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FINAL REMEDIAL INVESTIGATION REPORT FOR KAUFFMAN & MINTEER SITE

Jobstown, New Jersey

VOLUME I

EPA Work Assignment No. WA-004-2L1R

July 1995

Region II

ALTERNATIVE REMEDIAL CONTRACTING STRATEGY (ARCS) FOR HAZARDOUS WASTE REMEDIAL SERVICES

EPA Contract No. 68-S9-2001

TAMS CONSULTANTS, Inc.

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EXECUTIVE SUMMARY

A Remedial Investigation (RI) of the Kauffman & Minteer (K&M) Site, Jobstown, New Jersey was performed for the U.S. Environmental Protection Agency, Region II by TAMS Consultants, Inc. Historically, K&M transported bulk liquids consisting primarily of organic substances including plasticizers, resins, vegetable oils, soaps, petroleum oils, and alcohols. From 1960 through at least 1981, wastewater generated from the washing of tanker interiors was discharged to an on-site lagoon. The 0.7-acre, irregularly shaped, unlined lagoon was about three to 10 feet deep prior to being drained in the summer of 1991 by USEPA. Figure ES-1 shows features of the K&M Site.

Starting in 1978, a series of site inspections were initiated by State and County regulatory agencies. Regulatory directives, including an early order to dispose of lagoon and process wastewaters properly, were largely ignored by K&M. On June 1, 1984, the dike surrounding the lagoon broke and a portion of the lagoon contents was released to the adjacent marsh and downstream areas. A Hazard Ranking System (HRS) score of 28.51 was developed for the K&M Site in 1986, based on the groundwater route evaluation. The K&M facility was subsequently placed on the National Priorities List (NPL).

RI field activities were conducted at the site between September 1991 and March 1992. Volatile organic compounds (VOCs), including BTEX compounds and chlorinated aliphatics; semivolatile organic compounds (SVOCs), including phthalates and polynuclear aromatic hydrocarbons (PAHs); as well as several metals are the principal contaminants detected. The distribution and significance of these contaminants is as follows:

BTEX compounds and chlorinated aliphatics, PAHs, phthalates, and petroleum hydrocarbons were detected in the lagoon sediment samples. Selected metals were also detected above background levels. The concentration of trichloroethene detected in the TCLP extract of one sediment sample exceeds the TCLP regulatory criterion. No other samples analyzed for TCLP were found to exhibit hazardous characteristics. Lower concentrations of BTEX compounds and comparable concentrations of phthalates were found in lagoon berm soils.

In general, organic compound concentrations in a lagoon profile boring were found to decrease with depth. In addition, some contaminants identified in the lagoon sediments were detected in samples of surface and subsurface soils in other areas of the site, including an adjacent marsh and drainage features, but at substantially lower concentrations. Some inorganics not found in lagoon sediments were detected above background evaluation criteria in other areas of the site.

Samples of surface water from Barker's Brook, located to the south of the K&M facility, showed no detections of VOCs or SVOCs. In addition, detections of inorganics and conventional analytes are below New Jersey Surface Water Quality Criteria (NJSWQC). The corresponding sediment samples were found to contain phthalates and PAHs. PAH concentrations in the sediment samples were below the NOAA ER-M criteria. Petroleum hydrocarbons were also detected in the sediment sample downstream of the discharge of the drainage ditch but at a level below the NOAA ER-

M criterion for total organics. Various inorganics were also detected although none exceeded available NOAA ER-M criteria.

Chlorinated VOCs were detected in samples from two wells in the shallow Navesink Formation downgradient of the lagoon, at concentrations exceeding the New Jersey Groundwater Quality Criteria for class II-A waters. Of the chlorinated VOCs detected in MW102S, only tetrachloroethene exceeds the corresponding New Jersey MCL. Concentrations of vinyl chloride and trichloroethene detected in MW105S exceed both the state and Federal MCLs. BTEX compounds were also detected in MW105S. No VOCs were detected in any of the other shallow groundwater samples collected from the site. Trace levels of phthalates (SVOCs) were detected in wells MW104S (along the northwest marsh boundary) and MW106S (adjacent to the former washwater collection pit). Non-target SVOCs were detected in all the shallow well samples, except that from MW101S. The concentration of isophorone detected in MW105S exceeds the class II-A groundwater quality criterion. Inorganic analytes were typically present at higher concentrations in the unfiltered aliquot of a sample than in the filtered aliquot. Concentrations of a few metals detected exceed the class II-A groundwater criteria in unfiltered samples but either were not detected or were detected below the applicable criteria in the corresponding filtered samples. Manganese exceeds the class II-A criterion in six of the nine filtered samples as well as eight of the unfiltered samples. Nickel exceeds the criterion in both the filtered and unfiltered samples from MW106S.

With the exception of methylene chloride, a common laboratory contaminant detected in MW102D that was also detected in the method blank associated with the sample, no target or non-target VOCs or target SVOCs were detected in samples from monitoring wells in the deeper Wenonah-Mt. Laurel aquifer. Non-target SVOCs were detected in the samples from MW102D and MW103D at relatively low levels. As expected, detected inorganic analyte concentrations for the filtered sample aliquots are typically lower than the concentrations found in the unfiltered samples. Similar to the shallow groundwater samples, manganese exceeds the criterion in both the filtered and unfiltered samples from all three wells. The chromium concentration found in the unfiltered sample from MW101D exceeds the Federal and the New Jersey MCLs; however, chromium was not detected in the filtered sample. No other inorganic analyte concentrations in the filtered and unfiltered samples from the deep wells exceed the applicable criteria.

Three major contaminant transport pathways have been identified at the site, based on the data generated during the RI. These are:

(1) Vertical migration of mobile organics from the lagoon sediments through the underlying soil and into the shallow groundwater in the Navesink Formation, and subsequent migration of contaminated water. Chlorinated aliphatics and BTEX compounds have been detected in shallow groundwater samples from monitoring wells near the lagoon. However, there is no evidence to date of further horizontal or vertical migration of these contaminants to the deeper aquifer or to off-site wells.

(2) Transport of contaminants from the lagoon (by sediment or water) to the marsh immediately adjacent to the lagoon through overflow or breaching of the lagoon

berm. Phthalates, especially di-n-octylphthalate, were detected in high concentrations in marsh soil samples collected adjacent to the lagoon. Although phthalates were also detected in several other samples from the marsh, the concentrations decreased significantly with distance from the lagoon.

(3) Overland transport of contaminants via surface flow (stormwater runoff contaminated by contact with site soils and contaminated soils entrained in the runoff) to the drainage ditch and intermittent stream, followed by potential or actual transport of contaminated surface soils to Barker's Brook. High concentrations of phthalates, petroleum hydrocarbons, unidentified semivolatile organics, and to a lesser extent, BTEX compounds and chlorinated aliphatics were detected in the drainage ditch adjacent to the unpaved operations lot. Many of these contaminants were also detected farther downstream in the ditch and in Barker's Brook sediments, although at lower concentrations. Phthalates, unidentified semivolatile organics, and petroleum hydrocarbons were also detected at high concentrations in the intermittent stream connecting the marsh and Barker's Brook, although the concentrations are not as high as those in the ditch samples.

The human health assessment for the K&M Site examined current and future exposure scenarios to determine if concentrations of contaminants present in various media pose unacceptable carcinogenic or noncarcinogenic risks to potentially exposed populations. A total of 24 compounds of concern were examined in the six distinct media present. Exposures to site surface soils, site subsurface soils, lagoon sediments, ditch and marsh soils, Navesink Marl groundwater, and Wenonah-Mt. Laurel groundwater were examined.

Exposure to site surface soils, lagoon sediments, and Navesink Marl groundwater may potentially result in adverse health effects to residents, site workers and construction workers.

Residential risks above target levels were calculated for current and future exposure to the Navesink Marl groundwater (via ingestion and inhalation of volatiles), future ingestion of site soils, future ingestion of lagoon sediments, and future inhalation of volatile organics released from the lagoon. Local residents trespassing upon the site occasionally are not exposed to additional risks above target levels.

Site workers may be exposed to risks above target levels by inhalation of fugitive dust, ingestion of site soils, inhalation of volatile organics from the lagoon, and ingestion of groundwater from the Navesink Marl Formation. However, the zoning of the K&M Site has been changed to "Neighborhood Commercial", which reduces the possibility of long-term industrial workers at the K&M Site.

Future construction workers were calculated to be exposed to risks above target levels by ingestion of groundwater from the Navesink Marl Formation.

The primary objective of the environmental assessment was to estimate the potential ecological impacts associated with the release of contaminants from the K&M facility. No Federal or State protected vegetative or animal species were found during the ecological investigation; however, the breeding population of one observed species, the great blue heron, is listed as threatened in the State of New Jersey.

The only area where obvious contaminant-related stress to the ecosystem was observed was in an isolated portion of the marsh immediately adjacent to the lagoon. The flora in the remainder of the study area appeared healthy and obvious physical abnormalities were not observed in the fauna of the study area. Additionally, the assemblage of macroinvertebrate taxa found in Barker's Brook adjacent to, upstream of, and downstream of the K&M facility are typical for the habitat type. Since sensitive, intolerant macroinvertebrate taxa were collected from all three areas of Barker's Brook, it appears that the aquatic ecosystem is not experiencing adverse contaminant-related impacts.

Based on evaluation of receptors, pathways and chemical toxicity for the environmental assessment, contaminants of concern at the site for various media in identified habitats were defined as beryllium, chromium, lead, toluene, PAHs, and phthalates. Based on the site field surveys and available toxicity information for the contaminants of concern, there are no apparent contaminant-related impacts to aquatic and terrestrial ecosystems of the K&M study area, with the exception of the isolated area of stressed vegetation in the portion of the marsh directly adjacent to the lagoon.

The sampling program was targeted toward source areas, such as the lagoon and facility soils, and likely areas of contaminant migration. It is believed that these areas have been sufficiently characterized for conduct of the Feasibility Study. However, detailed delineation of areas of contamination may be required during Remedial Design, depending on the final remedial action objectives developed for the project.

Based on the results of the RI, general remedial action objectives originally presented in the RI/FS Work Plan have been refined as follows:

- Protect groundwater in the Wenonah-Mt. Laurel Aquifer from potential future degradation exceeding Federal and State drinking water standards by site-related contaminants.
- Prevent use of the Navesink Formation as a groundwater source in the immediate vicinity of the K&M Site.
- Prevent exposures to contaminated soil and exposed sediment that exceed risk-based levels developed in the risk assessment.
- Prevent exposures to lagoon sediments that exceed risk-based levels developed in the risk assessment and remediate hazardous (toxic) sediments.
- Prevent short term and long term degradation of Barker's Brook surface water and sediment by site discharges which may impair recreational use or the ability of the stream to support healthy aquatic life; or which may cause exceedances of NJ Surface Water Quality Criteria.

1.0 INTRODUCTION

TAMS Consultants, Inc. (TAMS) performed a remedial investigation (RI) at the Kauffman & Minteer (K&M) Site, Jobstown, Springfield Township, Burlington County, New Jersey, in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA). The firm of Fanning, Phillips & Molnar (Ronkonkoma, New York) assisted TAMS as a subconsultant, providing boring and monitoring well inspection, hydrogeologic testing, and evaluation of geologic and hydrogeologic information. The investigation was performed for the U.S. Environmental Protection Agency (USEPA), Region II under the Alternative Remedial Contracting Strategy (ARCS) program (Contract No. 68-S9-2001, Work Assignment No. WA-004-2L1R).

The purposes of the investigation were to determine the physical characteristics of the site and sources of contamination, to evaluate the nature and extent of contamination, and to characterize the potential health risk and environmental impact of the site. Other pertinent reports prepared by TAMS for the K&M Site include:

- Final Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the Kauffman & Minteer Site, May 1991
- Final RI/FS Field Operations Plan (FOP) for the Kauffman & Minteer Site, May 1991
- Addendum to the RI/FS Work Plan, January 1992

The Remedial Investigation Report is presented in a format consistent with the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final (USEPA, 1988a) and is organized as follows:

Section	Description of Contents
1	Introduction/Background Information
2	Description of Site Investigations
3	Physical Characteristics of the Study Area
4	Nature and Extent of Contamination
5	Contaminant Fate and Transport
6	Baseline Risk Assessment
7	Summary and Conclusions
8	References

The text of the RI Report is presented in Volume 1. The tables and figures referenced in the text are presented in Volume 2. Volume 3 contains the appendices to the RI Report.

1.1 Site Location and Description

Kauffman & Minteer, Inc. operated a bulk liquid transportation facility located on the eastern corner of the intersection of Monmouth Road (Route 537) and Jobstown-Juliustown Road in Jobstown, Springfield Township, Burlington County, New Jersey. Geographically, the site is located at latitude 40° 02' 10.8" N and longitude 74° 41' 37.5" W (USGS, 1957). Figure 1-1 shows the general location of the site.

The K&M property occupies approximately 5.5 acres in a sparsely populated, predominately rural area that primarily supports agriculture, horse farming, and related businesses. The K&M property is bordered on the north by residences and Route 537, on the northeast and east by a marsh area, on the south by an overgrown and wooded area traversed by Barker's Brook, and on the west by Jobstown-Juliustown Road. For the purposes of this RI/FS, the "site" is considered the approximately 25 acre area bounded by Route 537 on the north, by properties on Saylors Pond Road on the east, by Jobstown-Juliustown Road on the west, and by Barker's Brook on the south. Figure 1-2 is a topographic base map of the site. Boundaries of the K&M property and adjoining properties are shown on Figure 1-2.

Features of concern on the K&M property include a small, irregularly shaped, unlined lagoon, approximately 3 to 10 feet deep, with a low earthen berm, and formerly having a spray aeration system to enhance evaporation. The lagoon, which formerly received wash water from the tank truck interiors, has been dewatered by USEPA and is currently inactive. Since being drained in the summer of 1991, the lagoon has been partially refilled due to precipitation. Also on the site are nine underground storage tanks and a washwater collection pit that has been closed (filled). Three previously installed groundwater monitoring wells are located in the vicinity of the lagoon. Figure 1-3 shows features of the K&M property and the historical sampling locations.

A small marsh immediately adjacent to the eastern property boundary gives rise to an intermittent stream. This stream flows south-southeast into a branch of Barker's Brook which is located approximately 575 feet south of the K&M property.

The site area is not served by either sanitary or storm sewer systems. The K&M facility, like the surrounding residences and businesses, has a septic system to handle sanitary wastes. Stormwater runoff in the site area flows to Barker's Brook via drainage ditches and overland flow. A drainage ditch along the southwestern boundary of the K&M property, adjacent to Jobstown-Juliustown Road, carries runoff from the facility operations lot and parking areas to Barker's Brook.

There are three aquifers in the vicinity of the K&M site. In order of decreasing depth, the aquifers are the Raritan-Magothy, the Englishtown, and the Wenonah-Mt. Laurel. These aquifers dip to the southeast and strike northeast-southwest. The site rests on the Navesink Formation, a glauconitic, sandy clay layer, approximately 10 to 25 feet thick in the site vicinity. A shallow groundwater table exists within this formation; however, yields are insufficient for use as water supply. Below the site and directly below the Navesink Formation is the Wenonah-Mt. Laurel Aquifer, which is approximately 60 feet thick in the site vicinity. Because geologic units in the area dip toward the southeast, zones of principal aquifer use exist within boundaries along the strike of the units. In the area around the site, individual domestic wells are the primary source of drinking water. Within three miles of the site, but primarily in the Juliustown area (the principal use area of the Wenonah-Mt. Laurel Aquifer), approximately 560 people use water from private wells that tap the Wenonah-Mt. Laurel Aquifer (NUS, 1986). The nearest well drawing water from this aquifer is located on the north side of the intersection of Routes 670 and 537, approximately 500 feet from the K&M lagoon (NUS, 1986).

1.2 Site History

Historically, Kauffman & Minteer, Inc. has transported, in company owned tankers, bulk liquids consisting primarily of organic substances including plasticizers, resins, vegetable oils, soaps, petroleum oils, and alcohols. From 1960 through at least 1981, wastewater generated from the washing of tanker interiors was discharged to the on-site lagoon. During a site inspection conducted by TAMS and USEPA personnel on June 14, 1989, Mr. Kauffman (President of K&M, Inc.) indicated that tankers washed at the facility at that time carried only plasticizers and soaps. K&M has indicated that approximately 30 gallons of wastewater was generated per truck wash (NJDEP, 1982).

The 0.7-acre, irregularly shaped lagoon is about three to 10 feet deep and has been in operation since at least 1960. The lagoon is unlined and has inadequate runoff and runon control structures. The lagoon has no overflow diversion structure to protect the system from overflow during rainfall events, and there is only a low earthen berm to protect the adjacent marsh from overflow. An additional berm was installed in the summer of 1991 to divert parking area runoff away from the lagoon. A spray aeration system, consisting of seven sprinklers located along the western side of the lagoon, was formerly used to evaporate wastewater by spraying it over the lagoon. This aeration system was in operation in October 1982 but was discontinued prior to June 1989. According to local residents, spray from this system has been observed to be carried by the wind onto surrounding properties. The spray aeration system was dismantled prior to construction of the diversion berm.

On June 2, 1978, an Administrative Order was issued to K&M by the New Jersey Department of Environmental Protection (NJDEP) Division of Water Resources (DWR). The order stated that all existing lagoon water and process waters were to be transported to an acceptable waste processing center or, alternatively, the waters were to be treated and discharged on site pursuant to the State Treatment Works approval requirements. In the spring of 1981, K&M reported that the discharge of wastewater to the lagoon had stopped and that wastewater was being stored on the facility property in tank trailers. The first wastewater shipment was sent to the DuPont wastewater treatment facility, in Deepwater, New Jersey, approximately one year later (NJDEP, 1982).

On April 13, 1981, an inspection of the K&M facility was performed by NJDEP DWR. It was observed that the unlined, unpermitted lagoon surface was contaminated with oil and that the general area contained rusted drums and debris. Soils of the lagoon's earthen berm were discolored and contaminated by lagoon leachate. At the tank trailer wash-out area, potentially contaminated process water was being discharged into an unlined basin. Near the western boundary of the facility, a drainage ditch contained a straw filter berm that was used to remove oil and grease from parking lot runoff. Also, leaking drums at the rear of the site were contaminating unprotected soils.

K&M was initially issued a National Pollution Discharge Elimination System (NPDES) Discharge Permit, effective October 31, 1980 to October 31, 1985, for discharging surface runoff to Barker's Brook in accordance with effluent limitations. The permit required K&M to sample discharge on a quarterly basis and to submit a discharge monitoring report every twelve months (USEPA, 1980).

In April 1982 the first mobile tank trailer shipment of wastewater was transferred to the DuPont, Deepwater facility for disposal. The K&M wastewater shipments were manifested as waste water, Nonhazardous, Department of Transportation (DOT) hazard class NA9189, EPA waste type X724. DuPont sampled the 15,000-gallon shipment and found the material to be hazardous due to a low flash point (ignitability). Although DuPont found the wastewater to be hazardous, they accepted the improperly manifested shipment from an unlicensed hauler (K&M). Water samples collected from the lagoon by the NJDEP Bureau of Waste Management (BWM) showed concentrations of lead and cadmium above New Jersey Action Levels, qualifying the lagoon as a hazardous waste facility. After the samples from the lagoon were identified as hazardous, the K&M NPDES permit was voided and all surface waste was ordered to be removed and disposed in accordance with the waste regulations of BWM.

On April 21, 1982, a joint inspection of the site was conducted by NJDEP DWR and the Burlington County Health Department. During the inspection Mr. Kauffman indicated that the unlined pit next to the garage held tank trailer wash water until the wash water was transferred to a storage tank trailer for highway transport. In addition, Mr. Kauffman explained the use of two 1,000-gallon underground storage tanks; one was used to store waste crankcase oil and oil skimmed from the surface of the wash water collection pit, and the other was used to collect heels of shipments of a Monsanto plasticizer. The collected plasticizers were then shipped back to Monsanto for processing. Beginning in 1983, K&M wastewater was loaded into tank trailers and transported for disposal at the Mt. Holly Sewer Authority. The wash water collection pit was closed (filled) sometime between June 1989 and April 1990 without USEPA or NJDEP oversight.

