize, or photolyze during the test period.

1.5 *This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements are given in Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1129 Terminology Relating to Water[3]
D 4387 Guide for Selecting Grab Sampling Devices for Collecting Benthic Macroinvertebrates[4]
D 4822 Guide for Selection of Methods of Particle Size Analysis of Fluvial Sediments (Manual Methods)[5]
D 4823 Guide for Core Sampling Submerged, Unconsolidated Sediments[5]
E 729 Guide for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians[4]
E 380 Practice for Using the International System of Units (SI) (the Modernized Metric System)[6]
E 943 Terminology Relating to Biological Effects and Environmental Fate[4]
E 1023 Guide for Assessing the Hazard of a Material to Aquatic Organisms and Their Uses[4]
E 1295 Guide for Conducting Three Brood Renewal Toxicity Tests with *Ceriodaphnia dubia*[4]
E 1367 Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods[4]

3. Terminology

3.1 The words "must," "should," "may," "can," and "might" have very specific meanings in this guide. "Must" is used to express an absolute requirement, that is, to state that the test ought to be designed to satisfy the specified condition, unless the purpose of the test requires a different design. "Must" is only used in connection with the factors that directly relate to the acceptability of the test. "Should" is

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[1] This guide is under the jurisdiction of ASTM Committee E-47 on Biological Effects and Environmental Fate and is the direct responsibility of Subcommittee E47.03 on Sediment Toxicology.

Current edition approved Nov. 30, 1990. Published January 1991.

[2] The boldface numbers in parentheses refer to the list of references at the end of this guide.

[3] *Annual Book of ASTM Standards*, Vol 11.01.

[4] *Annual Book of ASTM Standards*, Vol 11.04.

[5] *Annual Book of ASTM Standards*, Vol 11.02.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

TABLE 1 Summary of Bottom Sampling Equipment[A]

Device	Use	Advantages	Disadvantages
Fluorocarbon plastic or Glass Tube	Shallow wadeable waters or deep waters if SCUBA available. Soft or semi-consolidated deposits.	Preserves layering and permits historical study of sediment deposition. Rapid-samples immediately ready for laboratory shipment. Minimal risk of contamination.	Small sample size requires repetitive sampling.
Hand Corer with removable Fluorocarbon plastic or glass liners	Same as above except more consolidated sediments can be obtained.	Handles provide for greater ease of substrate penetration. Above advantages.	Careful handling necessary to prevent spillage. Requires removal of liners before repetitive sampling. Slight risk of metal contamination from barrel and core cutter.
Box corer	Same as above	Collection of large sample undisturbed allowing for subsampling.	Hard to handle.
Gravity corers, that is, Phleger Corer	Deep lakes and rivers. Semi-consolidated sediments.	Low risk of sample contamination. Maintains sediment integrity relatively well.	Careful handling necessary to avoid sediment spillage. Small sample, requires repetitive operation and removal of liners. Time consuming.
Young Grab (fluorocarbon plastic- or kynar-lined modified 0.1 m² van Veen)	Lakes and marine areas	Eliminates metal contamination Reduced bow wake	Expensive. Requires winch.
Ekman or Box Dredge	Soft to semi-soft sediments. Can be used from boat, bridge, or pier in waters of various depths.	Obtains a larger sample than coring tubes. Can be subsampled through box lid.	Possible incomplete jaw closure and sample loss. Possible shock wave which may disturb the fines. Metal construction may introduce contaminants. Possible loss of "fines" on retrieval.
PONAR Grab Sampler	Deep lakes, rivers, and estuaries. Useful on sand, silt, or clay.	Most universal grab sampler. Adequate on most substrotes. Large sample obtained intact, permitting subsampling	Shock wave from descent may disturb "fines". Possible incomplete closure of jaws results in sample loss. Possible contamination from metal frame construction. Sample must be further prepared for analysis.
BMH-53 Piston Corer	Waters of 4–6 ft deep when used with extension rod. Soft to semi-consolidated deposits	Piston provides for greater sample retention	Cores must be extruded on site to other containers—Metal barrels introduce risk of metal contamination
Van Veen	Deep lakes, rivers, and estuaries. Useful on sand, silt, or clay	Adequate on most substrates. Large sample obtained intact, permitting subsampling.	Shock wave from descent may disturb "fines". Possible incomplete closure of jaws results in sample loss. Possible contamination from metal frame construction. Sample must be further prepared for analysis.
BMH-60	Sampling moving waters from a fixed platform	Streamlined configuration allows sampling where other devices could not achieve proper orientation	Possible contamination from metal construction. Subsampling difficult. Not effective for sampling fine sediments.
Peterson Grab Sampler	Deep lakes, rivers, and estuaries. Useful on most substrates.	Large sample; can penetrate most substrates	Heavy, may require winch. No cover lid to permit subsampling. All other disadvantages of Ekman and Ponar
Shipek Grab Sampler	Used primarily in marine waters and large inland lakes and reservoirs	Sample bucket may be opened to permit subsampling. Retains fine grained sediments effectively	Possible contamination from metal construction. Heavy. May require winch
Orange-Peel Grab Smith-McIntyre Grab	Deep lakes, rivers, and estuaries. Useful on most substrates.	Designed for sampling hard substrates.	Loss of fines. Heavy—may require winch. Possible metal contamination
Scoops, Drag Buckets	Various environments depending on depth and substrate.	Inexpensive, easy to handle.	Loss of fines on retrieval through water column