On June 1, 1984, the dike surrounding the lagoon broke and a portion of the lagoon contents was released to the adjacent marsh and downstream areas. The level of the lagoon dropped 18 inches before the dike could be repaired.

K&M was issued a NJPDES/DSW permit, effective November 1984 to October 1987, for discharge of surface water to Barkers Brook in accordance with effluent limitations. This permit was later modified (effective July 1986) to include discharge to groundwater. This major modification required closure of the lagoon and the wash water collection pit (NJDEP, 1986).

On September 5, 1985, NUS Corp. (NUS), the USEPA Region II Field Investigation Team (FIT) contractor, conducted a site inspection (SI) and collected three groundwater samples (i.e., one from each of the three monitoring wells), one aqueous sample, and seven soil/sediment samples. Tetrachloroethene, toluene, ethylbenzene, styrene, 2-methylnaphthalene, endosulfan sulfate, 4,4'-DDT, phenanthrene, and other compounds were detected in the samples (NUS, 1986).

The USEPA conducts SIs to determine whether sites are eligible for inclusion on the National Priorities List (NPL). Sites on the NPL receive further investigation to determine the nature and extent of contamination at the site and are eligible for Superfund cleanup funds. The principal mechanism for placing sites on the NPL is the Hazard Ranking System (HRS). The HRS is a structured value analysis approach that provides a consistent method for evaluating potential hazardous waste sites on a national basis. The HRS evaluates actual or potential contamination of three major pathways at a site: groundwater, surface water, and air. The potential for fire and explosion and for direct contact with site contaminants may also be evaluated. A numerical score is developed for each pathway and these scores are combined to arrive at a Migration Score or Sm. If this score is greater than 28.50, the site is eligible for inclusion on the NPL.

A Hazard Ranking System (HRS) score was developed for the K&M Site by NUS based on the site inspection and other records. NUS concluded that fire and explosion conditions did not exist and; therefore, the site was not scored for this element. The HRS score for direct contact (Sdc) was 25. The surface water and air routes were not scored due to lack of documented targets. As a result, only the groundwater route, which was the primary concern at the site, was scored. Based on the groundwater route evaluation, the Sm for the site was 28.51 (NUS, 1986). The K&M facility was subsequently placed on the National Priorities List (NPL).

On June 14, 1989 TAMS and USEPA personnel conducted a site reconnaissance at the K&M facility. The following is a summary of observations recorded during the reconnaissance:

- No gate or perimeter fence was present to restrict access to the lot or lagoon (currently, both the lot and the lagoon are fenced).

- The wash water collection pit was full (the pit was subsequently backfilled by K&M without USEPA or NJDEP approval).
- Soils in the marsh adjacent to the lagoon were irregularly stained black.
- Soils of the unpaved tank trailer parking area were stained.
- Soils in the drainage ditch adjacent to the western border of the property were stained by parking lot run-off and a straw berm in this stream was contaminated with oil.

During the TAMS site inspection, K&M reported that the liquid level of the lagoon is maintained by removal and transport of lagoon liquids after rainfall events.

In April 1991 USEPA reported that the site was active and tanker trailers continued to be washed down at the facility. Wastewater from the tanker washing operations was being collected in an unlined sump and transferred to tankers for transport to the Mt. Holly Sewer Authority for disposal.

In the summer of 1991 the USEPA removed and disposed of the liquid fraction of the lagoon. Since that time the liquid level in the lagoon has been gradually increasing due to the collection of rainwater. In mid-September 1991, a fence was installed around the lagoon by USEPA contractors. RI/FS field work was initiated at the K&M Site in September 1991 and was completed in March 1992. For most of this period the site remained active; however, the frequency of activity appeared to decrease since late 1991 and operations appear to have been discontinued.

1.3 Previous Investigations

Since 1978 numerous investigations have been conducted at the K&M facility. Some of the investigations included only visual observations of the K&M property and the surrounding area and interviews with the site owner/operator, while others included waste source and environmental sampling. Pertinent visual observations and site owner responses to interviews were provided above (Section 1.2). This section will focus on the results of sampling events at the K&M site.

Sampling was conducted at the site on at least nine occasions between August 1981 and January 1988. Sampling entities included NJDEP Central Enforcement; NJDEP DWR; USEPA Region II FIT (NUS); and Environics, Consultant to K&M. Media sampled included waste sources, groundwater, surface water, soils, and sediment. The information presented in this section is divided into waste sources and potential migration pathways (i.e. groundwater, surface water, soil and air). Tables 1-1 through 1-5 provide a summary of previous sampling events. Approximate sampling locations are shown on Figure 1-3.

1.3.1 Waste Source Investigations

The waste source area of primary concern at the K&M Site is the lagoon. At least until 1981, it received wash water from tankers that transported organics including petroleum oils, plasticizers, soaps, resins, vegetable oils, and alcohols. Other areas requiring investigation include nine underground storage tanks, a septic system, abandoned drums, excavated soils, the parking lot drainage ditch, and a former wash water collection pit that was used as temporary storage area for wastewater.

Source area sampling during previous investigations consists of lagoon aqueous and sediment sampling conducted by NJDEP and USEPA Region II FIT (NUS), and lagoon sediment sampling and wash water collection pit aqueous and sediment sampling conducted by Environics. Table 1-1 provides a summary of the waste source sampling data. Approximate sampling locations are shown on Figure 1-3.

Source Area Aqueous Sampling

On May 4, 1983 and April 24, 1984, NJDEP DWR sampled the liquid of the lagoon. Results of these analyses are shown in Table 1-1. Typical plasticizer constituents including di-n-octyl phthalate (28,490 ppb), butylbenzylphthalate (425 ppb), ethylhexylphthalate (3590 ppb) and di-n-butylphthalate (42 ppb) were detected. Polynuclear aromatic hydrocarbons (PAHs), constituents of petroleum products, including anthracene, phenanthrene, benzo(a)anthracene, chrysene, naphthalene were detected in the samples at concentrations ranging from 14.5 to 55 ppb. Benzene, which is also associated with petroleum products, was detected at a concentration of 85 ppb. A few halogenated compounds were also detected at concentrations ranging from 29 to 103 ppb. The samples contained measurable levels of methylene blue active substances (MBAS), indicating the presence of detergents. The metals cadmium, chromium, copper, nickel, lead, and zinc were present in the 1984 sample at detectable levels. Chemical oxygen demand (COD), total suspended solids (TSS), and total dissolved solids (TDS) were also reported.

On September 5, 1985, NUS Corporation sampled the lagoon liquid (NUS, 1986). Analyses performed included Target Compound List (TCL) volatile and semivolatile organics, pesticides/PCBs, and inorganics. Volatile compounds included 2-butanone, benzene, and toluene (19 ppb to 85 ppb). Semivolatile organic compounds associated with petroleum products and other substances transported by K&M were detected at concentrations ranging from 20 to 260 ppb. Di-n-butylphthalate (520 ppb), butylbenzyphthalate (9600 ppb), bis(2-ethylhexyl)phthalate (5700 ppb), and di-n-octylphthalate (44,000 ppb), were also detected in the sample. Semivolatile tentatively identified compounds (TICs) included 4 unknown hydrocarbons (19,100 ppb), 6 unknown substituted benzenes (16,400 ppb), and 10 unknown phthalates (23,370 ppb). The analyses for pesticides/PCBs did not pass laboratory QA/QC requirements.

On August 7, 1986, the collection pit liquid was sampled by Environics (Environics, 1987). The pit liquid was analyzed for the Priority Pollutant List plus 40 peak library search (PP+40). No pesticides or PCBs were detected. The typical plasticizer constituents di-n-octylphthalate and di-n-butylphthalate were detected at concentrations of 77,000 ppb and 790 ppb, respectively. Semivolatile TICs, including substituted benzenes, alkanes, and unknowns, were detected at a total concentration of 136,510 ppb. Ethylbenzene, toluene, and xylenes detected in the sample are typical petroleum constituents.

Source Area Sediment Sampling

Source area sediment sampling was conducted in 1983 by NJDEP, in 1985 by NUS, and in 1986 by Environics, as shown in Table 1-2. On May 3, 1983, NJDEP sampled the lagoon sediment at an unspecified location. No volatile organic compounds were detected. The PAH compounds anthracene, phenanthrene, benzo(a)anthracene, and chrysene were detected at concentrations ranging from 15 to 16 ppb. Barium, cadmium, chromium, lead, selenium, silver, and mercury were detected in the extraction procedure (EP) toxicity test at concentrations below the maximum allowable level (40 CFR 261).

On September 5, 1985, NUS collected one sediment sample from the southeast perimeter of the lagoon (NUS, 1986). The sample was analyzed for TCL organic and Target Analyte List (TAL) inorganic parameters. Trans-1,2-dichloroethene, tetrachloroethene, toluene, ethylbenzene, styrene, and xylenes were detected in the sample at concentrations ranging from 120 to 1300 ppb. Semivolatile organic compounds detected included phenanthrene (6,200 ppb), and 2-methylnaphthalene (2,500 ppb). Phthalates, including butylbenzylphthalate (5,970 ppm), di-n-octylphthalate (1430 ppm), bis(2-ethyhexyl)phthalate (414 ppm), and di-n-butylphthalate (55.6 ppm) were also detected in the lagoon sediment sample. Phthalates were detected in the sample at estimated values which were not reported in this document (NUS, 1986). Inorganic substances that were present at concentrations greater than the detection limit included cadmium, lead, mercury, tin, and thallium. Other inorganic compounds were detected, estimated concentrations which were not reported. The pesticide/PCB analysis did not pass QA/QC requirements.

On August 7, 1986 Environics collected five composite lagoon sediment samples (Environics, 1987). Each composite sample consisted of five subsamples that were collected from each of five approximately equal areas of the lagoon. Two composite samples were selected for base neutral analysis. EP Toxicity, total petroleum hydrocarbons (TPHC), cyanide/sulfide reactivity, and PCB analyses were performed on all samples.

The base-neutral compounds detected in both composite samples were similar and included butylbenzylphthalate, di-n-octylphthalate, and bis(2-ethylhexyl)phthalate. These phthalates were present in the samples at concentrations ranging from 14,000 to 4,800,000 ppb. Naphthalene was present in one composite sample at an estimated concentration of 14,000 ppb. TPHC concentrations ranged from 2,800 to 27,000 ppm, with the highest concentration found in the southwest corner of the lagoon. The EP Toxicity analysis revealed levels of metals that were well below the maximum allowable levels. No pesticides or PCBs were found in any sample and no sample was found to be reactive.

Also on August 7, 1986, Environics collected a sediment sample from the wash water collection pit floor. This sample, which was a composite of four grab samples, was analyzed for PP+40 compounds. No pesticides or PCBs were detected. Levels of cadmium, chromium, copper, lead, nickel, and zinc were detected in the sample which are within normal background levels (see Chapter 4). Volatile organic compounds detected included 1,2- and 1,4-dichlorobenzene, ethylbenzene, toluene, 1,1,1-trichlorethane, trichloroethene, and xylenes. Di-n-octylphthalate and di-n-butylphthalate were detected at concentrations of 2,200 and 13 ppm, respectively.

1.3.2 Groundwater Investigations

Figure 1-3 shows the locations of the existing monitoring wells at the K&M Site existing prior to the RI. These wells are labeled MW-1 (upgradient), MW-2, and MW-3. These wells were sampled in 1981, 1982, and 1983 by NJDEP; in 1985 by NUS; and in 1988 by NJDEP DWR. Analytical results for these sampling events are shown in Table 1-3 and are discussed below.

Monitoring wells MW-1 and MW-2 were sampled on several occasions by NJDEP and K&M. On August 6, 1981, the NJDEP Central Enforcement Bureau sampled the wells and analyzed the samples for pH, chloride, oil and grease, total petroleum hydrocarbons (TPHC), chemical oxygen demand (COD), and volatile organic compounds. None of the results for these analyses showed contamination except for an elevated COD level in MW-2.

On January 12, 1982 samples from both MW-1 and MW-2 were analyzed for COD, chloride, and pH. In addition, the sample from MW-2 was analyzed for semivolatile organic compounds and pesticides/PCBs. Results of these analyses indicate that there were no significant concentrations of organic contaminants detected in the sample from MW-2; (although chlorinated VOCs, including TCE at 7 ppb, were reported in the volatile organics of MW-2); however, the COD concentration in MW-2 (311 ppm) was higher than the level in MW-1 (13 ppm). To confirm previous results, MW-1 and MW-2 were sampled again for semivolatile organic compounds, pesticides/PCBs, metals and total organic carbon (TOC) on January 9, 1983. No significant concentrations of individual contaminants were detected in either sample. The TOC concentration in the sample from MW-2 (48 ppm) was higher than in the sample from MW-1 (20 ppm).

On September 5, 1985, NUS Corp. collected three groundwater samples, one from each of three existing monitoring wells on the site. The groundwater samples were analyzed for TCL volatile organics, semivolatile organics, pesticides/PCBs, and inorganics. No volatile organic compounds (other than those associated with field or laboratory blank contamination) or pesticides/PCBs were detected in the samples. Bis(2-ethylhexyl)phthalate was detected in MW-2 and MW-3 samples and di-n-octylphthalate was detected in samples from MW-2 and MW-3. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected in the aqueous blanks submitted with the three groundwater samples and bis(2-ethylhexyl)phthalate was also detected in the laboratory method blank analyzed with the samples. Therefore, the reported presence of these two phthalates in MW-2 and MW-3 may be an artifact of the sampling and analytical process, and not representative of environmental conditions at that time.

Several inorganics, including arsenic, cadmium and lead, were detected at higher concentrations in the sample from the presumed upgradient well (MW-1) than in the downgradient well (MW-2). It is, however, important to note that this presumed groundwater flow direction was subsequently shown to be erroneous due to the localized influence of the static head in the lagoon on the water level measurements recorded in these close monitoring wells.

On April 24, 1984 NJDEP collected a groundwater sample from a private well at the Kronan (sic, Cronin) residence. The sample was analyzed for volatile organics (VO Scan), base neutral extractables, and additional wet chemistry parameters shown in Table 1-3. Trichloroethene (27 ppb) and aromatic hydrocarbons (1 ppb) were detected in the VO scan. The total base neutral extractable concentration reported for the well sample is 5 ppb. The analysis did not identify specific base neutral compounds. The trichloroethene concentration in the sample exceeds both the current Federal and New Jersey drinking water maximum contaminant levels (MCLs) of 5 ppb and 1 ppb, respectively.

On January 19, 1988, NJDEP DWR collected groundwater samples from five residential wells located near the K&M site. These samples were analyzed for semivolatile organic compounds and volatile organic compounds (Table 1-3). No volatile organic compounds were detected in any of the five wells sampled. The semivolatile organic compounds di-n-butylphthalate and bis(2-ethylhexylphthalate) were detected in all samples at concentrations ranging from 2.7 to 23.4 ppb. Both of these phthalates were detected in the laboratory method blank analyzed with the groundwater samples. The reported presence of these compounds in the residential well samples may be an artifact of the sampling and analytical process, and not representative of groundwater contamination. One tentatively identified semivolatile compound (TIC) was detected in each of the residential well samples. Estimated TIC concentrations were 10 ppb or less. The TICs identified in the groundwater samples were also detected in the laboratory blank and, similar to the condition described above for phthalates, their reported presence in the samples may be an artifact of the sampling and analytical process.

1.3.3 Surface Water Investigations

Surface water samples were collected by NJDEP DWR in 1984 and 1987. The results of analyses of these samples are presented in Table 1-4 and are discussed below.

On April 24, 1984, NJDEP DWR sampled the surface water in the marsh adjacent to the lagoon. Butylbenzylphthalate, ethylhexylphthalate, and di-n-octylphthalate were detected at estimated concentrations of 334 ppb, 5,014 ppb, and 37,100 ppb, respectively. Inorganics detected included arsenic (14 ppb), cadmium (4 ppb), chromium (97 ppb), copper (86 ppb), lead (113 ppb), mercury (0.5 ppb), nickel (20 ppb), and zinc (361 ppb). The chromium and lead levels exceed the New Jersey Surface Water Criteria (NJAC7:9-4) of 50 ppb for both compounds. COD (471 ppm), TSS (805 ppm), MBAS (2.7 ppm), TPHC (15.85 ppm), and TDS (490 ppm) were also detected in the sample.

On December 15, 1987, two surface water samples were collected by NJDEP DWR personnel from Barker's Brook downstream of the drainage ditch. Analysis of these samples included COD, TSS, pH, chloride, MBAS, phenols, TPHC, and volatile organic compounds. A low level of toluene (2.4 ppb) was detected in the surface water sample collected near the bridge adjacent to the McGonigal residence. Other analytes detected in the samples include MBAS at 0.1 ppm to 0.4 ppm, COD at 5 ppm to 255 ppm, chloride at 20 ppm to 60 ppm, phenols at (0.05 ppm to 50 ppm), and TPHC at 1 ppm to 17.2 ppm.

1.3.4 Soils Investigations

On September 5, 1985 NUS Corp. collected six soil samples: four from the lagoon area; one near the wastewater collection pit; and one near the underground septic system. The soil samples were analyzed for TCL volatile organic compounds, semivolatile organic compounds, pesticides/PCBs, and inorganics as shown on Table 1-5. The four samples collected near the lagoon (NJQ3S1, NJQ3S3 - NJQ3S5) were found to contain one or more of the following volatile and semivolatile compounds: xylenes (6.5 ppb); 2-butanone (5.9 ppb - 14 ppb); benzene (1.3 ppb - 1.9 ppb); di-n-butyl phthalate (950 ppb to 1,400 ppb); diethylphthalate (85 ppb - 236 ppb); bis(2-ethylhexyl) phthalate (406 to 5,000 ppb); butylbenzylphthalate (240 ppb to 880 ppb); and di-n-octylphthalate (759 to 5,300 ppb). The only inorganic analyte detected exceeding NJDEP informal action levels was cadmium (3.6 ppm). The pesticides endosulfan sulfate (141 ppb) and 4,4'-DDT (42.6 ppb), were detected in the soil sample (NJQ3S1) collected east of the lagoon (marsh area) and may be attributable to use of pesticides for insect control in the marsh area.

In the soil sample collected near the washwater collection pit (NJQ3S6), the volatile organic compounds ethylbenzene, styrene, xylenes, 1,1,1 trichloroethane, and trichloroethene were detected at concentrations ranging from 9.9 ppb to 100 ppb; and the semivolatile organic compound 2-methylnaphthalene was detected at a concentration of 765 ppb. Butylbenzylphthalate (3,736,000 ppb), di-n-butylphthalate (16,992 ppb), and di-n-octylphthalate (1,104,500 ppb) was also reported in this sample, but these reported detection were associated with laboratory blank contamination. The soil sample collected near the septic tank (NJQ3S7) contained bis(2-ethylhexyl)phthalate (32,000 ppb), di-n-butyl phthalate (1,900 ppb), butylbenzylphthalate (460 ppb), di-n-octylphthalate (183 ppb), and various

PAHs at low concentrations (19 ppb to 150 ppb). No pesticides or PCBs were detected in the sample.

1.3.5 Air Investigations

The extent of air contamination on the site is unknown as there are no existing quantitative air sampling data for the K&M site. NUS Corp. reported on September 5, 1985 that no readings above background were detected when using the photoionization detector (PID) or flame ionization detector (FID) to monitor the air. The monitoring locations were not reported.

2.0 SITE INVESTIGATION

This section provides a description of remedial investigation activities conducted at the K&M Site. A more detailed description of the field procedures and activities can be found in the final Field Operations Plan (FOP) dated May 1991.

Prior to preparation of the Work Plan and Field Operations Plan, a site reconnaissance was conducted on June 14, 1989 to assess site conditions with respect to potential areas of environmental concern, worker health and safety, and mobilization logistics. The reconnaissance was conducted by TAMS and USEPA personnel and consisted of discussion with the site owner concerning current and historical site activities, and visual observation of the site and surrounding area. Results of the site reconnaissance are summarized in Section 1.2 of this report.

The site reconnaissance did not reveal any obvious health and safety problems or environmental concerns that were not previously identified in the existing background information. No major logistics problems were noted; however, as K&M was an active facility, mobilization was conducted so as to avoid unnecessary disturbance of facility operations.

Mobilization activities included the siting and placement of a combined office/equipment trailer and identification of health and safety zones. In mid-October 1991, prior to the initiation of subsurface investigation, a decontamination pad was constructed and a drum staging area was identified.

The RI field activities were sequenced so that results of initial activities could be used to direct and optimize subsequent field activities. Geophysical and soil gas screening surveys were performed to assist in identifying desirable surface and subsurface soil sampling locations, and to optimize the placement of monitoring wells. Subsequent field activities included subsurface borings and monitoring well installation, geological characterization, groundwater sampling, hydraulic conductivity testing, surface water and sediment sampling, and an ecological survey. Field investigation activities were conducted between September of 1991 and March of 1992.

2.1 Surface Features

A site land survey was performed to provide information on a number of physical site characteristics including the locations of property boundaries, a surveyed baseline for establishment of geophysical and soil gas survey sampling grids, sampling points, monitoring well and groundwater surface elevations, and other significant site and local features. The survey was performed by Diversified Technologies, Inc.

(DTC), a New Jersey licensed land surveyor. A topographic base map was prepared and the survey data were plotted on the map.

A site topographic base map having a horizontal scale of 1-inch equals 50 feet and a contour interval of 2 feet was prepared by PSI under contract to the U.S. Army Corps of Engineers (USACE) for USEPA using aerial photographic methods. Aerial photographs used for map development were taken on April 27, 1991, which was prior to dewatering of the lagoon by USEPA, as described in Section 1.2. The map includes a number of site features including Jobstown - Juliustown Road, Monmouth Road, the marsh, and Barker's Brook. Ground control survey points, referenced to the New Jersey State Plane Coordinate System and the National Geodetic Vertical Datum (NGVD, 1929), were established to aid in the development of the topographic map. Figure 1-2 provides the topographic contours along with site features and property boundary survey results.

Other surveying activities included the location of all sampling points, wetlands delineation lines, and ecological investigation points. The locations and elevations of existing and recently installed monitoring wells were also determined. Locations were referenced to the New Jersey State Plane Coordinate system and elevations were referenced to NGVD, 1929. The sampling locations and other investigation features were identified on the base map and are shown in Figure 2-1. Three permanent, mutually visible monuments, referenced to a local USGS benchmark, were installed on the site for future reference.

2.2 Cultural Resources Survey

A cultural resources survey is required prior to initiation of intrusive field investigations under CERCLA to take into account the effects of remedial activities on historic properties. As the first step in this process, a Stage 1A Cultural Resources Survey, consisting of a literature search and sensitivity study, was conducted to determine the presence or absence of architectural and archaeological resources in the potential impact area of the K&M Site. The survey encompassed the 25 acres of the K&M Site as described in Section 1.1. This survey was performed in compliance with Sec. 101 (b) (4) the National Environmental Policy Act 1969; Secs. 1 (3) and (2) (b) of the Executive Order 115593; Sec. 106 of the National Historic Preservation Act; 23 CFR 771 as amended October 30, 1980; and 36 CFR 66. The purpose of this survey was to provide information to minimize the impact to cultural resources during subsequent site related activities and to determine the necessity and scope of a Stage 1B field investigation during the remedial program to confirm the results of the Stage 1A survey.

The Stage 1A survey was performed by Richard Grubb and Associates. The site visit occurred August 30, 1992 and the final report was completed November 15, 1992. The activities performed to accomplished this survey include a site reconnaissance and a comprehensive literature, document, and map search. These efforts were designed to yield specific information to determine the differential sensitivity of the site for the presence of cultural resources. This information includes descriptions of the environmental setting as it pertains to actual or potential resources locations, prehistoric and historic cultural development and land use patterns, identification of sites within or near the study area that are eligible, listed or considered for inclusion in the National Register of Historic Places, identification of areas where significant land modification is evident, and maps and photos to support conclusions. The results of this survey are summarized in Section 3.2 and the detailed report of this survey is provided in Volume III - Appendix A.

2.3 Geophysical Survey

A geophysical survey was conducted to identify subsurface features at the site. The geophysical technique selected was electromagnetic (EM) conductivity. This technique can assist in identifying various subsurface features including hydrogeologic and geologic conditions, buried metal objects, potential conductive contaminant plumes, and buried pits and trenches by measuring the relative electromagnetic conductivity of these features. At the K&M Site, potential subsurface features to be identified and delineated by the EM survey included buried pits and metal objects; underground storage tanks; and a conductive contaminant plume, if present.

The EM survey was conducted on September 17 to 18, 1991 by Delta Geophysical Services (Delta) using a Geonics EM-31 Electromagnetic Terrain Conductivity Meter. This instrument is capable of an approximate exploration depth between 0 and 18 feet.

The EM survey was performed on a 20-foot grid over the K&M property. The grid lines were laid out by Delta and were referenced to a baseline established by the land surveyor, which is shown on Figure 2-1. Data were collected at 5-foot intervals along the survey lines and recorded on a digital data logger. The data were downloaded to a personal computer and contoured using surface contouring software. Results of the survey are summarized in Section 3.3 and are provided in Volume III - Appendix B.

2.4 Soil Gas Survey

A soil gas survey was conducted to assess the location, extent, and characteristics of contamination in the shallow subsurface (i.e., unsaturated zone) at the site. Increased soil gas concentrations of volatile organic compounds are commonly present in the pore spaces above buried wastes, above groundwater contaminant plumes, and within the unsaturated zone of soils contaminated with volatile organic compounds. Information obtained from the soil gas survey was used to refine the locations of borings and surface soil and sediment samples.

The soil gas survey was performed by Target Environmental Services, Inc. (Target) from September 11 to 18, 1991. A total of 116 soil gas samples were collected. Ninety samples were collected on the facility property and 26 were collected outside the facility property boundaries in the marsh, along the intermittent stream, and to the south of the property. The samples were collected from the nodes of a 50- by 75-foot grid placed over the entire K&M property, and from additional locations selected by TAMS and USEPA as areas of concern such as, the fuel pump island, underground storage tanks, marsh drainage, wash water pit. Figure 2-1 shows the surveyed baseline to which the sampling grid was referenced.

To collect the soil gas samples, a 1/2-inch hole, approximately four feet deep, was made using a drive rod or electric hammer drill. The sampling system was purged with filtered, ambient air and a stainless steel probe was inserted into the hole and sealed off from the atmosphere. The sampling system was purged with in-situ soil gas and a sample was collected in a pre-evacuated (15 psig), self-sealing glass vial. The samples were labeled, packaged, and shipped to Target's in-house laboratory for gas chromatograph (GC) analysis. Based on the results of GC analyses, 15 samples were selected by TAMS for confirmatory gas chromatograph/mass spectrograph (GC/MS) analysis by Maryland Spectral Services, Inc., a subcontractor to Target. The soil gas survey results are discussed in Section 4.3.1, and further details of the field and analytical procedures used are provided in Volume III - Appendix C.

2.5 Lagoon Sediment Investigation

The lagoon sediment investigation was conducted to characterize the chemical nature of the lagoon sediments, to estimate the lagoon sediment volume, and to evaluate whether contaminants in nearby surface waters and sediments are attributable to chemical releases from the lagoon (e.g., by breaching, overfilling, leaking).

Sediment samples were collected from six locations on the surface of the dewatered lagoon bed, including one sample at the location of boring B-2, as shown in Figure 2-1. Due to a misunderstanding by the sampling crew, the sample at location B-2 was analyzed for a more limited parameter set than the other samples. Two subsurface samples were also collected from boring location B-2. These samples are described in Section 2.8. Sediment samples were collected from 0 to 6 inches in depth at locations accessible from the lagoon berm using stainless steel sampling equipment consisting of bucket augers, spoons, and bowls. Sampling equipment was decontaminated using the eight-step procedure described in the FOP. For each sample, the aliquot for volatile organic compound analysis was removed from the auger first and placed directly into the sample containers. The remainder of the sample was homogenized in a stainless steel bowl prior to placement in the sample containers.

Lagoon sediment samples were analyzed for the parameters listed in Table 2-1. Quality control (QC) samples collected included one field duplicate (SD19, duplicate of SD18), one rinsate (field) blank, and one sample for matrix spike/matrix spike duplicate (MS/MSD) analysis (SD17).

For purposes of estimating the lagoon sediment volume, sediment depth measurements were taken at eleven locations using a graduated rod. The rod was inserted into the soft sediment by hand until the rod resisted further advancement. The rod was withdrawn and the height of the soft, black sediment was recorded. Measurements were taken as far toward the center of the lagoon as was possible using extension rods and hand pressure to insert the rod. The sediment depth measurements, together with the sediment bathymetric map previously prepared for K&M (Environics, 1986), were used to estimate the lagoon sediment volume.

2.6 Surface Water and Sediment Investigations

The surface water and sediment investigations were conducted to determine whether wastes have contaminated sediments or surface waters. Based on site history, a number of contaminant transport mechanisms including direct deposition, lagoon and collection pit overflow, surface runoff, and groundwater discharge, were considered in selecting surface water and sediment sampling locations.

It is important to note that samples collected from the marsh area, the drainage ditch, and the intermittent stream were designated as "sediment samples" in the FOP due to their shared characteristic of having been deposited or affected by a water system. These samples have all been affected by surface water runoff potentially contaminated by site operations. However, none of these locations is continuously submerged nor do they support developed aquatic ecosystems. In contrast, sediments from Barker's Brook were deposited along this watercourse both from upstream sources and from surface water runoff potentially contaminated by site operations, including overflow of the lagoon. Unlike the other sediment locations, Barker's Brook is a permanent freshwater stream capable of supporting an aquatic ecosystem. Therefore, in order to draw distinctions between the Barker's Brook sediment samples and sediment samples collected from the marsh, ditch and intermittent stream, these latter samples will be referred to as soil samples and will be discussed as part of the surface soil investigation presented in Section 2.8.

Seven surface water samples, consisting of six environmental samples and one duplicate, and three sediment samples were collected. Trip blanks and samples for MS/MSD analysis were submitted at the frequency specified in the FOP to the laboratory with the environmental samples. All surface water and sediment samples were grab samples.

Originally, at locations where both surface water and sediment samples were to be collected, it was intended that both of these matrices would be collected during the same sampling event, with the surface water sample at each location being collected first followed by the sediment sample. However, since the surface water samples required testing for a greater number of parameters not included in routine analytical services (RAS) under the (CLP), laboratory assignments for surface water and sediment sampling were not received during the same time period. Therefore, the sediment samples were collected on November 4 and 5, 1991, followed by the surface water samples on December 17 and 18, 1991.

2.6.1 Surface Water Sampling

Seven surface water samples, including one duplicate, were collected from the six sampling locations identified in Figure 2-1. Three samples were collected in the drainage ditch along the western site boundary, one sample was collected from the intermittent stream that runs from the marsh to Barker's Brook, and three samples were collected from Barker's Brook. Actual sample locations were determined based on historical information and on visual inspection of the site areas and potential contaminant migration paths.

Samples were collected in relatively slow-moving areas of the stream where contaminants might accumulate in bottom sediments. Samples collected in Barker's Brook were of running water and samples collected in the drainage ditch and intermittent stream were of stagnant water that had accumulated at low points. Sample collection proceeded in order from farthest downstream location to farthest upstream location. Samples were collected in a manner which, insofar as possible, minimized sediment disturbance. However, due to the very shallow (i.e., 1 to 3 inches), stagnant conditions in the intermittent stream and drainage ditch, some sediment disturbance was unavoidable.

At each location, field measurements for pH, conductivity, dissolved oxygen, Eh, and temperature were taken and recorded. Samples collected from Barker's Brook and the intermittent stream that drains the marsh were collected directly into sample bottles. Samples collected in the drainage ditch adjacent to the western property boundary were collected by using a wide-mouth sample bottle to collect the sample which was then transferred to the sample jars. In all cases, aliquots for volatile organic analysis were collected first.

Surface water samples were analyzed for the parameters listed in Table 2-2. "SW" is the prefix for surface water sample designations in this report. Surface water QC samples included one duplicate sample

(SW07), one MS/MSD sample (SW04), and two trip blanks. Since no field-cleaned sampling equipment was used, no field rinse blanks were required, as specified in the FOP.

2.6.2 Sediment Sampling

Sediment samples were collected at the three Barker's Brook locations selected for surface water sampling (described in the previous section). Sample locations are shown in Figure 2-1. "SD" is the designated prefix for sediment samples.

Sediment samples were collected using field decontaminated stainless steel bucket augers, spoons, and bowls. Aliquots for volatile organics analysis (VOA) were collected first as discrete grab samples and placed directly into 40-ml VOA vials. The remainder of each sample was placed in a stainless steel bowl and homogenized prior to placement in the remaining sample containers. All sampling equipment was decontaminated using the eight-step procedure described in the FOP.

Flowing water was present above the samples collected from Barker's Brook. To the extent possible, these samples were collected from depositional areas of low stream flow velocity. Care was taken to avoid sediment loss due to flowing water when retrieving samples.

All sediment samples were analyzed for TCL volatile and semivolatile organics, TOC, TPHC and TAL inorganics listed in Table 2-1. Some of the sediment samples were analyzed for additional parameters as shown in Table 2-1. QC samples collected included one MS/MSD (SD02), and one aqueous rinsate (field) blank.

2.7 Geological Investigations

A geological investigation was performed utilizing test borings and monitoring well installations. The locations of the borings and wells were based on site history investigations, geophysical surveys and soil gas surveys. The test boring and well boring locations are presented in Figure 2-1. A summary of the rationale for borings and well locations is provided in Table 2-3.

A total of nine test borings were drilled on site from October 16, 1991 to November 5, 1991. The test borings were drilled to a depth of approximately 12 feet utilizing hollow-stem augers. Geotechnical samples were obtained from each test boring using split-spoon or Shelby tube samplers. Soil samples for chemical analyses were also obtained from selected split-spoon samples. Subsurface soil samples were obtained in accordance with the approved Field Operations Plan (FOP).

In addition to the test borings, nine groundwater monitoring wells were installed at the site, consisting of six shallow monitoring wells and three deep monitoring wells. These new monitoring wells augment the three previously existing monitoring wells at the site (MW-1, MW-2 and MW-3). The purpose of installing the new monitoring wells was to obtain geologic and hydrogeologic data and to collect groundwater samples. Monitoring well construction logs and diagrams and soil boring logs are provided in Volume III - Appendix D.

The shallow monitoring wells were drilled with 12-inch outside diameter hollow-stem augers. The deep monitoring wells were drilled with 12-inch outside diameter hollow-stem augers through the Navesink Formation and completed by mud-rotary drilling with a 5-7/8-inch diameter tricone bit within the Wenonah-Mt. Laurel Formation. The borings penetrating the Navesink Formation were double cased to inhibit potential downward migration of contaminants or cross-contamination between formations. The previously existing wells, installed in 1980, were constructed of four-inch PVC and were screened to intercept the water table.

The new monitoring wells were installed from October 22 to November 5, 1991. The shallow monitoring wells (designated with an "S" suffix) were constructed to intercept the shallow groundwater table in the Navesink Formation. The deep monitoring wells (designated with a "D" suffix) were constructed with screened intervals within the upper portion of the underlying Wenonah-Mt. Laurel Aquifer.

Split-spoon samples were obtained continuously through the Navesink Formation and at five-foot intervals upon encountering the Wenonah-Mt. Laurel Formation. The purpose of the split-spoon samples was to obtain samples for chemical and geotechnical analysis at selected depths. Chemical and geotechnical analysis results are provided in Tables 4-3, and 4-7 through 4-14 and Volume III - Appendix E, respectively.) After obtaining chemical and geotechnical samples, the residual portion of the split-spoon sample was placed in glass jars and marked with the drilling location, depth interval and date obtained.

2.8 Soils Investigation

Surface and subsurface soil sampling was conducted to assist in determining the presence, nature, and extent of soil contamination at the site. Surface soil samples were collected at a depth of approximately 6 inches using manual sampling equipment. Subsurface soil samples were collected during drilling operations for test borings and monitoring well borings.

2.8.1 Surface Soil Sampling

Surface soil sampling was conducted on October 17 through 21, 1991, November 4 and 5, 1991, and March 12 and 13, 1992 to determine the nature and extent of shallow soil contamination in areas surrounding known or potential waste sources at the site. Sampling was conducted in the vicinity of the lagoon, the former collection pit, the excavation spoils pile, the abandoned drums, the septic drainage field, the intermittent stream and drainage ditch beds, the marsh area and in the unpaved operations lot. Marsh area samples were collected in the stained areas near the location of the lagoon overflow, near drainage paths leading from the marsh area, and along the perimeter of the marsh. Sample SS01, collected in the northwest corner of the study area, was intended as a background sample to provide a basis for the evaluation of the remaining surface soil samples.

A total of 30 surface soil samples, including two field duplicates and one background sample, were collected for chemical analysis. All surface soil samples were analyzed for TCL volatile and semivolatile organics, TOC, TPHC, and TAL inorganics. Some samples were analyzed for additional parameters as shown in Tables 2-1 and 2-4. Surface soil sampling locations are provided on Figure 2-1. "SS" is the prefix designated for surface soil samples with the exception of samples collected from the intermittent stream and drainage ditch beds and from the marsh area adjacent to the lagoon and along the drainage paths leading from the marsh area. As discussed in Section 2.6, these samples were designated as sediment samples in the FOP and, as a result, have a designated prefix of "SD".

Surface soil samples were collected in accordance with the sampling procedures outlined in the FOP. Samples were collected at a depth of 0 to 6 inches using field-decontaminated, stainless steel sampling equipment including bucket augers, spatulas, and spoons. Decontamination was performed according to the eight-step process described in the FOP. Aliquots for volatile organics analysis were collected first as discrete grab samples and placed directly in the sample containers. The remainder of the sample was homogenized in a stainless steel bowl prior to placement in the appropriate sample containers. Exact sample locations were determined in the field using visual observation and the results of the soil gas survey, when appropriate.

At the time of sampling there was little or no water present above the bed soils in the drainage ditch or intermittent stream. At these sample locations, visual observation was used to locate depositional areas (i.e., lower areas along the stream) where fine-grained sediments might collect. Visual observation of contamination (e.g., staining, absence of vegetation) and potential drainage paths were used to identify those marsh soil sample locations adjacent to the lagoon and along drainage paths leading from the marsh area.

All samples were grab samples, except for those collected from the unpaved operations lot, which were composite samples. The composite sampling areas were defined by dividing the operations lot into three 150-foot (N-S) by 100-foot (E-W) sections, and then subdividing the sections into four 75-foot (N-S) by 50-foot (E-W) grid rectangles. The dimensions of the grid rectangles were the same as those used during the soil gas survey. Each of the three composite areas, then, consisted of four grid rectangles surrounding a relative point of origin. Because of physical constraints (e.g., tanker trailers, lagoon fence) the point of origin for composite Area 3 was different than specified in the FOP. The actual points of origin were as follows:

Area	East North
Composite Area 1:	1100, 5300
Composite Area 2:	1200, 5300
Composite Area 3:	1125, 5150

One sample was collected from each of the four grid rectangles. The location of each sample was determined by considering the results of PID readings, the soil gas survey, and visual observations. One of the four subsamples from each composite area was selected for volatile organics analysis and placed directly into the appropriate container. The location of this sample was selected based on the following hierarchy of characteristics:

- The sample with the highest PID reading was selected;
- If there were no PID readings, the sample was selected based on visual evidence of contamination; and
- If there was no visual evidence of contamination, the sample was selected at random.

After collection of the aliquot for volatile organic analysis, the four subsamples that comprise a composite sample were collected, homogenized in a stainless steel bowl, and placed in the appropriate containers. Figure 2-1 shows the locations of the composite samples. A suffix letter, A through D (e.g., SS06A, SS06B, etc.), was assigned to each of the four subsamples that comprise a composite sample to maintain a unique identifier for each sample location.