[A] Comments represent subjective evaluations.

used to state that the specified condition is recommended and ought to be met in most tests. Although a violation of one "should" is rarely a serious matter, violation of several will often render the results questionable. Terms such as "is desirable," "is often desirable," and "might be desirable" are used in connection with less important factors. "May" is used to mean "is (are) allowed to," "can" is used to mean "is (are) able to," and "might" is used to mean "could possibly." Thus, the classic distinction between "may" and "can" is preserved, and "might" is never used as a synonym for either "may" or "can."

3.2 *Definitions*—For definitions of terms used in this guide, refer to Guide E 729, Terminology E 943, and Terminology D 1129, and Guide D 4387; for an explanation of units and symbols, refer to Practice E 380.

4. Summary of Guide

4.1 This guide provides a review of widely used methods to collect, store, characterize, and manipulate sediments for toxicity testing. Where the science permits, recommendations are provided on which procedures are appropriate, while identifying their limitations.

5. Significance and Use

5.1 Sediment toxicity evaluations are a critical component of environmental quality and ecosystem impact assessments, used to meet a variety of research and regulatory objectives.

5.2 The manner in which the sediments are collected, stored, characterized, and manipulated can greatly influence the results of any sediment quality or process evaluation. Addressing these variables in a systematic and uniform manner will aid interpretations of sediment toxicity or bioaccumulation results and may allow comparisons between studies.

6. Interferences

6.1 Maintaining the integrity of a sediment environment during its removal, transport, and testing in the laboratory is extremely difficult. The sediment environment is composed of a myriad of microenvironments, redox gradients, and other interacting physicochemical and biological processes. Many of these characteristics influence sediment toxicity and bioavailability to benthic and planktonic organisms, microbial degradation, and chemical sorption. Any disruption of this environment complicates interpretations of treatment effects, causative factors, and in situ comparisons. For additional information see Section 9.

7. Apparatus

7.1 A variety of sampling, characterization, and manipulation methods exist using different equipment. These are reviewed in Sections 9 through 14.

7.2 *Cleaning*—Test chambers and equipment used to prepare and store dilution water and stock solutions should be cleaned before use. New and used sample containers should be washed following these steps: (1) non-phosphate detergent wash, (2) triple water rinse, (3) water-miscible organic solvent wash, (acetone followed by pesticide grade hexane (2, 8)), (4) water rinse, (5) acid wash (such as 5 % concentrated hydrochloric acid), and (6) triple rinse with deionized-distilled water. Altering this cleaning procedure might result in problems. Many organic solvents might leave a film that is insoluble in water (Step 3). A dichromate-sulfuric acid cleaning solution can generally be used in place of both the organic solvent and the acid (Steps 3 through 5), but it might attack silicone adhesive. (See 9.10 for cleaning during sample collection.)

8. Safety Hazards

8.1 Many substances can adversely affect humans if adequate precautions are not taken. Information on toxicity to humans (18) and recommended handling procedures of toxicants (19) should be studied before tests are begun with any contaminant or sediment. Health and safety precautions should be considered before beginning a test.

8.2 Field-collected sediments might contain a mixture of hazardous contaminants, so proper handling to avoid human exposure is important. Therefore, skin contact with all test materials and solutions should be minimized by such means as wearing appropriate protective gloves, especially when washing equipment or putting hands in dilution water over sediments, or into sediments. Proper handling procedures might include sieving and distributing sediments under a ventilated hood or an enclosed glove box, enclosing and ventilating the toxicity test water bath, and using respirators, aprons, safety glasses, and gloves when handling potentially hazardous sediments. Special procedures might be necessary with radiolabeled test materials (20) and with materials that are, or are suspected of being, carcinogenic (19).

8.3 Disposal of sediments, dilution water over sediments, and test organisms containing hazardous compounds might pose special problems. For tests involving spiking sediments with known toxicants, removal or degradation of the toxicant(s) before disposal is sometimes desirable. Disposal of all hazardous wastes should adhere to the requirements and regulations of the Resource Conservation and Recovery Act and any relevant State or local regulations.

9. Sampling and Transport

9.1 Sediments have been collected for a variety of chemical, physical, toxicological and biological investigations. These collections have been made with both a series of grab sampling devices and core samplers (see Table 2 of Guide D 4823). The advantages and disadvantages of the various collection methods have been previously reported (3, 4) and are summarized in Table 1. All sampling methods disturb the sediment integrity to a degree. For purposes of sediment toxicity evaluations it is important to obtain sediments with as little disruption as possible, to allow for realistic laboratory evaluations of in situ conditions. Choosing the most appropriate sediment sampler for a study will depend on the sediment's characteristics, the efficiency required, and the study objectives. Several references are available which discuss the various collection devices (3, 4, 21, 22, 23). The efficiency of these samplers for benthic collections have been compared and in general the grab samplers are less efficient collectors than the corers but are easier to handle, work in heavier seas, often require fewer personnel and are more easily obtained (21, 23–31).

9.2 The principal disadvantage of dredge samplers varies: common problems are shallow depth of penetration and presence of a shock wave that results in loss of the fine surface sediments. Murray and Murray (32), however, described a dredge usable in heavy seas which quantitatively samples the top 1 cm of sediment and retains fine materials. Other grab samplers that quantitatively sample surface sediments have been described by Grizzle (33). The depth profile of the sample may be lost in the removal of the [redacted]

9.3 Studies of macroinvertebrate sampling efficiency with various grab samplers have provided useful information for sampling in sediment toxicity and sediment quality evaluations. The Ekman dredge is the most commonly used sampler for benthic investigations (21). The Ekman's efficiency is limited to less compacted, fine-grained sediments, as are the corer samplers. The most commonly used corer is the Kajak-Brinkhurst corer. In more resistant sediments the Petersen, PONAR, and Smith-McIntyre dredges are used most often (21). Based on studies of benthic macroinverte-

TABLE 2 Sampling Containers, Preservation Requirements, and Holding Times for Sediment Samples[A]

Contaminant	Container[B]	Preservation	Holding Time
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C	28 days
Sulfite	P, G	Cool, 4°C	48 h
Nitrate	P, G	Cool, 4°C	48 h
Nitrate-Nitrite	P, G	Cool, 4°C	28 days
Nitrite	P, G	Cool, 4°C	48 h
Oil and Grease	G	Cool, 4°C	28 days
Organic Carbon	P, G	Cool, 4°C	28 days
Metals			
Chromium VI	P, G	Cool, 4°C	40 h
Mercury	P, G		8 days
Metals, except above	P, G		6 months
Organic Compounds			
Extractables (including phthalates, atrosamines organochlorine pesticides, PCB's artroaromatics, isophorone, Polynuclear aromatic hydrocarbons, haloethers, chlorinated hydrocarbons and TCDD)	G, teflon-lined cap	Cool, 4°C	7 days (until extraction) 30 days (after extraction)
Extractables (phenols)	G, teflon-lined cap	Cool, 4°C	7 days (until extraction) 30 days (after extraction)
Purgables (halocarbons and aromatics)	G, teflon-lined septum	Cool, 4°C	14 days
Purgables (acrolein and acrylonitrate)	G, teflon-lined septum	Cool, 4°C	3 days
Orthophosphate	P, G	Cool, 4°C	48 h
Pesticides	G, teflon-lined cap	Cool, 4°C	7 days (until extraction) 30 days (after extraction)
Phenols	P, G	Cool, 4°C	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 h
Phosphorus, total	P, G	Cool, 4°C	28 days
Chlorinated organic compounds	G, teflon-lined cap	Cool, 4°C	7 days (until extraction) 30 days (after extraction)

[A] Taken from EPA 600-4-84-075. See also Ref. 85.

[B] Polyethylene (P) or Glass (G)

brate populations, the sediment corers are the most accurate samplers, followed by the Ekman dredge, in most cases (21). For resistant sediments, the PONAR dredge was the most accurate and the Petersen the least (21). A comparison of sampler precision showed the van Veen sampler to be the least precise; the most precise were the corers and Ekman dredge (21).

9.4 Many of the [illegible] with dredge samplers are largely overcome with the corers. The best corers for most sediment studies are hand-held fluorocarbon plastic, high density polyethylene, or glass corers (liners), or large box-corers. The corers can maintain the integrity of the sediment surface while collecting a sufficient depth. Furthermore, the box core can be sub-cored or sectioned at specific depth intervals, as required by the study. The box corer, unfortunately, is large and cumbersome; thus, it is difficult to use. Other coring devices which have been successfully used include the percussion corer (34) and vibratory corers (35–37).

9.5 Corer samplers also have several limitations. Most corers do not work well in sandy sediments; dredge samplers or diver-collected material remain the only current alternatives. In general, corers collect less sediment than dredge samplers which may provide inadequate quantities for some studies. Small cores tend to increase bow waves (that is, disturbance of surface sediments) and compaction, thus altering the vertical profile. However, these corers provide better confidence limits and spatial information when multiple cores are obtained (21, 24, 38–41). As shown by Rutledge and Fleeger (42) and others, care must be taken in subsampling from core samples, since surface sediments might be disrupted in even hand-held core collection. They recommend subsampling in situ or homogenizing core sections before subsampling.

9.6 Studies of sediment toxicity, interstitial waters, microbiological processes, or chemical fate probably will require core sampling to best maintain the complex integrity of the sediment. When obtaining cores from shallow waters one must ensure that the vessel does not disturb the sediments prior to sampling (30). Most of the studies in the literature employed grab samplers although box corers (43–45), gravity corers (46) and hand collection (47–49) methods are reported with increasing frequency. For additional information of various core types see reference USEPA (4).