The surface soil samples were analyzed for the parameters shown in Table 2-4. QC samples included one duplicate sample (SS20, duplicate of SS04), one MS/MSD (SS05), and two aqueous rinsate (field) blanks, which were collected and shipped to the laboratories with the environmental samples.

2.8.2 Subsurface Soil Sampling

A total of 17 subsurface soil samples, including one field duplicate, were collected for chemical analysis from various locations at the K&M Site between October 16 and November 6, 1991. Subsurface soil samples were analyzed for TCL volatile and semivolatile organics, TOC, TPHC, and TAL inorganics. Tables 2-3 and 2-5 provide a detailed summary of sample locations, sample identifiers, and sample depths for the subsurface soil sampling activities. Table 2-5 provides a summary of the analytical parameters for the subsurface soil samples.

Six subsurface soil samples (SB01, 03, 06, 07, 08, and 09) were collected from borings in the area of USTs on site. Subsurface soil sample SB04 was collected near the septic system area. Sample SB18 was collected from the area of the former wash water collection pit. Two samples, instead of the one originally planned, were taken at lagoon sediment boring B-2 and were designated as SB02 (10 to 12 feet below ground surface) and SB02A (2 to 4 feet below ground surface). One sample (SB16) was taken of the marsh soil at a depth of 0 to 2 feet below ground surface. Sample SB05, collected near the drainage sump adjacent to the K&M garage, was collected at a depth of 10 to 12 feet below ground surface.

The remaining five subsurface soil samples were taken from monitoring well borings. SB10 was taken from MW101S; SB12 from MW102S, SB15 from MW103D (replacing the planned SB14 from MW103S); and SB17 from MW105S. SB19 is a field duplicate of SB15. The sample from SB10 (MW101S) was originally intended as a background (upgradient) subsurface soil sample; however, a review of water elevation data obtained after monitoring well installation indicated that SB10 is not upgradient of the site.

Samples SB11, 13, and 14 were submitted for geotechnical analysis only; no chemical analyses were performed on these samples. QC samples submitted with the subsurface soil samples include one field duplicate, one sample for MS/MSD analysis (SB18), and five field rinsate blanks.

2.9 Hydrogeologic Investigations

Nine groundwater monitoring wells were installed on the site according to the procedures set forth in the FOP. The procedures are summarized as follows:

- Two-inch inside diameter, flush joint, stainless-steel riser and screen (0.010-inch slotted screen) were used for all monitoring wells. The monitoring wells were constructed with ten feet of screen with the exception of monitoring wells MW103S (seven-foot screen), MW104S (eight-foot screen) and MW106S (seven-foot screen). These monitoring wells were installed with screens less than ten feet to avoid penetrating clay lenses or, in the case of MW104S, to avoid penetrating and screening in the Wenonah-Mt. Laurel Formation.

- A clean, silica gravel pack appropriate for the geologic conditions (Morie size #1) was used in all monitoring wells with the exception of

MW102S (for which Morie size #0 was utilized). The sand was placed in the annulus between the borehole wall and the well screen. Generally, the gravel pack was placed to two feet above the top of the well screen. However, shallow water table conditions required the completion of the gravel pack less than two feet above the top of the well screen at monitoring wells MW104S (6 inches), MW103S (1 foot) and MW106S (1 foot).

- Approximately one to two feet of bentonite-pellet seal was placed above the gravel pack. Shallow water-table conditions required reduction of the thickness of the bentonite seal at MW104S to 10 inches.
- A cement/bentonite grout mixture was used to fill the remaining annulus to the ground surface.
- A five-foot, locking, steel protective casing extending approximately two feet above grade, or a flush-to-grade casing and frame was installed and concreted into place.

Monitoring well construction diagrams are included, along with the monitoring well and test boring logs, in Volume III - Appendix D.

After installation, monitoring wells were developed using centrifugal or peristaltic pumps or, in the case of low-recovery monitoring wells, a stainless-steel bailer. During well development, pH, specific conductance, salinity, temperature and turbidity were monitored a minimum of three times following the purging of a minimum of one well volume. A monitoring well development summary is provided in Table 2-6. Well development was concluded when pH, specific conductivity, salinity and temperature had stabilized (two successive sets of readings varied less than ten percent) and, either the well purge water had acquired a turbidity of less than 50 nephelometric turbidity units (NTUs), or had stabilized to a point that no further reduction in turbidity was observed. Three sets of water level measurements were obtained at each well location with an electronic water level indicator on November 13, 1991, February 28, 1992 and March 18, 1992.

2.9.1 Groundwater Sampling Procedures

The twelve groundwater monitoring wells were sampled from December 17 through December 20, 1991. The groundwater samples were obtained in accordance with guidelines set forth in the FOP. Groundwater samples were collected with dedicated, laboratory-cleaned, bottom-loading, teflon bailers attached to dedicated, teflon-coated, stainless-steel cable.

A minimum of three well volumes were purged from each well prior to sampling. Measurements of pH, specific conductance, salinity and temperature were collected after each volume was purged to determine stabilization of the well water. The well water was considered to have stabilized when two successive sets of indicator readings varied less than 10 percent. The groundwater samples were then obtained and transferred to the appropriate sample bottles. Groundwater samples for dissolved metals were field-filtered with a peristaltic pump equipped with dedicated tubing and a 0.45 micron dedicated filter. The groundwater samples collected were shipped on the day of collection via overnight courier to the analytical laboratory. Analytical parameters are listed in Table 2-7.

2.9.2 Hydraulic Testing Procedure

Upon completion of monitoring well sampling, hydraulic testing was performed on six monitoring wells: MW101S, MW101D, MW102S, MW102D, MW105S and MW3. A rising-head (slug removal) test was performed at each monitoring well. The slug consisted of a clean, stainless-steel cylinder with a length of approximately four feet with a diameter of 1.2 inches for the two-inch monitoring wells, and three inches for the four-inch well. Head versus time data were obtained utilizing a Druck pressure transducer (Model No. TBCR 830-0576 with sensor 477187) with a one-second data-interval capability and recorded with a Telog 2100 computer program. The testing procedure is outlined as follows:

- Measured depth to water to determine static water level.
- Installed pressure transducer approximately seven feet below the static water level and submerged slug just below the water table.
- Re-measured depth to water to determine if the water level had returned to static condition, if not, waited for water level to return to static condition.
- Removed slug from water and recorded changes in head vs. time until a minimum of 90 percent recovery was observed.

The slug test data were evaluated using the Bouwer-Rice (1976) method. Slug testing was performed December 17 through December 20, 1991.

The results of the hydraulic testing are presented and discussed in Section 3.7.3. Hydraulic testing calculations and data are presented in Volume III - Appendix F.

2.10 Human Population/Land Use Survey

The purpose of this survey was to identify possible land use and human population activities that may be affected by conditions at the K&M Site.

Potential contaminant transport pathways were also investigated. The survey consisted of the following components:

- Contacted State and local agencies for information and performed records searches where necessary.
- Conducted a local land use survey in areas where there were indications of off-site contamination.
- Used field observations of adjacent properties to evaluate land use practices and evidence of recreational activities.

2.11 Ecological Investigation

The purpose of the ecological investigation was to provide baseline information on the biological resources of the K&M Site. The study was designed to document existing floral and faunal species with particular emphasis placed on the possible existence of threatened, rare or endangered species and to identify and classify the wetlands on-site. The field investigation was conducted during the period of August 26-30, and October 21 and 29, 1991, and entailed the following components:

-- strip census of birds, mammals and herpetofauna
-- vegetation survey
-- wetland delineation
-- qualitative macroinvertebrate sampling

It was determined that four distinct communities exist within the K&M Site: marsh; stream; open field; and floodplain. Within each of the three land communities, transect lines were established and a strip census of birds, mammals and herpetofauna was conducted. These strip censuses were done twice per day, once at dawn and once at dusk, when animals are most active. Additionally, mammals and herpetofauna were also sought out in areas most likely to be found. Transects were also utilized for conducting the vegetation study, in which dominant species existing in the study area were identified. Particular attention was paid to seek out rare and endangered vegetative species in likely habitats.

The wetland delineation was conducted in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands ("the Manual", USACE, et. al., 1989). In accordance with the methodology presented in the Manual, the three parameter approach was used to determined the upland/wetland boundary. The three parameter approach is the examination of three separate ecological factors: soil; hydrology; and vegetation. Determinations were recorded on data forms describing each of the three parameters at a surveyed observation point.

Qualitative macroinvertebrate samples were collected from Barker's Brook upstream, adjacent to and downstream of the K&M facility.

Samples were collected using a long-handled dip net, and by turning over rocks to hand-pick organisms. The organisms and material that were collected from a sampling location were placed in a labeled jar. The organisms were then identified in order to determine whether pollution tolerant or sensitive species were existing in each area of the stream.

The results of the ecological investigation are presented in Section 3.9. A more detailed description of field procedures and results of the investigation is included as Volume III - Appendix G of this report.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section provides a summary of the physical characteristics of the site and surrounding area. Information presented in this section is based on data collected during the field investigation, previous studies, and on published literature. Figure 1-2 provides a topographic map of the K&M property and surrounding area, while Figure 2-1 shows the sampling locations.

3.1 Surface Features

The K&M Site is located in Springfield Township in northeastern Burlington County, New Jersey approximately 6 miles south-southeast of the Delaware River. Burlington County lies in the Atlantic Coastal Plain Physiographic province, which extends from Massachusetts to Florida. The Atlantic Coastal Plain has been divided into two subprovinces, the Inner and Outer Coastal Plains, based on the character and stratigraphy of the Coastal Plain deposits. Springfield Township lies nearly completely within the Inner Atlantic Coastal Plain subprovince.

Monmouth Road divides the Township into two topographically different areas. Northwest of Monmouth Road is a broad plain with slopes less than one percent and elevations less than 100 feet. Southeast of Monmouth Road the topography is characterized by gently rolling land rising to a maximum elevation of 240 feet at Arney's Mount and approaching 200 feet near Juliustown and Saylor's Pond Road (Rush, 1968).

The land surface in the general area of the site slopes gently toward the west from more elevated areas northeast, east, and southeast of the site. Barker's Brook, a major stream in Springfield Township, originates in the elevated areas east of the site and flows west through much of Springfield Township. Topography in the immediate vicinity of the site slopes generally south toward Barker's Brook and the drainage ditch that runs along Jobstown-Juliustown Road.

Two wetland areas were identified and mapped as part of the ecological investigation. One wetland (marsh area) is located northeast of the K&M property and extends from the lagoon northeast toward Saylor's Pond Road. The width of this wetland (northwest-southeast direction) ranges from about 250 to 300 feet, which is approximately the same as the length of the lagoon. This wetland occupies approximately 2.3 acres and is at a lower elevation than the surrounding topography. Surface elevations in this wetland range from 71.4 feet NGVD to 72.5 feet NGVD.

Drainage from the marsh area wetland is via an intermittent stream that flows southeast towards Barker's Brook. The channel of this intermittent stream fans out near its junction with Barker's Brook. A second wetland, approximately 2.5 acres in size, is located southeast of the K&M property and adjacent to Barker's Brook as shown in Figure 2-1. It is connected to the marsh area wetland via the intermittent stream and extends from the drainage ditch along Jobstown-Juliustown Road in the southwest to the intermittent stream in the northeast. Refer to Section 3.9 for further information concerning these wetlands and the K&M wetland delineation.

Access to the K&M facility is provided via an entrance road extending along a narrow corridor of the property abutting Monmouth Road. The entrance to the property is secured by a chain-link gate, which is locked when the facility is not in operation. With the exception of a small area near the western corner of the property, the entire property including the lagoon is surrounded by a chain-link fence. Five residential properties abut the northeast K&M property boundary. The distance from the lagoon to the nearest of these residences is 210 feet. Immediately southeast of the K&M property is the Trolley Valhallah property. This area contains at least ten abandoned vehicles including buses, trucks, cars, and trolleys, and assorted wood and metal debris.

Major surface features on the K&M property include a garage/office building, the lagoon, the unpaved operations lot, and a soil and rubble pile. The garage/office building covers approximately 10,000 square feet of the 5.56-acre property. The lagoon is approximately 0.7 acres (32,000 square feet) in area and is surrounded by a berm. The elevation of the lagoon berm ranges from 74.5 feet NGVD to 78.5 feet NGVD. The berm elevation is lowest on the northeast side of the lagoon, adjacent to the marsh, and highest near the southern corner of the lagoon. Based on the topography, any overflow from the lagoon would be expected to occur near the northeast side, adjacent to the marsh. Drainage from the northeast side of the lagoon is toward the marsh (wetland) northeast of the lagoon. Drainage from the southwest side of the lagoon is generally toward the south and the drainage ditch.

The unpaved operations lot, which comprises a large portion of the K&M property, is essentially flat. The surface of this area is composed of firmly-packed gravel and silty soil, and is relatively impermeable as evidenced by water that remains ponded on the lot surface for long periods after precipitation events. Drainage from the operations lot is to the south and southeast toward the drainage ditch along Jobstown-Juliustown Road.

A soil and rubble pile is located in the southern corner of the K&M property. This pile is elevated approximately 9 feet with respect to the surrounding topography and it covers an area of approximately 1,800 square feet.

3.2 Cultural Resources Survey Results

A Stage 1A Cultural Resources Survey was performed at the K&M site prior to intrusive field work. A detailed report of this survey is provided in Volume III - Appendix A. A moderate to high potential exists for the presence of prehistoric and archaeological sites. The K&M property is covered by a layer of sand and gravel. Direct examination of sample excavations would be required to determine if intact archaeological deposits are present. Deposits in areas disturbed by modern features such as the lagoon, the drainage ditch, buildings and underground facilities are unlikely to be found.

Significant historical period archaeological and architectural resources are likely to have been created along Monmouth Road (County Route 537). A series of 19th century structures are documented along this road with the surrounding land apparently undisturbed. The only historic period activity documented in this area is farming. However, significant cultural resources, both historic and prehistoric, may be present, although there is a lack of documentation.

Due to the potential for prehistoric and historic deposits, performance of a Stage 1B Field Investigation was recommended prior to ground-disturbing activities. At the direction of USEPA Region II, this second survey may be undertaken prior to remedial construction activities.

3.3 Geophysical Survey Results

The performance of the electromagnetic conductivity (EM) geophysical survey by Delta Geophysical Services revealed the presence of three anomalous areas believed to be associated with buried metal objects in the vicinity of the garage. A conductivity anomaly map is presented as Figure 3-1. This figure is based on site sketches provided to Delta prior to preparation of the topographic base map.

The anomaly farthest to the east (5320 N to 5380 N, 1170 E to 1210 E) is likely associated with the two underground storage tanks (USTs) in this area. There are also underground pipes in this area that are used to transfer fuel oil from an above ground tank to the garage. A second anomaly (5335 N to 5390 N, 1080 E to 1150 E) was detected adjacent to the garage. There are no known tanks in this area but there are underground pipes running from the refueling island tanks to the garage. The third anomaly (5305 N to 5365 N, 1040 E to 1080 E) is probably attributable to the six USTs in this area. There is also underground piping from these USTs to the refueling island in this area.

Other anomalies detected during the survey may be attributed to surface cultural interferences such as fences and tanker truck trailers. Because of these interferences it was not possible to determine whether a conductive contaminant plume was present. The complete documentation of the EM survey prepared by Delta is provided in Volume III - Appendix B.

3.4 Lagoon Sediment Volume Estimate

An estimate of the lagoon sediment volume was made using eleven lagoon sediment thickness measurements made by TAMS personnel in March 1992, and an additional eleven lagoon sediment thickness measurements made by Environics, Inc. in August 1986 (Environics, 1987). On both occasions, sediment thickness was measured by hand-driving a graduated rod into the sediment, withdrawing the rod, and measuring the depth of the soft black sediment. Sediment thickness measurements made by TAMS were restricted to the perimeter of the lagoon. Environics' measurements were fairly evenly distributed over the lagoon. Figure 3-2 shows the locations of the measurements and the associated sediment thickness values. Sediment thickness measurements range from 0.3 foot to 1.9 feet.

It is evident from Figure 3-2 that the sediment thickness is not uniform over the area of the lagoon. Sediment thickness values are lowest at the north end of the lagoon; intermediate at the center and western perimeter; and highest at the east, south, and southwest perimeter of the lagoon. These conditions are consistent with field observations that suggest that wastes were discharged near the northern end of the lagoon. Higher fluid velocities near the discharge would limit settling near the northern end of the lagoon. Decreasing fluid velocities near the center and perimeter of the lagoon would result in increased settling and, therefore, thicker sediment deposits. Based on the distribution of the sediment thickness values and considering the probable settling regime in the lagoon, the area of the lagoon was divided into three zones as shown in Figure 3-2.

A weighted average sediment volume was determined for the lagoon by calculating the average depth for each zone and multiplying it by the area of the zone to obtain a sediment volume. The volumes calculated for each zone were added to obtain an estimate of the total lagoon sediment volume. The estimated sediment volume for the lagoon is approximately 900 cubic yards. As this sediment volume estimate is based on limited data, a range of sediment values was calculated using the extreme sediment thickness values in each zone (i.e., the highest and lowest values in each zone). Using this approach, the lagoon sediment volume is estimated to be within the range of 600 to 1,200 cubic yards. It should be noted that the sediment volume estimate applies only to the soft sediments that have settled in the lagoon and does not consider any underlying materials that may have been contaminated by the overlying sediments or liquids. Discussion of the subsurface contaminant levels and the consequence of these levels is found in Section 4.2.3 and Chapter 5.

3.5 Surface Water Hydrology

The K&M Site is drained by Barker's Brook, which is the major drainage basin in Springfield Township. Barker's Brook originates approximately 2.5 stream miles east of the site near Saylor's Pond Road (a topographic high in the site area) and flows in a generally westward direction through much of Springfield Township and discharges to Assiscunk Creek, a tributary of the Delaware River. The Barker's Brook drainage basin is approximately 23 square miles (mi^2) approximately 4 mi^2 of which is upstream of the site. The total stream length is approximately 9.5 miles and basin slopes range from 16.5 feet per mile (ft/mi) near the headwaters to 8.0 ft/mi near the discharge point. Owing to its shallow gradient and to streambed obstructions (e.g., fallen trees, snags), Barker's Brook is subject to frequent flooding.

In Springfield Township, stormwater runoff is generally managed using a system of ditches, creeks, and streams to collect and convey runoff. Stormwater runoff from the site is conveyed off-site to Barker's Brook via an intermittent stream and a drainage ditch. The drainage ditch which borders the western property boundary, intercepts runoff from the operation lot and flows southeast along Jobstown-Juliustown Road toward Barker's Brook. From its point of origin on the K&M property to its discharge point at Barker's Brook, the average slope of the drainage ditch is 8.1 feet/1000 feet. The garage/office building roof drains also discharge to this ditch.

The intermittent stream drains the wetland area east of the lagoon and flows southeast towards Barker's Brook. Near its point of discharge to Barker's Brook, this intermittent stream channel broadens out into the surrounding wetland. The average slope of the intermittent stream, from its origin in the marsh area to its point of discharge to Barker's Brook, is approximately 8.5 feet/1000 feet. Expected drainage for the K&M property, based on topography, is generally to the south toward Barker's Brook.

Drainage in the wetland area northeast of the lagoon (marsh) is affected by the low elevation of this area. As the wetland elevation is lower than the surrounding area, drainage is expected to be from all directions toward the center of the wetland. Overflow from the wetland flows in a southeast direction toward Barker's Brook via the intermittent stream and, at times of heavy precipitation, via drainage routes farther east, indicated by the topography of the area shown in Figure 1-2. Drainage from the northeast side of the lagoon is expected to be northeast toward the center of the wetland (marsh). Drainage from the southwest side of the lagoon is expected to be toward the south and the drainage ditch.