9.7 Subsampling, compositing, or homogenization of sediment samples is often necessary and the optimal methods will depend on the study objectives. Important considerations include: loss of sediment integrity and depth profile; changes in chemical speciation by means of oxidation and reduction or other chemical interactions; chemical equilibrium disruption resulting in volatilization, sorption, or desorption; changes in biological activity; completeness of mixing; and sampling container contamination. In most studies of sediment toxicity, it is advantageous to subsample the inner core area (not contacting the sampler) since this area is most likely to have maintained its integrity and depth profile and not be contaminated by the sampler. Subsamples from the depositional layer of concern, for example, the top 1 or 2 cm should be collected with a nonreactive sampling tool, such as, a polytetrafluoroethylene-lined calibration scoop (50). Samples are frequently of a mixed depth but a 2-cm sample (51) is the most common depth obtained, although depths up to 40 ft have been used in some dredging studies. For some studies it is advantageous or necessary to composite or mix single sediment samples (16, 50). Composites usually consist of three to five grab samples. Subsamples are collected with a nonreactive sampling scoop and placed in a nonreactive bowl or pan. The composite sample should be stirred until texture and color appear uniform.

9.8 Due to the large volume of sediment which is often needed for toxicity or bioaccumulation tests and chemical analyses, it might not be possible to use subsampled cores because of sample size limitations. In those situations, the investigator should be aware of the above considerations and their possible affect on test results as they relate to in situ conditions.

9.9 Assessment of in situ sediment toxicity or bioaccumulation is aided by collection and testing of reference and control samples. For purposes of this guide, a reference sediment is defined as a sediment possessing similar charactics to the test sediment but without anthropogenic taminants. Sediment characteristics, such as particle size ribution and percent organic carbon, should bracket that the test sediment. If there is a wide range of test sediment pes, the reference sediment characteristics should be in an ermediate range unless the test species is affected by ticle size. The appropriate ASTM guides for marine and hwater invertebrates should then be consulted to deter- e the particle size requirements of the test species. It is ferable that reference sediments be collected from the e aquatic system, located close to, and have similar ysical, chemical, and biological characteristics to the test diment. In some situations, the reference sediment might toxic due to naturally occurring chemical, physical, or ological properties. For this reason, it is important to also the toxicity of control sediments. The reference sediment results might be analyzed as either a treatment or as a ntrol variable, depending on the study objectives. For pur- es of this guide, a control sediment might consist of natu- or artificially prepared sediments of known composition d of consistent quality that have been used in prior sedi- ent toxicity tests or culturing, and for which baseline data ists which shows they do not cause toxicity. Control sedi- ents have been successfully used in toxicity evaluations (52).

9.10 When collecting sediment grab samples, it is important to clean the sampling device, scoop, spatula, and mixing bowls between sample sites. The cleaning procedure can follow that outlined in Section 7 or the following (53): 1) soap and water wash, 2) distilled water rinse, 3) methanol rinse, 4) methylene chloride rinse, and 5) site water rinse. Waste solvents should be collected in labelled hazardous waste containers.

9.11 In most cases the transport conditions for the samples were not specified in the references reviewed. Where conditions were specified, the sediments were usually transported whole, in both plastic, polyethylene (54–56), and glass (48, 49, 57) containers and transported under refrigeration or on ice (48, 49, 51, 57–62).

9.12 Collection, transport, storage, and test chamber material composition should be chosen based on a consideration of sorption effects, sample composition, and contact time. For example, in sediments where organics are of concern, brown borosilicate glass containers with fluorocarbon plastic lid liners are optimal, while plastic containers are recommended for metal samples. Polytetrafluoroethylene (PTF) or high-density polyethylene containers are relatively inert and optimal for samples contaminated with multiple chemical types. Additionally, polycarbonate containers have been shown not to sorb metal species (63). Additional information on sample containers, preservation, storage times and volume requirements, in regards to chemical analyses, are available in other guidance documents (3–6, 10, 16). In many cases these criteria are applicable to toxicity test chamber requirements.

10. Storage

10.1 Containers for storage were generally not specified although it was assumed that the containers were the same as the transport containers, where specified, and were generally polyethylene (see 9.12). Where sediments contain volatile compounds, transport and storage should be in air-tight PTF or glass containers with PTF-lined screw caps. For further information on storage requirements for chemical analyses see Table 2 and EPA, 1982ab.

10.2 Drying, freezing, and cold storage conditions all affect toxicity (17, 64–69). Often the storage time of sediments used in toxicity tests was not specified and where specified ranged from a few days (70) to one year (55). Storage of sediments after arrival at the laboratory was generally by refrigeration at 4°C (54–56, 58–62, 67, 70–73). Significant changes in metal toxicity to cladocerans and microbial activity have been observed in stored sediments (68, 74). Recommended limits for storage of metal-spiked sediments have ranged from within 2 days (64) to 5 days (70) to 7 days (75, 76). A study of sediments contaminated with nonpolar organics found that interstitial water storage time did not affect toxicity to polychaetes when samples were frozen (77). Cadmium toxicity in sediments has been shown to be related to acid volatile sulfide (AVS) complexation (78). When anoxic sediments were exposed to air, AVS were rapidly volatilized. AVS is apparently the reactive solid phase sulfide pool that binds metal, thus reducing toxicity. If a study objective is to investigate metal toxicity and the sediment environment is anoxic, then exposure to air might reduce or increase toxicity due to oxidation and precipitation of the metal species or loss of acid volatile sulfide complexation. It is generally agreed that sediments to be used for toxicity testing should not be frozen (17, 67, 69, 70, 75, 79).