A water level gauge was installed in the standing water at the head of the intermittent stream to monitor the water level in the marsh as shown on Figure 2-1. The top of the gauge was surveyed and referenced to the

NGVD. Once the gauge was surveyed, water level readings taken from it could be related directly to the NGVD. Water level readings were taken on three occasions: November 7 and 11, 1991, and December 10, 1991. Water elevations in the marsh were as follows: 70.76 feet NGVD (November 7, 1991), 70.83 feet NGVD (November 11, 1991), and 71.26 feet NGVD (December 10, 1991). Water was flowing from the marsh towards Barker's Brook at the time of the December 10, 1991 reading, but not at the time of the November readings.

3.6 Geology and Soils

Geologic information was obtained from published sources and from on-site field activities including test borings and monitoring well borings.

3.6.1 Regional Geology

Rush (1968) reports that Burlington County is underlain by unconsolidated beds of clay, sand and gravel. These beds dip gently to the southeast (generally at 10 to 100 feet per mile) and strike generally northeast-southwest.

In the Jobstown area, the bedrock consists of a Precambrian igneous basement rock which occurs at a depth of approximately 650 feet below grade. The bedrock is overlain by the Magothy and Raritan Formations. The Raritan Formation is described as a light gray to white, cross-stratified, medium-to-coarse grained quartz sand interbedded with white variegated clays. The Magothy Formation is similar to the Raritan Formation, but generally contains more sand than clay. The upper surface of the Raritan and Magothy Formations is estimated to occur at 160 to 185 feet below grade in the site vicinity.

Overlying the Magothy and Raritan Formations is the Englishtown Formation with the upper surface occurring at an approximate depth of 110 feet below grade. The Englishtown Formation is described as characteristically a light gray to white, micaceous, lignitic, fine-grained quartz sand. Overlying the Englishtown Formation is the Marshalltown Formation, which is approximately 10 feet thick in the site vicinity and is described as characteristically a dark gray to black, micaceous, glauconitic, quartz sandy clay to very clayey sand.

Overlying the Marshalltown Formation is the Wenonah-Mt. Laurel Formation which is approximately 60 feet thick in the site vicinity and is described as characteristically a dark gray silt to medium quartz sand with small amounts of glauconite, mica and lignite. In general, the grain size and glauconite content increase upward in the unit. Overlying the Wenonah-Mt. Laurel Formation is the Navesink Formation which is reported to be approximately 25 feet thick in the site vicinity and is characteristically a clayey glauconitic sand to glauconitic, micaceous, sandy clay. The Navesink Formation is the uppermost unit in the

Jobstown area. With the exception of the Navesink Formation, which is reported to be generally of uniform thickness throughout Burlington County, the units underlying the site are reported to thicken in the down-dip direction.

3.6.2 Site-Specific Geology

Site-specific geologic information was obtained from on-site drilling activities. Two geologic formations were encountered during the drilling activities, which correlate with the Navesink and Wenonah-Mt. Laurel geologic formations. In addition to the naturally occurring geologic units, a thin layer of imported fill material was encountered within the K&M property limits. The fill material is generally one to four feet thick, and consists of sand and gravel material, with lesser amounts of silt and organic matter.

The upper formation (the Navesink Formation) was evaluated based on geologic data obtained from the shallow test borings and the groundwater monitoring well borings. Data obtained from the visual descriptions of the split-spoon samples indicate that four of the site borings fully penetrated the Navesink Formation. These borings are: MW101D, MW102D, MW103D and MW104S. Based upon the well logs, the depth below grade at which the Navesink/Wenonah-Mt. Laurel interface was encountered ranged from 10 feet at MW104S to 28 feet at MW102D. Cross sections of the site geology which show the estimated depth of the Navesink Formation and Wenonah-Mt. Laurel Formation contact are presented in Figure 3-3. This contour map indicates that in the site vicinity, the contact dips to the south-southwest. This represents a minor deviation from the regional dip direction which is to the southeast.

Based on the visual geologic descriptions from the boring logs, the Navesink Formation is described as olive green and brown, fine sand with silt and clay. Occasional lenses of very fine sand and silt and clay, or of blue-green, greenish-brown or gray-black clay to clay and silt, were observed in several borings. Significant percentages of fine gravel were encountered from 6 feet to 8 feet and 10 feet to 12 feet below ground surface in borings B-1 and B-2, respectively; and at 6 feet to 8 feet and 10 feet to 12 feet in monitoring well borings MW105S and MW102D, respectively.

The Wenonah-Mt. Laurel Formation is described as primarily a uniform unit of dark green fine sand with silt. At boring MW101S, trace gravel was encountered within a limited upper portion of the Wenonah-Mt. Laurel Formation. At boring MW103D, black fine sand with silt was encountered at a depth of 19 feet, which was deemed by the field geologist to be visually indistinguishable (other than color differences) from the dark green fine sand with silt noted in the Wenonah-Mt. Laurel Formation. Due to this correlation, as well as the lack of clay noted, this sample was deemed a color variation, and was identified as the Mt. Laurel Formation.

Geotechnical samples were obtained at selected intervals. The locations and intervals of the geotechnical samples along with the sampling methods and geotechnical analyses which were performed are provided in Tables 2-3 and 2-5. Soil gradation curves are presented in Volume III - Appendix E. Geotechnical analytical results are presented in Section 3.7.1.

A total of 20 particle size and hydrometer analyses were performed on selected soil samples across the site. Based on a review of these analyses, the on-site soils are predominantly comprised of sand with varying amounts of silt, with lesser percentages of clay. Fine gravel percentages range from 0 to 33.9%; sand percentages range from 50.6 to 87.5%; silt percentages range from 4.4 to 41.0%; and clay percentages range from 0.7 to 41.8%. Sand, silt, and clay were found in each sample analyzed; gravel was encountered in nine of 20 samples. Atterberg limits analyses were performed on seven samples, with the plasticity index for these samples ranging from non-plastic to 19. This corresponds to the higher percentage of silt particles as compared to clay in most of the soil samples.

A review of the geotechnical laboratory descriptions versus the field classifications for the respective samples indicates that the field classifications tended to describe a higher silt and clay content than was actually present in the samples. The laboratory analyses also show that the samples contained greater percentages of fine sand than were described in the field. Overall, the field classifications tended to be skewed toward the finer end of the soil description system. Since not every soil sample received geotechnical testing, the soil descriptions on the boring logs have been kept unchanged to preserve continuity. A comparison of the geotechnical descriptions and the field descriptions is presented as an introductory page to Volume III - Appendix D, Monitoring Well Construction Logs and Diagrams and Boring Logs.

3.7 Hydrogeology

The two water-bearing geologic formations encountered during drilling at the site were the unconsolidated deposits of the Navesink Formation and the Wenonah-Mt. Laurel Formation. Rush (1968) reports that the Wenonah-Mt. Laurel Formation appears to receive part of its recharge by vertical leakage from overlying formations.

3.7.1 Horizontal Groundwater Flow Direction

Three rounds of groundwater elevation measurements were performed on November 13, 1991, February 28, 1992 and March 18, 1992. The results of the measurements are presented in Table 3-1. The water table contour maps for these three rounds of measurements are presented in Figures 3-4, 3-5, and 3-6. Due to the limited number of available measurement locations, other information such as lagoon and marsh water elevations and general topography were used in constructing the groundwater contour maps. The water elevations in the lagoon and the marsh were estimated based on topographic elevations and field observations. There were anomalous water level measurements at certain well locations (MW-106S and MW-1). It is assumed that these anomalous readings were due to extreme variablilities in hydraulic conductivities of the formations in the immediate vicinities of these wells. This assumption is supported by the relatively long recovery periods observed at these locations during well development (MW-106S recovery after development required in excess of 24 hours).

The flow direction of the groundwater within the Navesink Formation as determined from the November 13, 1991, February 28, 1992 and March 18, 1992 measurements was generally southwest. However, there is a localized mounding effect due to the presence of the lagoon. Therefore, groundwater flow in the immediate vicinity of the lagoon is radially outward from the lagoon. This localized influence of the lagoon is overcome in areas away from the lagoon by the general southwesterly flow within the site.

Potentiometric surface contour maps (presented in Figures 3-7, 3-8, and 3-9) were constructed based on information obtained from the deeper wells screened in the Wenonah-Mt. Laurel Formation water levels measured on November 13, 1991, February 28, 1992 and March 18, 1992 indicate that the groundwater flows generally south-southwest. This flow direction generally correlates with the regional groundwater flow direction in the site vicinity for the Wenonah-Mt. Laurel Aquifer as presented by Rush (1968).

Comparison of average water table and potentiometric elevation changes from the November 13, 1991 measurements (representing low water-table conditions) to the February 28, 1992 measurements (representing high water-table conditions) shows that water table (Navesink Formation) elevations increased by an average of 2.4 feet (not including well MW106S which increased by 6.8 feet). The potentiometric (Wenonah-Mt. Laurel Aquifer) monitoring wells showed elevation increases of an average of 1.6 feet. This agrees with Rush (1968) who reports that groundwater levels are generally highest during the winter and lowest during mid-autumn.

3.7.2 Hydraulic Gradients

The horizontal hydraulic gradients were evaluated for both the Navesink Formation and the Wenonah-Mt. Laurel Aquifer. These data were obtained from the groundwater contour maps. Based on the November 13, 1991 measurements, the average horizontal gradient in the groundwater of the Navesink Formation in the general direction of flow (based on an average from three measurements) ranges from about 0.05

foot/foot (5 centimeters per meter) near the lagoon to about 0.003 foot/foot (0.3 centimeters per meter) in areas downgradient of the lagoon and the average horizontal gradient in the Wenonah-Mt. Laurel Aquifer (based upon an average from three measurements) is about 0.01 foot/foot (1 centimeter per meter).

The hydraulic relationship between the Navesink Formation and the Wenonah-Mt. Laurel Aquifer was evaluated by comparison of head measurements in the paired piezometers MW101S and MW101D, MW102S and MW102D, and MW103S and 103D, as shown in Table 3-2. The shallow monitoring wells are screened in the Navesink Formation and the deep monitoring wells are screened in the Wenonah-Mt. Laurel Aquifer. In general, a downward component of flow was found in all instances with the exception of the November 13, 1992 measurements at the MW101 cluster, which indicated no measurable vertical gradient.

3.7.3 Hydraulic Conductivity Testing Results

Based on the slug testing results, average hydraulic conductivity estimates were calculated using the Bouwer and Rice (1976) method of analysis. While the Field Operations Plan called for use of the Hvorslev method, USEPA approved use of the Bouwer and Rice method, at the request of TAMS' subconsultant, Fanning, Phillips & Molnar. A summary of the hydraulic conductivity results is presented in Table 3-3. Refer to Volume III - Appendix F for raw data and graphs.

Estimates of hydraulic conductivity range from 1.4×10^{-5} to 6.0×10^{-4} centimeter per second (cm/sec) for the Navesink Formation. The mean hydraulic conductivity for the four monitoring wells tested is 2.8×10^{-4} cm/sec. For the Wenonah-Mt. Laurel Aquifer, the hydraulic conductivity estimates range from 1.1×10^{-3} to 1.4×10^{-3} cm/sec. The mean for the two monitoring wells tested for the Wenonah-Mt. Laurel Aquifer is 1.3×10^{-3} cm/sec. Thus, based on the averages, an order-of-magnitude difference in hydraulic conductivity was observed between the Navesink and Wenonah-Mt. Laurel Formations. Combined with the information presented above on hydraulic gradients, these values indicate that, while the Navesink does provide recharge to the Wenonah-Mt. Laurel Aquifer in the vicinity of the site due to the downward flow, the rate of recharge is relatively slow compared to the rate of lateral flow in the Wenonah-Mt. Laurel.

Regional hydraulic conductivity values were derived from Rush (1968) for the Navesink Formation (7.1×10^{-4} cm/sec) and the Wenonah-Mt. Laurel Formation (7.4×10^{-3} cm/sec). The site hydraulic conductivity values roughly agree with these values in that, in general, the Navesink Formation was found to be an order of magnitude lower than the hydraulic conductivity estimates for the Wenonah-Mt. Laurel Formation.

For comparison with field slug tests, seven samples were to be analyzed in the laboratory for vertical permeability (K_V); however, Shelby Tube Sample SB02A collected from the 2 to 4 foot depth interval in boring B-2, the lagoon profile boring, contained insufficient material to perform the test. Therefore, results were reported by the laboratory for only six of the samples. Two of the six samples were also analyzed for horizontal permeability (K_H). Results are shown in Table 3-4. (It should be noted that all samples for permeability analysis were obtained from the Navesink Formation in the deep, as well as shallow, well borings.) The horizontal permeability results range from 5.5 x 10^{-8} cm/sec at MW106S to 4.8 x 10^{-7} cm/sec at MW103D. The vertical permeability results range from 5.4 x 10^{-8} cm/sec at MW103D to 9.0 x 10^{-5} cm/sec at MW101S. One well location, MW101S, received both a field hydraulic conductivity test and a laboratory permeability test. The laboratory determined value of 9.0 x 10^{-5} cm/sec is noted to be lower than the field determined estimate of 6.0 x 10^{-4} cm/sec at this location.

This difference may have been due to the influence of the more permeable sand pack which surrounds the monitoring well screen. Also, the test interval of the slug test involves up to three feet of formation material, while the laboratory test involves approximately three inches of undisturbed sample. Therefore, the larger test interval might incorporate zones of higher permeability. Because the field test includes many natural variables, it is not uncommon to observe a difference in the field test results when compared to the more controlled laboratory test results. A comparison of the mean hydraulic conductivity values for the laboratory tests (1.7 x 10^{-5} cm/sec) with the field determined estimates (2.8 x 10^{-4} cm/sec) also demonstrates this relationship. It should also be noted that, with the exception of MW101S, the laboratory tests and the slug tests were performed at different locations.

3.7.4 Groundwater Pore Velocity Estimates

Using the calculated values for average hydraulic conductivity based on field slug tests, horizontal hydraulic gradients, and effective porosity estimates (derived from Fetter [1980]), groundwater pore velocity estimates were calculated using the following formula:

$$v = \frac{KI}{n_e}$$

Where:

v = average linear groundwater velocity in cm/sec
K = formation hydraulic conductivity in cm/sec (average)
I = horizontal hydraulic gradient (unitless)
n_e = effective porosity estimate (unitless)

For the groundwater of the Navesink Formation, the range of hydraulic conductivity values of 1.4×10^{-5} to 6.0×10^{-4} cm/sec were used along with a hydraulic gradient of 0.003 (for areas away from the lagoon) and an effective porosity value of 14 percent (derived from Fetter [1980] by averaging estimates for fine sand [21%] and sandy clay [7%]). The resulting estimate of horizontal groundwater pore velocity ranges from 3.0×10^{-7} to 1.3×10^{-5} cm/sec. For areas near the lagoon, with a hydraulic gradient of 0.05, the groundwater pore velocity ranges from 5×10^{-6} to 2.1×10^{-4} cm/sec.

For the Wenonah-Mt. Laurel Aquifer, the range of hydraulic conductivity values of 1.1×10^{-3} to 1.4×10^{-3} cm/sec were used along with a hydraulic gradient of 0.01 and an effective porosity value of 19.5 percent (derived from Fetter [1980] by averaging the estimate for fine sand [21%] and silt [18%]). The resulting estimated horizontal groundwater pore velocity for the Wenonah-Mt. Laurel Aquifer ranges from 5.6×10^{-5} to 7.1×10^{-5} cm/sec.

3.8 Human Population/Land Use Survey

A Human Population/Land Use Survey was performed by TAMS personnel the week of May 18, 1992, and also as appropriate during the field investigation. The survey included a review of records obtained from USEPA and NJDEP files, plus visits or telephone interviews with local and State agencies; a local land use inventory (including zoning); and field observation of actual land use practices.

Information from the following agencies was reviewed as part of the record search:

- USEPA Region II Project File
- NJDEP Division of Fish, Game and Wildlife
- NJDEP Division of Water Resources
- NJDEP Bureau of Water Allocation
- National Agricultural Statistics Service, US Department of Agriculture
- Rutgers Cooperative Extension - Burlington County
- Springfield Township Police Department, Zoning Department, and Town Clerk

Springfield Township is a 29-square mile rural township with agriculture, small businesses and light industry located along the principal routes, including Route 206 and Route 537. The township consists of three unincorporated villages: Jobstown, Jacksonville, and Juliustown. The Springfield Township Municipal Building and elementary school are located approximately one-half mile west of the site on Jacksonville-Jobstown Road.

According to 1985 census statistics, the township population was 2,819, averaging 97 persons per square mile. Large residential lots are characteristic of the zoning where 85 percent of the housing units are single family dwellings, and 79 percent are owner-occupied. Approximately 75 percent of land within the township is used for agricultural purposes. The primary crops include corn, soy beans, small grains (wheat, barley, and rye), and alfalfa. Smaller land usage for vegetables, nurseries, and sod was also reported. Other notable uses include a small airfield, and numerous horse stables and dairy farms.

Zoning in the immediate area of the K&M site is either "Residential" or "Neighborhood Commercial". The K&M property, and properties on each side except southwest across Jobstown-Juliustown Road, are zoned "Neighborhood Commercial". K&M is a non-conforming business, established prior to this zoning restriction. Expansion of the K&M business at this site is prohibited and, once the present operation is discontinued, future activities must conform to this zoning code. Properties outside this area and within one mile of the site are zoned "Residential". Two new residential developments, containing large "estate" size lots with single family homes, are currently under construction north of Columbus-Jobstown Road, approximately one mile north of the site.

Springfield Township does not operate a public water supply system or a sanitary sewer system. Potable water is obtained by private on-site wells, which reportedly draw water from one of three aquifers; however, 80 percent of the wells reportedly draw from the shallower Wenonah-Mt. Laurel Aquifer. The typical intake depth of these wells ranges from 90 to 120 feet below grade. The second most common aquifer tapped for potable water is the Englishtown Formation; with typical intake depths of 160 to 180 feet below grade. All of Springfield Township is located within New Jersey's Water Supply Critical Area Number 2. Therefore, where water is obtained from the deeper Potomac-Raritan-Magothy Aquifer (approximately 600 feet below grade), a water allocation permit is required for the withdrawal of 10,000 gallons per day or more, or to housing complexes of thirty or more units. Sanitary sewage is handled by on-site septic systems, which is partially responsible for the larger lot sizes.

No specific hunting or fishing restrictions were identified for areas within the township, including Barker's Brook; however, no response to TAMS' inquiry has been received to date from the Division of Fish, Game and Wildlife. As noted above, the vast majority of properties within one mile of the site have agricultural uses. Based on a windshield survey of these properties, they are posted to restrict trespassing and unauthorized hunting or fishing. The Trolley Valhalla property, located adjacent to the site, was at one time intended to be developed as a trolley museum. However, due to zoning restrictions and other constraints, the planned development has not occurred (Metz, 1991). The property is therefore not currently a recreational location.

Six horse stables were found to be located within one and one-half mile of the site; however these are reportedly for boarding and breeding purposes and do not offer recreational horseback riding to the general public. In addition, there are no advertised "pick your own" orchards or farms open to the public within one mile of the site.

3.9 Ecological Investigation Results

The purpose of the ecological investigation was to provide baseline information on the biological resources of the K&M Site and its general vicinity. The field study, which was conducted during the period of August 26-30, and October 21 and 29, 1991, entailed a strip census of birds, mammals and herpetofauna, a vegetation survey, a wetland delineation and qualitative macroinvertebrate sampling. A detailed report of the ecological investigation is provided in Volume III - Appendix G.

Four major community types were identified within the K&M Site, which include the marsh, stream, riparian woodlands, and open field. The primary ecological features and community types were defined in order to establish appropriate inventory transect lines and specific sampling points.

A total of 44 avian species were identified during the field investigation. None of these has a federally protected status; however, the breeding population of one species, the great blue heron, is listed as threatened in the state of New Jersey by NJDEP. The most common avian group observed in the study area was the passerine (perching birds) group, as 32 passerine species were recorded, which account for approximately 70 percent of the total species observed.

A variety of common mammals, which are characteristically found in Northeastern deciduous forests and open fields, were noted throughout the study area. None of these species has a protected status. The only herpetofaunal species observed were green frogs and common garter snakes. Neither has a federal or state protected status.