10.3 Although risking changes in sediment composition, several studies elected to freeze samples (51, 67, 80–84). Fast-freezing of sediment cores has been recommended for chemical analyses; however, this alters sediment structure and profile distortion occurs (42). Freezing has been reported to inhibit oxidation of reduced iron and manganese compounds (81). It has also been recommended for stored sediments which are to be analyzed for organics and nutrients (85).

[illegible] water chemistry changed significantly after 24 h storage (86, 87), even when stored at in situ temperatures (87). Coagulation and precipitation of the humic material was noted when interstitial water was stored at 4°C for more than one week (88). Oxidation of reduced arsenic species in pore water of stored sediments was unaffected for up to 6 weeks when samples where acidified and kept near 0°C, without deoxygenation. When samples were not acidified, deoxygenation was necessary (89).

10.5 In summary, sediments for toxicity tests and chemical analyses are typically refrigerated or placed on ice in polyethylene containers during transport. If, in addition, samples are to be used for chemical analyses, then the appropriate container should be used as described above. The storage conditions should be refrigeration at 4°C and under anoxic conditions if appropriate (10, 16, 90). It has been shown that sediments can be stored at 4°C for up to 12 months without significant alterations in toxicity (91). Limits to storage time before testing, therefore, appear to be a function of both sediment and contaminant characteristics. While it is prudent to complete the testing of sediments with a minimum of storage time (probably less than 2 weeks) this may not be possible for any number of reasons.

11. Collection of Interstitial Water

~~11.1 Isolation of sediment interstitial water can be accom~~plished by several methods: centrifugation, ~~squeezing,~~ suction, and equilibrium dialysis. In general, methods for recovery of relatively large volumes of interstitial water from sediments are limited to either centrifugation (57, 88, 92, 93) or squeezing (94–97). Other methods, such as suction (98), gas pressurization (50), in situ samplers (99), and equilibration by using dialysis membrane or a fritted glass sampler (100–103), do not produce large quantities of interstitial water. In the case of the dialysis, sufficient time must be allowed to ensure that the sample has come to equilibrium with the interstitial water. The suction and dialysis equilibrium methods are most useful for laboratory studies. Some pore water constituents, for example, dissolved organic carbon or dimethylsulfide, might be significantly affected by the collection method (99). Other constituents, such as salinity, dissolved inorganic carbon, ammonia, sulfide, and sulfate, might not be affected by collection methods providing oxidation is prevented (99). If sediments are anoxic, all steps involved in sample processing might need to be conducted in inert atmospheres to prevent oxidation of reduced species (99, 104, 105).

11.2 If interstitial water is collected by centrifugation and filtration, then effects on the interstitial chemistry need to be considered after centrifugation. Centrifugation followed by 2 µm filtration yielded similar metal concentrations to dialysis methods (106). However, filtration with glass fiber or plastic filters is not appropriate in some cases and has been shown to remove nonpolar organics (107). Centrifugation at 7600 × g with glass contact only was shown to be superior to filtration methods (107). Other studies have produced contrary results, recommending filtration with polycarbonate filters (98, 108). Filtration is normally conducted to remove particles with a 0.45-µm pore size, however 0.20-µm or smaller pore size membranes have been recommended (81). Removal of all bacteria and colloidal materials might require filter pore sizes of less than 0.2-µm. Immediate collection of interstitial water is recommended since chemical changes might occur even when sediments are stored for short periods at in situ temperatures (87) (see 10.4).

12. Characterization

12.1 The characteristics that have been most often measured in sediments are moisture content, organic carbon or volatile matter content, and particle size. When attempting to characterize a sediment, quality assurance should always be addressed (3, 4, 16). Sediments, by their nature, are very heterogeneous; they exhibit significant temporal and spatial heterogeneity in the laboratory and in situ. Replicate samples should be analyzed to determine the variance in sediment characteristics and analytical methods. Sediment characterization will depend on the study objectives and the contaminants of concern, however, a minimum set of characteristics should be included which are known to influence toxicity and will aid data interpretation: in situ temperature, particle size distribution, moisture or interstitial water content, ash-free weight, organic carbon (determined by titration or combustion), pH, Eh, acid volatile sulfides, ammonia, and cation exchange capacity. Many of the methods of characterization have been based on analytical techniques for soils and waters and the literature should be consulted for further information (15, 23, 109, 110).

12.2 The moisture content of sediments is measured by drying the sediments at 50 to 105°C to a constant weight (23).

12.3 Volatile matter content is often measured instead of, and in some cases in addition to, organic carbon content as a measure of the total amount of organic matter in a sample. This measurement is made by ashing the sediments at high temperature and reporting the percent ash free dry weight (7, 111, 112). Although the exact method for ashing the sample is often not specified, the normally accepted temperature is 550 ± 50°C (16, 23).

12.4 Carbon fractions which may be of importance in determining toxicant fate and bioavailability include: total organic carbon (16, 113–115), dissolved organic carbon (88), dissolved inorganic carbon, sediment carbonates, and reactive particulate carbon (116, 117). *Reactive* particulate carbon is that portion which equilibrates with the aqueous phase. The organic carbon content of sediments has been measured by wet oxidation which is also useful for the determination of the organic carbon content of water (118). Organic carbon analyses have also been conducted by titration (119), modification of the titration method (120), or combustion after removal of carbonate by the addition of HCl and subsequent drying (73).

12.5 Particle sizing of sediments can be measured by numerous methods (15, 121, see Guide D 4822) and the most effective method is dependent on the particle properties of the sample (122). Particle size distribution is often determined by wet sieving (2, 15, 16, 23, 123). Particle size classes might also be determined by the hydrometer method (124, 125), the pipet method (15, 126), settling techniques (127), X-ray absorption (123, 126) and laser light scattering (128). The pipet method may be superior to the hydrometer method (129). To obtain definite particle sizes for the fine material, a Coulter (particle size) counter method might be employed (130–131). This method gives the fraction of particles with an apparent spherical diameter. Another potential method for determining the particle size distribution of a very fine fraction is through the use of electron microscopy (132). The collection technique for the very fine materials can result in aggregation to larger colloidal structures (132–135). Comparisons of particle sizing methods have shown that some produce similar results and others do not. These differences might be attributed to differences in the particle property being measured, that is, the Malvern Laser Sizer and Electrozone Particle Counter are sizing techniques, and the hydrophotometer and SediGraph determine sedimentation diameter based on particle settling (132, 136–138). It is preferable to use a method which incorporates particle settling as a measure, as opposed to strictly sediment sizing.

12.6 Various methods have been recommended to determine bioavailable fractions of metals in sediments (78, 139–141). One extraction procedure, cation exchange capacity, provides information relevant to metal bioavailability studies (109). Amorphic oxides of iron and manganese, and reactive particulate carbon have been implicated as the primary influences on metal sorption potential in sediments (81, 140, 142–144). Measurement of acid volatile sulfide

AVS) and divalent metal concentrations associated with AVS extraction provides insight into metals availability in anaerobic sediments (78). Easily extractable fractions are usually removed with cation displacing solutions, for example, neutral ammonium acetate, chloride, sodium acetate, or nitrate salts (145). Extraction of saltwater or calcareous sediments, however, is often complicated by complexation effects or dissolution of other sediment components (141, 146). Other extractants and associated advantages and disadvantages have been recently discussed (141, 144, 147, 148). Some extractants which have been successfully used in evaluations of trace metals in nondetrital fractions of sediments are EDTA or HCl (141, 149, 150). Metal partitioning in sediments might be determined by using sequential extraction procedures which fractionate the sediments into several components such as interstitial water, ion exchangeable, easily reducible organic and residual sediment components (93, 148, 151, 152). Unfortunately at this time no one method is clearly superior to the others (147). This might be due, in part, to site specific characteristics which influence bioavailability, for example, desorption and equilibration processes.

12.7 pH is important for many chemicals and can be measured directly (23) or in a 1 to 1 mixture of sediment/soil to water (153).

12.8 Eh measures are particularly important for metal speciation and for determining the extent of sediment oxidation. Redox gradients in sediments often change rapidly over a small depth and are easily disturbed. Care must be taken in probe insertion to allow equilibration to occur when measuring Eh. These measurements are potentiometric and measured with a platinum electrode relative to a standard hydrogen electrode (23).

12.9 Biochemical oxygen demand and chemical oxygen demand might provide useful information in some cases (23). Sediment oxygen demand might also be a useful descriptor; however, a wide variety of methods exist (90, 154–157).

12.10 Analysis of toxicants in sediments is generally performed by standard methods such as those of the EPA (2, 23). Soxhlet extraction is generally best for organics but depends on extraction parameters (158, 159). Concentrations are generally reported on a dry weight basis.

13. Manipulation

13.1 Manipulation of sediments is often required to yield consistent material for toxicity testing and laboratory experiments. The manipulations reviewed in this section are: spiking (dosing) regimes for laboratory and control sediments; mixing; sieving for attainment of maximal particle sizes; dilutions for concentration-effect determinations; elutriates; capping; air drying; and sterilization. For discussion of subsampling, compositing, or homogenization effects see 9.7.

13.2 *Spiking*—The spiking method to be used is contingent on the study objectives. For example, when attempting to mimic in situ conditions, sediment cores should be spiked by adding aqueous or suspended sediment solution of toxicants to the overlying water column; or when investigating dredging effects or conditions of sediment perturbation where toxicant sorption processes are accelerated, mixing toxicants into sediment slurries may be advantageous. When investigating the source of sediment toxicity or interactive effects of sediment toxicants, it is useful to spike both reference and control sediments with the toxicant of concern present in the test sediment. Mixing time should be limited to a few hours and temperatures kept to a minimum, due to the rapid alterations which occur in the sediment's physicochemical and microbiological characteristics, which thereby alter bioavailability and toxicity. Recalcitrant organics and some metals, for example, cadmium and copper, might be mixed for extended periods without adverse effects (see Sections 9 through 12 for additional discussion).