Three vegetative communities were identified within the study area - marsh, riparian woodlands and open field. The marsh was found to be characterized by a variety of herbaceous species (e.g. cattail, barnyard grass, sedges, etc.), with species dominance dictated by the relative wetness of a given area of the marsh. The riparian woodlands were found to be characterized by mature floodplain species with black walnut and black cherry trees dominating. The open field had previously been cleared of trees and appears to be periodically "maintained" or mowed. Opportunistic herbaceous and shrub species have colonized on the open space. No federal or state protected vegetative species were found within the study area.

Approximately 4.8 acres of freshwater wetlands were identified and mapped within the study area. These are delineated on Figure 2-1 as areas enclosed by lines W, IS, WB and WC. Wetland areas W and IS are classified as Palustrine Emergent (PEM) wetlands and occupy approximately 2.3 acres. Within wetland W, an approximately one-half acre Palustrine Broad-leaved scrub/shrub wetland exists. The remaining 2.5 acres of wetlands, delineated as WB and WC on Figure 2-1 consist of a floodplain which lies adjacent to the intermittent stream and Barker's Brook. These wetlands include riparian woodland areas of different ages and cover types.

A total of 18 macroinvertebrate taxa were collected during qualitative sampling of Barker's Brook. The taxa collected were compared to published lists to determine their pollution tolerance classifications; i.e., tolerant, facultative or intolerant to pollution stress. It was found that there was no clear pattern of tolerance - intolerance among organisms found at sampling locations upstream, adjacent to, and downstream of the K&M facility. Considerably fewer taxa were collected from the area adjacent to the facility, as compared to upstream and downstream areas; however, this is not likely a function of pollution stress, as three taxa collected there are generally intolerant to such stress.

In terms of obvious pollution-related stress to the ecosystem, the only area where phytotoxic effects are apparent is the marsh, identified as wetland W on Figure 2-1. In the immediate area where the lagoon has overflowed into the marsh, the vegetation is either dead, is yellow and withered, or is covered with a petroleum based product.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the sample analytical results and an evaluation of their significance with respect to Federal and State guidelines, background sample concentrations, and literature values representative of background or typical concentrations. Tables 4-1 and 4-2 provide the regulatory and literature values employed to evaluate the analytical results. The validated analytical data from this investigation are summarized in Tables 4-3 through 4-14. The subsections that follow consist of a presentation of the analytical results for the sampled media followed by a discussion of the results with respect to applicable standards and guidelines. The sampling locations are shown on Figure 2-1 and in various figures identified in the appropriate subsections. Tables 2-1 through 2-7 provide the sample identifiers and analyses conducted for samples collected during this investigation.

Samples submitted for chemical analysis were analyzed by USEPA Contract Laboratory Program (CLP) protocols for Target Compound List (TCL) volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), as well as Target Analyte List (TAL) inorganics. In addition, most soil samples were also analyzed for total petroleum hydrocarbons (TPHC) and total organic carbon (TOC), and some were analyzed for the hazardous characteristic of toxicity by the Toxicity Characteristic Leaching Procedure (TCLP). Surface water samples were also analyzed for various conventional and wet chemistry analytes (e.g., nitrate, biochemical oxygen demand). The results of the specific analyses conducted on the various site matrices are discussed below. The matrices include: lagoon sediments and soils (Section 4.2); facility lot soils (Section 4.3); marsh soils and sediments (Section 4.4); surface water and sediment (Section 4.5); and groundwater (Section 4.6). Each of these major matrices are further divided into submatrices, as discussed in the introductory paragraphs for each specific matrix.

4.1 Evaluation Criteria

In order to present a meaningful discussion of the analytical data, it was necessary to determine what criteria were applicable to specific matrices and samples. The discussion in this chapter is based on the evaluation criteria presented below.

4.1.1 Regulatory Criteria

Surface Soils

Federal contaminant-specific soil cleanup guidelines exist only for PCBs (which are not of concern at the K&M Site) and lead. In addition, there are no promulgated state regulatory criteria for surface soils.

For metals, concentrations were compared to New Jersey background concentrations. Development and use of metals background concentrations are discussed further in Section 4.1.2.

Subsurface soils

As with surface soils, there are no Federal or state regulatory criteria for subsurface soil contaminants detected at the K&M Site. Subsurface soil metals concentrations were evaluated against New Jersey background concentrations.

Sediments

There are no specific Federal or state regulatory criteria for sediments. However, a recent (1990) comprehensive literature review by the National Oceanic and Atmospheric Administration (NOAA) developed values for some organic contaminants and metals for which adverse biological effects may be observed. From this review, NOAA developed the ER-M values (Effects Range-Median); the 50th percentile of the data, the concentration above which adverse biological effects were frequently or always observed or predicted among most species (NOAA, 1990). The ER-M values for PAHs and metals were used to evaluate the sediment data from the three Barker's Brook sediment samples, which were considered to be the only sediment samples collected from areas capable of sustaining aquatic life.

Surface Water

Barker's Brook is a permanent water body capable of sustaining an aquatic biosystem, therefore, both state (NJAC 7:9-4 aquatic criteria for FW-2 water) and Federal fresh water chronic criteria (Quality Criteria for Water, 1991a - "Gold Book") were used to evaluate data from Barker's Brook samples (SW01, SW02, and SW03). Sample SW03 was collected upstream of the inlet of the drainage ditch and intermittent stream, so the data from SW02 and SW01 are also discussed in terms of comparison with SW03.

The surface water samples collected from the drainage ditch (SW05 and SW06) and intermittent stream (SW04) were of stagnant water that had collected at low points. There are no state or Federal regulatory criteria appropriate for use in evaluating these samples.

Groundwater

Federal Maximum Contaminant Levels (MCLs) (40 CFR 141 and 40 CFR 143), New Jersey groundwater standards (NJAC 7:9-6) and New Jersey drinking water standards (NJAC 7:10-16) were considered to be applicable to the three deep monitoring wells (MW101D, MW102D, and MW103D), as these wells are screened in the Wenonah-Mt. Laurel Aquifer which is used as a drinking water source for residences in the area. The comparatively low hydraulic conductivity associated with the Navesink Formation largely precludes its use as a potable water source. However, because there are no regulatory restrictions against installation of potable wells in the Navesink Formation, the aforementioned standards were also considered to be applicable to the remaining monitoring wells which are screened in the shallow Navesink Formation.

4.1.2 Background Concentrations

As mentioned above, background concentrations of metals were used to evaluate data from a few sample types. Data on background concentrations were developed based on the following hierarchy:

- New Jersey - specific soil data cited by NJDEP (NJDEP[E], 1993).
- Other New Jersey - specific soil data from the literature (e.g., Tedrow, 1986).
- Literature review of regional soil data (e.g., eastern U.S. data from USGS, 1984).

It should be noted that site-specific background data were not used for three reasons:

1. Only one intended background sample (SS01) was collected; this is not a sufficient database for evaluating the site data.
2. Data from the intended background sample SS01 indicates that the sample was affected by the roadway or site operations, as evidenced by the high concentrations of PAHs in the sample.
3. No other surface soil samples collected were designed to represent background conditions; all other surface soil samples are located in areas of potential contamination.

Due to the diversity and range of contaminant measurements in soils typically observed, even in adjacent locations, site data were considered to warrant discussion in cases where concentrations exceed two times the background concentration.

The background criteria used for this RI, and the sources of the values, are listed on Table 4-1.

4.2 Lagoon Sediments and Soils

The lagoon sediments and soils consist of lagoon bottom sediments (Section 4.2.1), lagoon berm soils (Section 4.2.2), and subsurface soils beneath the lagoon (Section 4.2.3).

Seven lagoon sediment samples were collected from six locations on the surface of the dewatered lagoon bed. Five samples (SD14 through SD18) were collected from locations near the perimeter of the lagoon as shown in Figure 2-1. One sediment sample (SB02S) was collected from the surface of the lagoon near the location of boring B-2. Two subsurface samples were also collected from boring B-2. One sample (SB02) was collected from a depth of 2 to 4 feet below the lagoon bottom surface, and a second sample (SB02A) was collected from a depth of 10 to 12 feet below the lagoon bottom. Two soil samples, SS12 and SS13, were collected from the berm of the lagoon adjacent to the marsh. Table 2-1 shows the analytical parameters for the lagoon bottom, berm and subsurface soil samples. Analytical results are provided in Table 4-3.

4.2.1 Lagoon Bottom Sediments

With the exception of SB02S, the lagoon surface sediment samples were analyzed for TCL volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), and TAL inorganic parameters, total organic carbon (TOC) and total petroleum hydrocarbons (TPHC), as shown on Table 2-1. Samples SB02S, SD15, SD17 and SD18 were analyzed for full TCLP organics and inorganics.

Volatile organic compounds including chlorinated solvents and BTEX compounds (toluene, ethylbenzene, and xylene), but not benzene, were detected in the sediment samples collected from the lagoon bottom. Concentrations measured in sample SD15 were typically substantially greater than levels measured in the remaining lagoon sediment samples. Specifically, toluene was detected at a concentration of 2,200,000 ppb (0.22%) in sample SD15 while concentrations ranged from an estimated value of 580 ppb to an estimated value of 1,700 ppb in the remaining lagoon sediment samples. Ethylbenzene and total xylenes were detected at respective concentrations of 1,300,000 ppb (0.13%) and 3,700,000 ppb (0.37%) in sample SD15. Concentrations of ethylbenzene and total xylenes ranged from estimated concentrations of 880 ppb to 3,800 ppb and 3,200 ppb to 24,000 ppb, respectively in the remaining lagoon sediment samples. Total BTEX concentrations range from 4,660 ppb in SD14 to 7,200,000 ppb in SD15.

As can be seen, the concentrations of BTEX compounds in the lagoon sediment samples are not uniform over the lagoon bottom. Concentrations of BTEX compounds found in sample SD15 are two to three orders of magnitude greater than the highest concentrations detected in the other lagoon samples. In the remaining samples, the concentrations of total BTEX compounds increase in order from sample SD14 to SD18 to SD16 to SD17. Samples SD14 and SD18 were collected near the northern end of the lagoon. Samples SD16 and SD17 were collected from the southeast and south corners of the lagoon, respectively.

Elevated concentrations of chlorinated VOCs, totaling over 6,000,000 ppb (0.6%), were also detected in sample SD15. Individual compounds detected in sediment sample SD15 include 1,1-dichloroethane (27,000 ppb), 1,2-dichloroethene (1,100,000 ppb), 1,1,1-trichloroethane (1,600,000 ppb), trichloroethene (3,100,000 ppb), and tetrachlororethene (230,000 ppb). These VOCs were not detected in the four other lagoon sediment samples..

Non-chlorinated VOCs including carbon disulfide (2,500 ppb), acetone (1,200 ppb), and 2-butanone (980 ppb), were detected in SD17, and 2-butanone (1,300 ppb) was also detected in SD18. No other target volatile organic compounds were detected in the sediment samples collected from the surface of the lagoon bottom. Two to nine non-target VOCs were found in each of these samples, ranging in total estimated concentration from 1,580 ppb in SD14 to 290,000 ppb in SD15. The sum of the concentrations of target volatile organic compounds (chlorinated VOCs and BTEX) detected in sample SD15 is 13,257,000 ppb (1.3%)

Semivolatile organic compounds were detected in all of the lagoon sediment samples. As with the volatile organic compounds, concentrations of semivolatile compounds detected in sample SD15 were substantially greater than concentrations measured in the remaining four lagoon sediment samples. Phenol and 1,2-dichlorobenzene were both detected in sample SD15 at approximate concentrations of 110,000 ppb and 15,000 ppb, respectively. These compounds were not detected in the remaining four lagoon sediment samples. Polynuclear aromatic hydrocarbon (PAH) compounds including naphthalene (41,000 ppb), 2-methylnaphthalene (66,000 ppb), and anthracene (13,000 ppb) were also detected in SD15. 2-methylnaphthalene was also detected in samples SD14 and SD18 but at concentrations more than an order of magnitude below that measured in SD15.

Phthalates, which are typical plasticizer constituents, were detected in all of the lagoon sediment samples in which they were analyzed and, as is the case with volatile organic compounds, SVOC concentrations detected in sample SD15 are one to two orders of magnitude greater than the concentrations detected in the other lagoon sediment samples. Di-n-butylphthalate was detected in sample SD15 at an estimated concentration of 120,000 ppb while concentrations in samples SD14 and SD16 were estimated as 1,900 ppb and 1,800 ppb, respectively. Butylbenzylphthalate and di-n-octylphthalate were detected in all the lagoon sediment samples which were analyzed. The concentration of butylbenzylphthalate in SD15 was estimated as 31,000,000 ppb while estimated concentrations in samples SD14, SD16, SD17, and SD18 ranged from 250,000 ppb to 690,000 ppb. The sum of the phthalate concentrations in sample SD15 is 35,520,000 ppb (3.6%). Substantial concentrations of non-target compounds (365,900 ppb in SD18 to 9,084,000 in SD15) were detected in all the lagoon sediment samples.

Total organic carbon results have all been qualified as estimated and vary from 3,080 ppm (0.3%) in sample SD18 to 103,000 ppm (10.3%) in sample SD15. TPHC concentrations range from 1,215 ppm in sample SD14 to 249,000 ppm (25%) in sample SD15. The TPHC concentration found in SD15 indicates the sediment at that location is a New Jersey hazardous waste, number X725, defined as contaminated beyond saturation (NJAC 7:26-8.20). Saturation is generally considered to be about 3% TPHC.

Inorganic analyte concentrations detected in lagoon sediment samples are generally within the background evaluation criteria. However, both SD17 (56.6 ppm) and SD18 (50.9 ppm) exceed background levels for chromium and SD14 (12.6 ppm) exceeds background levels for copper. In addition, inorganic analyte concentrations detected in sample SD15 are typically elevated with respect to the other lagoon sediment samples; barium (168 ppm), cobalt (4.6 ppm), manganese (136 ppm), zinc (345 ppm) and nickel (10.4 ppm) were present in sample SD15 at concentrations that ranged from two to eight times the highest concentration detected in the other lagoon sediment samples. Further, concentrations of copper (85.8 ppm), cadmium (3.1 ppm), and zinc (345 ppm) were detected in SD15 at concentrations exceeding the background evaluation criteria.

Sediment samples SBO2S, SD15, SD17, SD18 and SD19 were analyzed for toxicity characteristic leaching procedure (TCLP) organics and inorganics. Toxicity, as defined by TCLP test results, is one of four characteristics used to identify hazardous wastes under the Resource Conservation and Recovery Act (RCRA). No TCLP analyte, except trichloroethene in SD15, exceeds the regulatory limits, as shown on Table 4-3. Wastes associated with samples that exceed the regulatory levels are considered hazardous under RCRA (40 CFR 261.24). Therefore, the concentration of trichloroethene detected in the TCLP extract of sample SD15 would cause it to be classified as hazardous waste (USEPA hazardous waste number D040).

4.2.2 Lagoon Berm Soils

Relatively low levels of BTEX compounds and other VOCs, compared to concentrations detected in lagoon sediments as well as most other surface soil samples, were found in sample SS13. Estimated concentrations of toluene (2 ppb), ethylbenzene (5 ppb), and total xylenes (37 ppb) were detected as shown in Table 4-3. In addition, tetrachloroethene was detected at an estimated concentration of 3 ppb. No VOCs were detected in sample SS12.

Semivolatile organic compounds identified are limited to phthalates, whereas lagoon sediments were found to contain PAHs and other compounds, as well. Di-n-butylphthalate (approximately 4,600 ppb), and butylbenzylphthalate (approximately 270,000 ppb, or 0.03%) were detected in sample SS12. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected at 58,000 and 500,000 ppb, respectively in sample SS12, and at 7,000 and 67,000 ppb, respectively in SS13. The total phthalate concentrations identified, therefore, are 832,600 ppb in SS12 and 74,000 ppb in SS13. These levels are comparable to concentrations found in the lagoon sediments, with the exception of sample SD15.

TPHC concentrations detected are approximately 42,600 ppm in SS12 and 2,880 ppm in SS13. These levels are consistent with concentrations detected in lagoon sediment samples. TOC concentrations are estimated and range from 29,300 ppm (2.9%) in SS13 to 41,300 ppm (4.1%) in SS12. Concentrations of inorganics detected are consistently below the background evaluation criteria with exception of the chromium concentration of 44.1 ppm in SS13 which slightly exceeds the background evaluation criteria.

Sample SS13 was analyzed for TCLP parameters. No constituents were found in excess of the regulatory limits for toxicity.

4.2.3 Lagoon Subsurface Soils

BTEX compounds and other VOCs were detected in the subsurface soil samples collected, SB02 (2 to 4 feet) and SB02A (10 to 12 feet). (These depth intervals are referenced to the bottom of the sediment/soil interface.) BTEX compounds, including toluene, ethylbenzene, and total xylenes were detected at a total concentration of 1920 ppb in sample SB02. The same BTEX compounds were also detected in sample SB02A, but at a lower concentration (118 ppb). Low concentrations (1 to 7 ppb) of the chlorinated volatile organic compounds 1,1-dichloroethane, 1,2-dichloroethene, and trichloroethene were found in sample SB02A; chlorinated VOCs were not detected in SB02. Low concentrations of the ketones 2-butanone (31 ppb), 4-methyl-2-pentanone (4 ppb), and 2-hexanone (4 ppb) were also detected in sample SB02A. 2-butanone was detected in SB02 at a concentration of 130 ppb. Non-target VOCs at approximate total concentrations of 3,520 ppb and 197 ppb, respectively, were found in samples SB02 and SB02A.

Phthalates, including di-n-butylphthalate, butylbenzylphthalate, and di-n-octylphthalate, were detected in samples SB02 and SB02A. In the shallow sample (SB02), phthalate concentrations ranged from 210 ppb for di-n-butylphthalate to 12,000 ppb for butylbenzylphthalate. In SB02A, the deeper sample, phthalate concentrations detected range from 150 ppb for di-n-butylphthalate to 1,500 ppb for butylbenzylphthalate. Phenol, 2-methylphenol, and isophorone were detected in sample SB02A at estimated concentrations ranging from 41 ppb to 310 ppb. Phenol, 2-methylphenol, and 2-methylnaphthalene were detected in sample SB02 at estimated concentrations ranging from 240 ppb to 680 ppb. Concentrations of non-target SVOCs range from approximately 80,600 ppb in SBO2 to 5,268 ppb in SBO2A.

Generally, inorganics detected in the subsurface samples were present at concentrations within the background evaluation criteria. However, in both SB02 and SB02A, chromium was detected at concentrations of 101 ppm and 69.4 ppm, respectively, which exceed the background evaluation criterion for chromium. In addition, concentrations of antimony (3.3 ppm), selenium (0.25 ppm), and vanadium (52.8 ppm) detected in SB02 are in excess of the background evaluation criteria.

TPHC was detected at a concentration of 272 ppm in subsurface sample SB02, which is greater than the TPHC concentration detected in any other subsurface sample collected from the K&M Site. TPHC was detected in sample SB02A at a concentration of 48 ppm.

In general, phthalate concentrations at the location of SB02 decrease with depth, with the concentrations in SB02A about one order of magnitude less than in surface sample SB02. A similar pattern is apparent for BTEX, other VOCs, and TPHC.

4.3 Facility Lot Soils

Surface and subsurface soil samples were collected from the K&M operations lot, waste storage and disposal areas, and from other potentially contaminated areas on or near the K&M property. Prior to collection of soil samples a soil gas survey was conducted to assess the location and extent of volatile organic contamination in near surface soils and to refine other sampling locations.

Surface soil sample SS01 was collected to provide background contaminant concentrations for evaluating the surface soil samples. However, analytical results for this sample suggest that it is not representative of background conditions. It is, therefore, evaluated along with other soil samples in Section 4.3.4. No other surface soil samples were designed to represent background conditions; all other surface soil samples are located in areas of potential contamination. Surface soil samples are compared below to the background evaluation criteria.

Sample SB10, collected from boring MW101S, was the designated background subsurface soil sample based on its presumed location upgradient of site waste sources. However, groundwater elevation data collected after monitoring well installation indicate that subsurface soil sample SB10 is not entirely upgradient of site sources and, therefore, it is not considered to be a representative background sample. As with surface soil samples, no other subsurface sample was designed to represent background conditions; all of these remaining subsurface samples are in areas of potential contamination.

The text in this section presents the results of the soil gas survey (4.3.1) and results of the soil sampling conducted in areas in which the soil gas survey was conducted (underground storage tank area in 4.3.2, former washwater collection pit in 4.3.3, unpaved operations lot in 4.3.4, abandoned drums and excavation spoils areas in 4.3.5, septic system in 4.3.6, and miscellaneous samples in 4.3.7).

Background values for soils shown in Table 4-1 were used to evaluate subsurface soil contamination.

4.3.1 Soil Gas Survey Results

A report of the soil gas survey by Target Environmental Services is provided as Volume III - Appendix C. Results of the soil gas survey are summarized below.

Tables 4-4 through 4-6 provide a summary of the soil gas samples in which contaminants were detected. Data are tabulated and discussed in units of milligrams of contaminant per cubic meter of air (mg/m^3). The sample grid location is shown on Figure 2-1.

Results of the soil gas survey indicate low levels of VOCs distributed primarily over the central, most active portion of the facility. The soil gas samples were collected with the probe tip at a depth of approximately four feet. Generally, this depth was within one to two feet of the bottom of the fill and the top of the Navesink marl in the central section of the K&M property. Locations along the intermittent stream, the marsh, and the area northeast of the office building were found to have little or no fill layer.

There is no apparent trend or pattern in the distribution of the number or concentration of detected contaminants. The highest concentration detected in any sample is 1,446 mg/m^3 of total volatile organics (as analyzed by GC flame ionization detector or FID) at approximately the center of the property (grid location 1150-5300). The greatest number of discrete analytes, nine, was detected adjacent to the northwest corner of the garage (grid location 1100-5450), near the outdoor washwater collection sump. The total volatile organic compounds concentration detected at this location was 585 mg/m^3.

Concentrations of total volatile organic compounds were detected near underground storage tanks (USTs) Nos. 1 through 6 (916 mg/m^3, grid location 1075-5263), UST No. 7 and the collection pit (721 mg/m^3, grid location 1050-5375), and approximately 75 feet west of the western edge of the lagoon (690 mg/m^3, grid location 1225-5263). Very low levels (less than 4.3 mg/m^3) were detected in a sample in the marsh and in samples in the bed of the intermittent stream that drains the marsh area. It should be noted that carbon disulfide was detected in all of the fifteen samples analyzed by GC/MS. The subcontractor's report states that the carbon disulfide reported in these samples is believed to be the result of outgassing of the sample bottle septa and does not reflect conditions in the soil gas. However, CS_2 was detected in soil/sediment samples from the marsh, as discussed below in Section 4.4.

The levels of contaminants detected in the soil gas survey are low and there is no apparent pattern to the distribution of contaminants. Soil gas sampling data were used to refine the location of monitoring wells MW103S and MW103D. These wells were installed adjacent to the intermittent stream bed and soil gas sample 1500-4900. Total FID volatile organics were detected at a concentration of 4.3 mg/m^3 at this location.

Soil gas sample data, photoionization detector (PID) readings, and visual observation were used collectively to determine the location of the three composite soil samples collected from the operations lot. Trichloroethene and tetrachloroethene were detected in soil gas sample 1100-5300 (soil sample locations SS06A through C), and soil gas sample 1150-5150 (soil sample locations SS08A through C). Ethylbenzene, toluene, and xylene were detected in soil gas sample 1150-5300 (near soil samples SS07A through C). Due to the apparently random distribution and low levels of the detections, the soil gas results did not indicate that additional sampling locations were necessary or that other proposed locations should be modified.

4.3.2 Underground Storage Tank Areas

Subsurface samples for chemical analysis were collected from six locations near underground storage tanks (USTs) on the K&M property, as shown on Figure 2-1. Samples SB01 (B-1, 9 to 10 ft) and SB08 (B-8, 6 to 8 ft) were collected near USTs 1 through 6, samples SB06 (B-6, 6 to 8 ft) and SB07 (B-7, 6 to 8 ft) were collected near UST 9, and samples SB03 (B-3, 4 to 7 ft) and SB09 (B-9, 6 to 8 ft) were collected near USTs 7 and 8. Table 2-3 provides sample depths and rationales for the boring locations. Analytical results are shown on Table 4-7.

No target VOCs or SVOCs were detected in any of the samples. One non-target VOC at an estimated concentration of 11 ppb was found in sample SB01. Concentrations of total non-target SVOCs ranged from none detected (SB07) to 23,350 ppb (SB01).

TPHC was detected only in sample SB01 at 33.1 ppm. Detected inorganic analyte concentrations are within the concentration ranges expected in natural soils and are below the background evaluation criteria for all inorganics except chromium. Specifically, the detected chromium level exceeds the background evaluation criteria in SB01 (48.6 ppm), SB03 (48.5 ppm), and SB07 (97.8 ppm).

4.3.3 Former Washwater Collection Pit

Surface soil samples SS03, SS04, and SS05, as well as subsurface soil sample SB18 (MW106S, 6 to 8 ft) were collected to investigate potential contamination in the former washwater collection pit area. Analytical results for these samples are provided in Table 4-8. Sampling locations are shown on Figure 2-1. No VOCs were detected in the surface soil samples. Methylene chloride and acetone were found in sample SB18 at approximate concentrations of 6 ppb and 170 ppb, respectively. Both are common laboratory solvents, neither compound was found in the groundwater sample from MW106S, and acetone is used in field cleaning of split spoon samplers and other equipment. Trace estimated concentrations of 2-butanone (10 ppb), toluene (3 ppb) and total xylenes (5 ppb) were also detected in sample SB18.

The PAH 2-methylnaphthalene was detected in sample SB18 at 3,300 ppb. No other PAHs were detected in these samples. Sample SS05, collected from the runoff path from the former collection pit to the drainage ditch, was found to contain the SVOC di-n-octylphthalate at a concentration of 56,000 ppb. Butylbenzylphthalate and di-n-octylphthalate were detected in subsurface sample SB18 at concentrations of 38,000 ppb and 65,000 ppb, respectively. Butylbenzylphthalate was also found in SS04 at 200 ppb. Di-n-octylphthalate was also detected in surface soil sample SS04 (1,000 ppb).

TPHC concentrations detected in surface soil samples range from 35 ppm in sample SS03 to 2,130 ppm in sample SS04. The TPHC analysis for subsurface soil sample SB18 was rejected in data validation.

Detected inorganic analyte concentrations for the surface soils are consistently within the background evaluation criteria. However, the concentration of chromium (85.5 ppm) detected in the subsurface sample SB18 is in excess of the background level. Further, the concentration of copper in SB18 (11.2 ppm) slightly exceeds the background evaluation criterion of 11.1 ppm.

4.3.4 Unpaved Operations Lot

Surface soil sample SS01 was collected adjacent to the K&M facility entrance, composite surface soil samples SS06, SS07, and SS08 were collected from the unpaved operations lot, and surface soil sample SS09 was collected from the vicinity of the boring for MW102S. Subsurface samples SB05 and SB17 were collected from the locations of soil boring B-5 and the boring for MW105S, respectively. Analytical results for these samples are provided in Table 4-9. Sample locations are shown in Figure 2-1.

Target VOCs were detected in surface soil samples SS06 and SS08 ranging from a trace concentration of 1,2-dichloroethene (3 ppb) in SS08 to approximately 1,600 ppb total xylenes in sample SS06. Compounds detected also include acetone, 2-butanone, and toluene. Non-target VOCs were detected in samples SS06, SS07 and SS08 at concentrations ranging from 389 ppb to 469 ppb. No VOCs were detected in samples SS01 or SS09.

The SVOCs detected include phthalates and PAHs (or related compounds). Phthalate compounds, including butylbenzylphthalate, di-n-octylphthalate, and bis(2-ethylhexyl)phthalate, were detected in surface soil samples SS01, SS07, SS08 and SS09. Concentrations range from approximately 120 ppb for butylbenzyl phthalate (SS09) to an estimated concentration of 37,000 ppb for bis(2-ethylhexyl)phthalate (SS07).

Several PAH (or related) compounds were detected in surface soil samples with the exceptions of SS06 and SS08 at individual concentrations of 820 ppb or less. The concentrations of total target PAHs and related compounds detected in surface soil samples ranges from 1,220 ppb in SS07 to 4,649 ppb in SS01. In addition, carbazole was detected at 83 ppb in SS01.

TPHC concentrations detected in the surface soil samples range from 56 ppm (SS07) to 21,000 ppm (SS08). Concentrations of copper (116 ppm), manganese (287 ppm), and zinc (201 ppm) detected in SS01 exceed the background evaluation criteria. In addition, cyanide was detected in SS01 at a concentration of 1 ppm. The concentrations of cadmium (0.9 ppm), copper (28.2 ppm), and zinc (94.1 ppm) detected in SS09 also exceed the background criteria as does the concentration of copper (13.1 ppm) detected in SS07.

Subsurface soil sample SB05 was collected at a depth of 10 to 12 ft from boring B-5 adjacent to the exterior truck wash pit near the garage. Subsurface soil sample SB17 was collected at a depth of 6 to 8 ft from the location of the boring for monitoring well MW105S. SB17 is the nearest subsurface sample downgradient of the lagoon. Low concentrations (3 to 89 ppb) of target VOCs were found in subsurface soil samples SB05 and SB17. Compounds detected in SB05 include vinyl chloride (11 ppb), methylene chloride (7 ppb), acetone (89 ppb), 1,2-dichloroethene (6 ppb), and toluene (3 ppb). The compound 2-butanone was found in SB17 at 37 ppb. Non-target VOCs were detected at concentrations of 40 ppb in SB05 and 30 ppb in SB17, respectively.

The only SVOC detected in these subsurface samples is di-n-butylphthalate, which was detected in SB17 at an estimated concentration of 12,000 ppb. TPHC was detected at concentrations of 35.7 ppm in sample SB05 and 47.1 ppm in SB17.

While the concentrations of chromium in SB05 (101 ppm) and SB17 (57.5 ppm) exceed the background evaluation criterion (41.4 ppm) all other subsurface metals concentrations are within the background concentrations.

4.3.5 Abandoned Drums and Excavation Spoils Areas

Surface soil samples SS11 and SS10 were collected from the abandoned drums and excavation spoils areas, respectively. Sample locations are shown on Figure 2-1 and analytical data are provided in Table 4-10. No VOCs were detected in either sample. Di-n-octylphthalate was detected in samples SS10 and SS11 at concentrations of 66 ppb and 820 ppb, respectively. Butylbenzylphthalate was detected in the abandoned drums area sample SS11 at a concentration of 110 ppb. Non-target semivolatile compounds, consisting predominantly of unknown phthalates, were detected in sample SS11 at a concentration of 17,700 ppb.

TPHC concentrations detected in samples SS10 and SS11 are 320 ppm and 72 ppm, respectively. Cyanide was detected at a concentration of 0.7 ppm in SS10. Concentrations of the remaining inorganics detected are all within background evaluation criteria.

4.3.6 Septic System

Surface soil sample SS02 and subsurface soil sample SB04 were collected to investigate the septic system area. Analytical results are provided in Table 4-10. Sample locations are shown on Figure 2-1.

No target or non-target volatile organic compounds were detected in either sample. No target SVOCs were detected in sample SB04. Non-target SVOCs were detected in sample SS02 at 9,280 ppb and in SB04 at 400 ppb. Low levels (less than 64 ppb) of the PAHs naphthalene, phenanthrene, fluoranthene, and pyrene were detected in sample SS02. Butylbenzylphthalate and di-n-octylphthalate were detected in sample SS02 at estimated concentrations of 60 ppb and 320 ppb, respectively.

TPHC was detected in samples SS02 and SB04 at estimated concentrations of 191 ppm and 200 ppm, respectively. Inorganic analyte concentrations are below the background evaluation criteria with the exception of chromium (41.6 ppm) in SB02 which is slightly in excess of the background criterion.

4.3.7 Other Subsurface Soil Samples

Three additional subsurface soil samples were collected at monitoring well installation locations. They include samples SB10 (MW101S), SB12 (MW102S), and SB15 (MW103D). The locations of the samples are shown on Figure 2-1. Analytical data are provided in Table 4-10.

The VOC 2-butanone was detected at a concentration of 13 ppb in sample SB10. Methylene chloride was detected at trace levels in sample SB15 (6 ppb). A single non-target VOC was detected in sample SB10 and in sample SB12 at 22 ppb and 11 ppb, respectively. No target SVOCs were detected in these subsurface samples. Non-target SVOCs were detected in the three samples, ranging from 217 ppb in sample SB15 to 6,500 ppb in sample SB12.

TPHC were detected in two subsurface samples at concentrations of 47 ppm in sample SB10 and 34 ppm in sample SB12. Cyanide was detected at low (1 ppm and less) concentrations in samples SB10 and SB12. Concentrations of inorganics detected are consistently within the background evaluation criteria with the exception of chromium which was detected in SB10 (44.4 ppm) and SB15 (50.6 ppm) at levels slightly greater than the background criterion for chromium.

4.4 Marsh Soils

As shown on Figure 2-1, six surface soil samples, SD07 through SD12, were collected from the marsh in the lagoon overflow area; six surface soil samples, SS14 through SS19, were collected in the marsh area on somewhat drier ground and farther from the lagoon; and surface soil sample SB16 was collected from the boring for monitoring well MW104S (0 to 2 foot interval), which was installed in the marsh, adjacent to the location of SS18. Analytical results are provided in Table 4-11.

It should be noted that carbon disulfide, a VOC, was detected at low levels (less than 8 ppb) in three of the six surface soil samples collected in the lagoon overflow area. Biogenic carbon disulfide emissions have been identified in soils, oceans, marshes, animal wastes, and other natural sources (USEPA, 1986c). A maximum concentration of 13.2 ppb and a mean concentration of 5.53 ppb was reported in USEPA's STORET database for carbon disulfide in sediment samples from six locations (USEPA, 1986c). The presence of this compound is not considered to be indicative of contamination from site sources. Therefore, the reported presence of carbon disulfide in sediment samples will not be discussed further in this section.

Samples SD07 through SD09, which were collected nearest to the lagoon, were found to contain toluene at concentrations ranging from 4 ppb in sample SD08 to 940 ppb in sample SD09 and trace levels (17 ppb and less) of total xylenes. These compounds are typically associated with petroleum products. Acetone was detected in sample SD07 at 230 ppb with associated method blank contamination. Methylene chloride was detected in five of the thirteen samples (SD07 through SD10 and SD12) at trace concentrations of 2 to 14 ppb. No other target VOCs were detected in the marsh area surface soil samples. Non-target VOCs were detected in samples SD07 through SD10, SD12, and SS16 through SS19 at concentrations ranging from 11 ppb in SD07 to 472 ppb in SD10.

Phthalates comprise the primary SVOC contaminant type detected in samples SD07 through SD12. Di-n-octylphthalate was detected in all six samples; butylbenzylphthalate was detected in five samples, di-n-butylphthalate was detected in two samples, and bis(2-ethylhexyl)phthalate and diethylphthalate were each detected in a single sample. Concentrations range from 58 ppb of diethylphthalate in sample SD12 to 480,000 ppb of di-n-octylphthalate in sample SD08. Total target phthalates concentrations in marsh area sediment samples range from 358 ppb (SD12) to 910,000 ppb in sample SD08.

When non-target tentatively identified compound (TIC) phthalates are included, total phthalate concentrations in samples SD08 and SD09 are 5,308,000 ppb (0.5%) and 1,193,200 ppb (0.1%). Concentrations detected are highest in samples SD08 and SD09 collected near the lagoon overflow point. Phthalates are typical plasticizer constituents and their presence in the marsh area is consistent with the past disposal practices at the site. Washwater from tankers that hauled plasticizers was disposed in the lagoon, which subsequently overflowed into the marsh area as a result of heavy rains. Phenol was detected in sample SD09 at a concentration at 720 ppb. No polynuclear aromatic hydrocarbons (PAHs) were detected in SD07 through SD12.

Phthalates were also detected in the surface soil samples, SS14 through SS19 and SB16, although generally at concentrations below those measured in the surface soil samples collected within the lagoon overflow area. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected in sample SS14 at concentrations of 1,600 and 2,200 ppb, respectively. The latter compound was also detected in sample SS15 at an estimated concentration of 470 ppb. Diethylphthalate and di-n-butylphthalate were detected in sample SB16 at estimated concentrations of 44 ppb and 310 ppb, respectively. In contrast to the surface soil samples collected in the lagoon overflow area, low levels of PAHs (56 to 100 ppb) were also detected in samples SS14 and SS15, collected near the southern border of the marsh area. No other target SVOCs were detected in these surface soil samples. However, non-target SVOCs were detected in all seven samples with concentrations ranging from 2,390 ppb in sample SB16 to 74,100 ppb in sample SS17.

TPHC levels detected in the surface soil samples SD07 through SD12, collected nearest to the lagoon, range from approximately 193 ppm in sample SD12 to 4,610 ppm in sample SD08. Sample SD08 was collected adjacent to the lagoon berm. Sample SD10, which was the sample collected farthest from the point of the lagoon overflow, showed a TPHC concentration of 2,610 ppm.

TPHC concentrations detected in the marsh area surface soil samples SS14 through SS19 and SB16 range from approximately 60 ppm (SB16) to 220 ppm (SS14). The highest concentrations were detected in sample SS14 (220 ppm) which was collected in an area of the marsh adjacent to the lagoon overflow. However, samples SS16 (218 ppm) and SS18 (217 ppm) showed nearly identical concentrations. Sample SS16 is the farthest of any sample from the overflow area, and sample SS18 is adjacent to SB16 which showed the lowest concentration of the group. The higher TPHC concentrations measured in the samples collected outside of the lagoon overflow area are only slightly higher than the lowest concentrations in samples collected within the overflow area and are an order of magnitude lower than the highest concentrations measured within the overflow area.

Several metals concentrations detected in the marsh surface soils samples exceed background criteria. Specifically, cadmium concentrations detected in SD9 (0.6 ppm), SD10 (0.6 ppm), and SD11 (0.7 ppm), all of which were collected within the lagoon overflow area, exceed the background cadmium criterion of 0.26 ppm. Cadmium was not detected above background in the samples collected outside of the overflow area. Chromium was detected at concentrations above the background criterion (41.4 ppm) in 11 of the 13 marsh samples. While the highest concentration of chromium (131 ppm) was detected in sample SD07, within the overflow area, chromium concentrations detected in samples collected within lagoon overflow area were generally comparable to concentrations detected in samples collected beyond the overflow area.

Copper concentrations in two of the seven samples collected within the lagoon overflow area exceeded the background criterion of 11.1 ppm. Similarly, concentrations detected in three of the six samples collected beyond the overflow area were greater than the background criterion. The highest concentration was detected in sample SS17 (31.5 ppm), collected outside of the lagoon overflow area.

Concentrations of selenium detected in six of the seven surface soil samples collected within the overflow area and in one sample (SB16) collected beyond the overflow area, ranging from 0.5 ppm to 1.4 ppm, were above the background criterion of 0.26 ppm. Selenium was not detected in the remaining marsh surface soil samples. Zinc was detected at slightly elevated concentrations, with respect to the background criterion of 70.2 ppm, in one sample collected within the overflow area and in two samples collected outside of the overflow area. The maximum concentration of zinc (119 ppm) was detected in sample SS17 located outside of the lagoon overflow area. Vanadium was detected at concentrations greater than the background criterion of 47.2 ppm in sample SD07 (63.9 ppm), collected within the overflow area, and in sample SB16 (54.7 ppm), collected outside of the overflow area. In addition beryllium was detected in sample SD07 at a concentration of 2.3 ppm, which slightly exceeds the background criterion of 2.14 ppm. Cyanide was detected in samples SS16 through SS19, all of which were collected beyond the lagoon overflow area, at concentrations ranging from 1.1 ppm in SS16 to 2.2 ppm in SS19.