13.3 Organic compounds are generally added by means of a carrier solvent such as acetone or methanol to ensure that they are soluble and that they remain in solution during mixing. While organic compounds are generally added in an organic carrier, metals are generally in aqueous solutions. Compounds are also added to water overlying sediments and the compound allowed to sorb with no mixing (71, 160–167). Occasionally the carrier has been added directly to sediment (52, 82–84, 112, 137, 168–171) and the carrier evaporated before addition of water. This approach does not seem to result in compounds being sorbed to sediment at the same sites as dosing under aqueous conditions (172). Word, et al. (107) compared several sediment-labelling techniques using methylene chloride, ethanol, and glycine as carriers. They found glycine was superior when mixed with sediment for 7 days. In most cases, the compound is either coated on the walls of the flask and an aqueous slurry (sediment and water in various proportions) added, or the carrier containing mixture is added directly to the slurry. When the sediment to water ratio is adjusted for optimal mixing, sediments that are too dense to mix by slurrying in water have been successfully mixed using a rolling mill (72). Other mixing techniques may be used for spiking specific sediments but care should be taken to ensure complete mixing and analyses of spiked compounds run to ensure that labelling is uniform in the mixed material. The use of a polar, water soluble carrier such as methanol has little effect on the partitioning of nonpolar compounds to dissolved organic matter at concentrations up to 15 % carrier by volume (173). Another study, however, shows that changes in partitioning of a factor of approximately two, might well occur with 10 % methanol as a cosolvent for anthracene sorption (174). Thus, caution should be taken to minimize the amount of carrier used. The time between the spiking of the compounds and the use of the test sediment has been variable (46, 47, 70, 72, 73, 80, 111, 168, 175) and does seem to effect the biological availability of compounds (37, 67, 175).

13.4 Highly volatile compounds have been spiked into sediments in a similar manner to the less volatile materials using cosolvents and mixing in an aqueous slurry by shaking. These experiments were tested immediately in covered flow-through systems (108).

13.5 If a solvent other than water is used, both a sediment solvent control and a sediment negative control or reference sediment, or both, must be included in the test. The solvent control must contain the highest concentration of solvent present and must use solvent from the same batch used to make the stock solution (see Practice E 729).

13.6 Because the organic carbon content of the sediments might be one of the most important characteristics affecting the biological availability of contaminants, modifications of the carbon content have been made in many studies. Methods used include dilution with clean sand (55, 56, 62, 108), although humics, (170) and other organics such as sheep manure (52) have also been added. Such dilutions also change the particle composition and the size distribution of the particles; thus, results from such experiments should be interpreted with care. The organic carbon content has also been altered by the use of combustion (14, 52). Combustion may alter the type of carbon as well as oxidize some of the inorganic components thus altering greatly the characteristics of the sediment.

13.7 A variety of methods have been used to spike sediments with metals. The two principal categories of methods are: metal addition directly to the sediment which is mixed and then water added (64, 68, 176–178); and addition of the metal to the overlying waters (80, 166, 179–180). Thorough mixing of spiked sediments has been accomplished using the rolling mill technique, Eberbach and gyro-rotary shakers.

13.8 Equilibration and mixing conditions vary widely in spiking studies. The duration of contact between the toxicant and sediment particles can affect both the partitioning and bioavailability of the toxicant. This effect apparently occurs because of an initial rapid labile sorption followed by movement of the toxicant into resistant sorption sites or in the particle (181–183). Because of the kinetically controlled changes in the partitioning that results in changes in bioavailability (174, 184–185), the contact time can be important when spiking sediments. Bounds on the sorption time can be estimated from the partition coefficient for the sediment following the calculations in Karickhoff and Morris (182). In addition, it is important to recognize that the quantity of toxicant spiked might exceed the complexation capacity of the test sediment system and not allow reactions to attain equilibrium. These phenomena will complicate test result interpretation (68, 147).

13.9 Mixing and sieving are two other manipulations of sediments that are often performed before toxicity testing (46, 52, 58–60, 67, 78, 111, 112, 163, 168, 170, 175, 186). Sediment samples have been sieved for a variety of reasons including the removal of large debris and stones, thereby increasing the sample's homogeneity and method replicability; the increased ease of counting organisms; the increased ease of sediment handling and subsampling; and the ability to study influence of particle size on toxicity, bioavailability, or contaminant partitioning. Sieving of material to a specific size fraction might alter the concentration of contaminant in the sediment by removing large, low-sorptive materials.

13.10 Toxicants and organic carbon concentrations tend to be higher with fine-grained sediments (that is, clay and silt) due to increased surface area (in relation to the weight of the sample) and sorptive capacity. Measuring size fractions of less than 63 µm has been recommended in contaminant studies, particularly for metals (172, 187). In studies of sediment metal concentrations, normalizing to the <63-µm size fraction was superior for describing metal binding in sediments as compared to sediment concentrations normalized to dry weight, by organic carbon content, or corrected by a centrifugation procedure (172). Small size fractions are characteristic of depositional areas in aquatic systems; however, sieving of sediments from non-depositional sites to obtain the fine fraction might significantly alter the sediment characteristics. The usual sieve size for toxicity testing is greater than 500-µm. If sieving is performed it should be done for all samples to be tested including control and reference sediments.

13.11 Mixing of various layers of sediments might result in either dilution or enhancement of concentrations. The sediment quality will be influenced by the depth of sampling, depth of biological activity, contaminant solubility and partitioning characteristics, and depth of the contaminant concentration peak which is dependent on historical contamination and sedimentation rates for the study site (see Section 10 for additional relevant discussion).

13.12 Another manipulation of sediments for toxicity testing is sediment dilution. In order to obtain concentration-effect information in solid phase sediment toxicity evaluations, differing concentrations of the test sediment should be used. Currently, there is little information available on the most appropriate method for diluting test sediments to obtain a graded contaminant concentration or concerning the methodological effects of such a dilution. A "clean" noncontaminated sediment should be used as the "diluent" which optimally consists of physicochemical characteristics similar to the test sediment, such as organic matter/carbon, particle size, but does not contain elevated (above background) levels of the toxicants of concern. Refer to the preceding sections for relevant information.

13.13 Many studies of sediment toxicity have been conducted on the elutriate or water-extractable phase (188). This method was developed to assess the effects of dredging operations on water quality. Sediments are shaken in site or reconstituted water (1 to 4 volume to volume ratio) for 30 min. The water phase is then separated from the sediment by centrifugation, followed by filtration of the supernatant through a 0.45-µm filter when conducting some tests, such as algal growth assays. The filtration step may be removed depending on the study objectives (see Section 11 for interferences).

13.14 Sediment pollution remediation alternatives might include capping the contaminated sediments with "clean" sediments. Laboratory design of such experiments should vary the depth of both the contaminated sediments and the capping sediment layers to evaluate contaminant transport by means of physicochemical and biological (bioturbation) processes.

13.15 Sometimes sediments have been air dried before use (56, 168, 189–190) but these sediments have generally been used for laboratory studies after some additional manipulation, such as spiking sediments with various levels of contaminants for concentration-effect data (111, 190). Air drying would result in losses of volatile compounds and might result in changes in the sediment characteristics, particularly particle size (see Section 10). The presence of air and air drying have all been shown to change metal availability and complexation (141).

13.16 Sterilization of sediments to inhibit biological activity has been performed in some studies. Autoclaving is used in most cases (191). Other sterilization techniques have included antibiotic addition, addition of chemical inhibitors such as $HgCl_2$ or sodium azide, or gamma irradiation. The technique chosen should be contingent on study objectives. Antibiotics, such as streptomycin and ampicillin, have been successfully used in sediment studies (192, 193). Some antibiotics, however, are labile and light sensitive, or readily bind to organic matter. Mercuric chloride appears to be superior to sodium azide as a bacteriocide. Autoclaving is the least desirable method as it causes the greatest alteration to the sediments physical and chemical characteristics. In studies requiring sterility, it is crucial that a sterility control be incorporated.

14. Quality Assurance

14.1 Quality assurance guidelines (3, 4, 10, 16) should be followed. Quality assurance considerations for sediment modeling, QA-QC plans, statistical analyses (for example, sample number and location) and sample handling have been addressed in-depth (10).

14.2 Sediment heterogeneity significantly influences studies of sediment quality, contaminant distribution, and both benthic invertebrate and microbial community effects. Spatial heterogeneity might result from numerous biological, chemical, and physical factors and should be considered both horizontally (such as, the sediment surface) and vertically (that is, depth). Accumulation areas with similar particle size distributions might yield significantly different toxicity patterns when subsampled (79, 194); therefore, an adequate number of replicates should be processed to determine site variance. When determining site variance one should consider within sample (that is, subsample) variance, analytical variance (for example, chemical or toxicological), and the sampling instruments' accuracy and precision. After these considerations a sampling design can be constructed which addresses resource limitations and study objectives.

14.3 As stated in previous sections, the methodological approach used, such as, number of samples, will be dependent on the study objectives and sample characteristics. For information on sediment heterogeneity, splitting, compositing, controls, or determining sample numbers, sampler accuracy and precision, and resource requirements, there are a number of references available (4, 10, 21, 85, 172, 195, 196).

15. Report

15.1 *Documentation*—The record of sediment collection, storage, handling, and manipulation should include the following information either directly or by reference to existing documents. Published reports should contain enough information to clearly identify the methodology used and the quality of the results.

15.1.1 Name of test and investigator(s), name and location of laboratory, and dates of starting and ending of sampling and sediment manipulation,

15.1.2 Source of control, reference or test sediment, method for handling, storage, and disposal of sediment,

15.1.3 Source of water, its chemical characteristics, and a description of any pretreatment,

15.1.4 Methods used for, and results (with confidence limits) of, physical and chemical analyses of sediment, and

15.1.5 Anything unusual about the study, any deviation from these procedures, manipulations, and any other relevant information.

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