4.5 Drainage Ditch and Intermittent Stream Bed Soils

As discussed in Section 2.6, samples collected in the drainage ditch and intermittent stream bed were designated as "sediment samples" in the FOP due to their shared characteristic of having been deposited or affected by a water system. These samples have all been affected by surface water runoff potentially contaminated by site operations. However, none of these locations is continuously submerged nor do they support developed aquatic ecosystems. Therefore, in order to differentiate between these samples and Barker's Brook sediment samples, which are capable of supporting a developed aquatic ecosystem, the drainage ditch and intermittent stream bed samples will be referred to as surface soil samples and will be discussed separately from the Barker's Brook sediment sample results presented in Section 4.5.

The drainage ditch and intermittent stream bed soil samples were collected from locations corresponding to the surface water samples, which were collected from pools of stagnant water that had accumulated at low points in the intermittent stream and drainage ditch. Analytical results are provided in Table 4-13. Sample locations are shown on Figure 2-1.

It should be noted that carbon disulfide, a VOC, was detected at low levels (8 ppb or less) in the intermittent stream bed soil sample and one of the two drainage ditch soil samples. Biogenic carbon disulfide emissions have been identified in soils, oceans, marshes, animal wastes, and other natural sources (USEPA, 1986c). A maximum concentration of 13.20 ppb and a mean concentration of 5.53 ppb was reported in USEPA's STORET database for carbon disulfide in sediment samples from six locations (USEPA, 1986c). The presence of this compound is not considered to be indicative of contamination from site sources. Therefore, the reported presence of carbon disulfide in these soil samples will not be discussed further in this section.

Intermittent Stream Soil Sample

Surface soil sample SD04 was collected from the intermittent stream that drains the marsh area. The BTEX VOC toluene was detected in this sample at 2 ppb. Methylene chloride was detected in sample SD04 at an estimated concentration of 19 ppb. The target SVOCs butylbenzylphthalate and di-n-octylphthalate, which were also detected in at least five of the marsh area surface soil samples, were detected in sample SD04 at concentrations of 72,000 ppb and 91,000 ppb, respectively. Non-target SVOCs were detected at a total concentration of 1,115,000 ppb, of which 999,000 ppb were identified as unknown phthalates.

TPHC was detected at a concentration of 21,000 ppm (2.1 percent) in sample SD04, which is more than three times the highest concentration (4,610 ppm) detected in the marsh samples collected within the lagoon overflow area. The inorganic analyte concentrations are consistently within the background evaluation criteria with the exception of chromium (68.1 ppm) and selenium (0.8 ppm) which both exceed the applicable criteria.

Drainage Ditch Soil Samples

A total of two surface soil samples, SD05 and SD06, were collected from the drainage ditch that adjacent to Jobstown-Juliustown Road. Sample SD06 was collected on the K&M property, directly opposite the lagoon. The BTEX compounds benzene, toluene, ethylbenzene, and total xylenes were detected in sample SD06 at a total concentration of about 292,000 ppb. Low levels (58 ppb and less) of the chlorinated VOCs 1,1-dichloroethene, trichloroethene, and tetrachloroethene were also detected in sample SD06. Vinyl chloride was detected at a concentration of 830 ppb and 1,2-dichloroethene was detected at 27,000 ppb. Methylene chloride was detected in sample SD06 at 14 ppb. No target VOCs were detected in sample SD05, collected farther downstream, closer to the discharge to Barker's Brook (although toluene, ethylbenzene, and xylene data were rejected [unusable] in SD05). The total concentration of non-target VOCs was 1,201 ppb in sample SD05 and 5,920 ppb in sample SD06.

The SVOCs butylbenzylphthalate and di-n-octylphthalate were detected in both samples SD05 and SD06. Concentrations of these compounds range from the lower values in sample SD05 of 73,000 ppb and 350,000 ppb, respectively, to 2,300,000 ppb and 1,900,000 ppb, respectively, in sample SD06. Non-target SVOCs were detected in samples SD05 and SD06 at total concentrations of 2,858,000 ppb and 22,580,000 ppb, respectively. The non-target compounds identified as unknown phthalates show a total concentration of 2,617,000 ppb in SD05 and 19,490,000 ppb in sample SD06. TPHC concentrations follow the same distribution, ranging from 57,200 ppm in sample SD05 to 85,400 ppm in sample SD06, farther downstream.

Concentrations of antimony (3.4 ppm), cadmium (2.8 ppm), chromium (103 ppm), copper (43.9 ppm), mercury (0.2 ppm), selenium (0.7 ppm), vanadium (54.8 ppm), and zinc (283 ppm) detected in SD05 all exceed the background evaluation criteria. Similarly, concentrations of cadmium (1.9 ppm), chromium (98.8 ppm), copper (28.6 ppm), selenium (0.6 ppm), vanadium (53.7 ppm), and zinc (180 ppm) detected in SD06 all exceed the background evaluation criteria.

4.6 Surface Water and Sediments

Surface water and associated sediment samples were collected to determine whether on-site waste sources are migrating off-site. Analytical results are provided in Tables 4-12 and 4-13, respectively. Results of surface water field measurements are shown in Table 4-12. The locations of the surface water and sediment samples are shown in Figure 2-1.

4.6.1 Surface Water

A total of six surface water samples were collected from the K&M Site. Two samples, SW05 and SW06, were collected from two locations in the drainage ditch adjacent to Jobstown-Juliustown Road; one sample, SW04, was collected from the intermittent stream that drains the marsh; and three samples, SW01, SW02 and SW03, were collected from Barker's Brook. Sample SW03, the intended background sample, was collected upstream of recognized potential site contaminant migration pathways. However, it is important to note that the sampling plan was prepared prior to the availability of a topographic base map for the K&M Site. Subsequent review of the marsh area topography suggests that flooding may provide an alternate overland route for contamination from the marsh to Barker's Brook which is upstream of sample SW03. Samples collected from Barker's Brook (SW01 through SW03) were of running water. Samples collected from the drainage ditch (SW05 and SW06) and intermittent stream (SW04) were of stagnant water that had collected at low points.

Both unfiltered and field-filtered aliquots were collected from each sampling location for metals analysis. The field-filtered fractions are designated by the suffix "A" (e.g., SW04A).

Intermittent Stream and Drainage Ditch Samples

Two surface water samples (SW05 and SW06) were collected from the drainage ditch that runs along the western property border and one surface water sample (SW04) was collected from the intermittent stream that drains the marsh area. Analytical data for the surface water samples is provided in Table 4-12. Figure 2-1 shows the sample locations. No target or non-target VOCs were detected in the intermittent stream or drainage ditch samples.

Semivolatile organic compounds were detected in the samples collected from the intermittent stream and the drainage ditch. Phenol was detected at a concentration of 1 ppb in the drainage ditch samples SW05 and SW06. Phenol was the only target SVOC detected in sample SW05, which was the drainage ditch sample nearest to Barker's Brook. Bis(2-ethylhexyl) phthalate (3 ppb) and di-n-octylphthalate (6 ppb) were detected in sample SW04 collected from the intermittent stream. Di-n-octylphthalate was detected in sample SW06 at a concentration of 140 ppb. Butylbenzylphthalate was detected at a trace concentration of 2 ppb in sample SW06. (These phthalates were detected at higher concentrations [72,000 to 2,300,000 ppb] in surface soil samples collected from the corresponding locations). Non-target SVOCs were detected in all samples with total concentrations ranging from 10 ppb in SW05 to 1,565 ppb in sample SW06.

Inorganic analyte concentrations detected in the unfiltered surface water samples were typically higher than those in the filtered samples. This result is expected for samples containing suspended and settleable solids that filtering removes. However, as indicated in Section 2.6.1, water in the intermittent stream and drainage ditch was very shallow (i.e., 1 to 3 inches) and stagnant.

Under such conditions, the sampling process caused surface soil disturbance which resulted in the collection of suspended solids with the aqueous phase of the sample. These conditions likely contributed to the difference in the inorganic analyte concentrations in the filtered and unfiltered samples collected from these locations.

In general, the highest inorganic concentrations were detected in unfiltered ditch sample SW06. While filtered samples SW04A and SW05A show similar concentrations of inorganic analytes, filtered sample SW06A tends to have slightly, but noticeably, higher inorganic concentrations. Thus, the drainage ditch, which was intentionally used for site stormwater discharge, exhibits higher concentrations of inorganics than the intermittent stream, which only received occasional discharge due to lagoon overflow events.

Surface water samples were also analyzed for eight wet chemistry parameters as shown in Table 4-12. TPHC was not detected in any of the surface water samples in contrast to the surface soil samples collected from the same locations which show TPHC concentrations ranging from 21,000 ppm to 85,400 ppm. MBAS, which is indicative of detergents was detected in sample SW04 at 1.6 ppm. Oxygen demanding substances, as indicated by BOD and COD, were found in samples SW04 and SW06. The COD to BOD ratios in samples SW04 and SW06 are 54.6 and 46.2, respectively. These ratios suggest that a large fraction of the oxygen demanding substances in the sample are not amenable to biological oxidation. The drainage ditch sample SW06 shows the highest concentrations of detected wet chemistry parameters, including TSS (1030 ppm), TDS (710 ppm), chloride (250 ppm), Nitrate (1.6 ppm), COD (328 ppm), and BOD (7.1 ppm).

Field parameters, including temperature, dissolved oxygen, pH, Eh, and conductivity, were measured at each surface water sampling location and results are shown in Table 4-12. Dissolved oxygen measured in the intermittent stream and drainage ditch samples ranges from 4.2 ppm to 6.1 ppm. These levels are well below saturation for the temperatures observed. Measurements of pH range from 4.76 in sample SW05 to 7.37 in sample SW06, and Eh measurements range from 71.6 mV in sample SW06 to 134.2 mV in sample SW04. Conductivity readings range from 160 umho/cm in sample SW04 to 900 umho/cm in sample SW06. The relatively high conductivity detected in sample SW06 is consistent with the high concentration of chloride (250 ppm) and sodium (172 ppm) in the sample and suggests the presence of de-icing or other salt residues in the drainage ditch.

Barker's Brook Samples

Three surface water samples were collected from Barker's Brook. As was noted previously, sample SW03 was collected upstream of the discharge of the intermittent stream and was intended as the background sample. However, the sampling plan was prepared prior to the availability of a topographic base map for the site. Subsequent review of the marsh area topography suggests that flooding may provide an alternate overland route for contamination from the marsh to Barker's Brook which is upstream of sample SW03. Sample SW02 was collected downstream of the discharge of the intermittent stream to Barker's Brook. Sample SW01 was collected downstream of the discharge of the drainage ditch to Barker's Brook.

The VOC methylene chloride was detected in sample SW01 at an estimated concentration of 39 ppb with associated method blank contamination. No other target or non-target VOCs were detected. No SVOCs, target or non-target, were detected in any Barker's Brook sample.

Sample SW03 was intended as the background sample location for the Barker's Brook surface water samples; however, validation of the analytical data resulted in rejection of the data for manganese, nickel, and zinc in both the filtered sample (SW03A) and the unfiltered sample (SW03). Manganese exceeds the applicable criterion in both the filtered and unfiltered samples at SW01 and SW02. Concentrations of other inorganics detected in the Barker's Brook surface water samples, SW01 and SW02, are comparable to the concentrations detected in SW03 and are below applicable New Jersey surface water quality limits.

Of the wet chemistry results shown in Table 4-12, MBAS, BOD, and TPHC were not detected in any of the Barker's Brook surface water samples. COD was detected at the low level of 5.8 ppm in all the samples. TSS and chloride levels detected in all three samples are below applicable New Jersey surface water quality limits of 25 ppm for TSS and 250 ppm for chloride.

Field parameters measured at the Barker's Brook surface water sampling locations are shown in Table 4-12. Dissolved oxygen concentrations range from 10.2 ppm in sample SW03 (74% saturation) to 12.6 ppm in sample SW02 (91% saturation). Measurements of pH decreased in the downstream direction, ranging from 5.3 in sample SW01 to 6.5 in sample SW03. Eh measurements were essentially the same in all three samples (78.9 to 83.1 mV). Conductivity measurements were similar for all three samples, ranging from 90 umho/cm at SW03 to 100 umho/cm at SW01.

4.6.2 Surface Water Body Sediments

Sediment samples were collected from the three Barker's Brook locations selected for surface water sampling (described in the previous section). Analytical results are provided in Table 4-13. Sample locations are shown on Figure 2-1.

The intended background sediment sample, SD03, was collected upstream of known overland contaminant migration paths. However, as noted previously, the sampling plan was prepared prior to the availability of a topographic base map for the site. Subsequent review of the marsh area topography suggests that flooding may provide an alternate overland route for migration of contaminants from the marsh to Barker's Brook which is upstream of SD03. Di-n-butylphthalate (700 ppb) and low levels of PAHs (76 to 150 ppb) were detected in this sample. The presence of these compounds, particularly di-n-butylphthalate, suggests that sample SD03 is not representative of background sediment conditions. Sample SD02 was collected downstream of the discharge of the intermittent stream and sample SD01 was collected downstream of the discharge of the drainage ditch.

It should be noted that carbon disulfide, a VOC, was detected at a low level of 3 ppb in one of the three sediment samples collected. Biogenic carbon disulfide emissions have been identified in soils, oceans, marshes, animal wastes, and other natural sources (USEPA, 1986c). A maximum concentration of 13.20 ppb and a mean concentration of 5.53 ppb was reported in USEPA's STORET database for carbon disulfide in sediment samples from six locations (USEPA, 1986c). The presence of this compound is not considered to be indicative of contamination from site sources. Therefore, the reported presence of carbon disulfide in the sediment sample will not be discussed further in this section.

VOCs detected in Barker's Brook sediment samples include acetone, 2-butanone, and methylene chloride. These VOCs are common laboratory contaminants. Acetone and 2-butanone were detected in all three of the Barker's Brook sediment samples as well as in the soil samples collected from the drainage ditch and the intermittent stream. Due to the associated blank contamination, the reported detections of these two compounds were negated during data validation in each of these sediment/soil samples except in samples SD01 and SD02. Although the concentrations reported in SD01 and SD02 exceeded 10 times the concentration in the associated blanks, the reported detection of these common laboratory contaminants is not consistent with the site-related VOCs (i.e., 1,2-dichloroethene and BTEX compounds in the drainage ditch sample SD06). Rather the prevalence of acetone and 2-butanone in the lab, trip, and rinsate blanks indicates a high likelihood that these laboratory-reported detections are artifacts of the sampling and analytical process. Although methylene chloride was not detected in blanks specifically associated with the sediment samples, it was detected in many other blanks associated with the K&M samples. In addition, the presence of methylene chloride is not consistent with site-related VOCs. Therefore, the reported detections of methylene chloride are also considered to be artifacts of the sampling and analytical process.

Low levels (62 to 240 ppb) of individual PAHs were detected in all three samples with total PAH concentrations ranging from 140 ppb (SD02) to 879 ppb (SD01). One or more of the following phthalates were detected at low concentrations (63 to 960 ppb) in all the Barker's Brook sediment samples: diethylphthalate, di-n-butylphthalate, and di-n-octylphthalate. Concentrations of di-n-butylphthalate range from 700 ppb in sample SD03, the most upstream sample, to 960 ppb in sample SD01, the most downstream sample.

Stream sediment sample TPHC concentrations were found to increase in the downstream direction, ranging from 83 ppm in sample SD03 to 5,360 ppm in sample SD01.

Inorganic analytes in the sediment samples were less than the applicable NOAA ER-M guidelines used to evaluate sediments in aquatic environments. While no NOAA criteria are available for barium, beryllium, cobalt, manganese, selenium, and vanadium, the detected concentrations of barium, cobalt, and manganese are within the background soil criteria and the concentrations of beryllium and vanadium are only slightly greater than the background criteria. Selenium concentrations measured in all three sediment samples range from 0.6 ppm to 0.8 ppm and exceed the background soil criterion of 0.22 ppm.

4.7 Groundwater

Twelve groundwater samples were collected at the K&M Site monitoring wells from December 17 through 20, 1991. Groundwater sampling was conducted to assess the impact of site waste sources on groundwater and to assess whether contamination, if present, is migrating offsite through any of the monitored aquifers. Groundwater sample analytical results are provided in Table 4-14. Figure 2-1 shows the locations of the monitoring wells.

Discussion of the groundwater sampling results is presented in two sections: analytical sampling results from shallow wells that monitor the Navesink Formation, and analytical results from wells that monitor the deeper Wenonah -Mt. Laurel Aquifer.

Existing information, collected prior to the initiation of the RI field work, indicated that groundwater flow direction was toward the east. Based on this information, monitoring wells MW101D and MW101S were installed at a presumed upgradient location and were designated as background groundwater sampling locations. Water level data, collected after monitoring well installation, indicate that the groundwater flow direction is to the south-southwest. Given this condition, monitoring wells MW101D and MW101S are not upgradient of the site and, therefore, they are not considered as representative background sampling locations. Other site monitoring wells are not suitable as substitute background sampling locations either because they are not upgradient of site sources or because they were installed to monitor potentially contaminated areas. As there is no acceptable background well for the site, groundwater data are evaluated based on the criteria discussed in Section 4.1.

4.7.1 Navesink Formation (Shallow Monitoring Wells)

A total of ten samples were collected from nine shallow monitoring wells on the K&M Site. Three monitoring wells (MW-1 through MW-3) existed prior to the initiation of RI activities and were installed to monitor effects of the lagoon. MW101S through MW103S are the shallow wells of three two-well clusters, each consisting of one shallow and one deep well. MW104S was installed in the marsh area east of the lagoon, MW105S is the downgradient well nearest to the lagoon, and MW106S was installed to monitor the area of former washwater collection pit.

Methylene chloride, a common laboratory contaminant, was detected in groundwater sample MW105S and in the laboratory method blank associated with that sample. Its presence in the sample is therefore not considered to be indicative of contamination from the site and, therefore, it will not be discussed further in this section.

Chlorinated VOCs, which are typically associated with solvents, were detected in samples from MW102S and MW105S. BTEX compounds were also detected in MW105S. The total chlorinated VOC concentration in MW102S, comprised of 1,1,1-trichloroethane (15 ppb), tetrachloroethene (4 ppb), and 1,1-dichloroethene (2 ppb) was 21 ppb. Chlorinated VOCs detected in the sample from MW105S total 131 ppb and include vinyl chloride (17 ppb), 1,2-dichloroethene (94 ppb), trichloroethene (16 ppb), 1,1-dichloroethane (4 ppb). Trace concentrations (8 ppb and less) of the BTEX compounds benzene and total xylenes were also detected in the sample from MW105S. No non-target VOCs were detected in any sample. No volatile organic compounds were detected in any of the other shallow groundwater samples collected from the site.

As shown on Table 4-14, the concentrations detected in MW 102S of 1,1 dichloroethene, 1,1,1-trichloroethane, and tetrachloroethene are all within the Federal MCLs. Only tetrachloroethene (4 ppb) exceeds the state MCL. The concentrations in MW105S of benzene and total xylenes are also within the state and Federal MCLs. However, the concentrations of vinyl chloride (17 ppb), trichloroethene (16 ppb) exceed both the state and Federal MCLs. It cannot be determined if the total 1,2-dichloroethene concentration detected in MW105S (94 ppb) exceeds the proposed criteria for the individual 1,2-dichloroethene isomers (10 ppb for the cis isomer and 100 ppb for the trans isomer). There is no state or Federal drinking water criterion available for 1,1-dichloroethane. However, the concentration of 1,1-dichloroethane detected in MW105S is within the New Jersey groundwater quality criterion for class II-A waters.

The SVOC bis(2-ethylhexyl)phthalate was detected at trace concentrations in samples from MW104S and MW106S (1 ppb and 2 ppb, respectively). Isophorone was detected at a concentration of 570 ppb in the sample from MW105S. Naphthalene was detected at the trace level of 1 ppb in the sample from MW105S and the duplicate. Trace concentrations (1 ppb) of di-n-octylphthalate and butylbenzylphthalate were detected in MW106S. Non-target SVOCs were detected in all the shallow well samples, except the sample from MW101S, with concentrations ranging from 3 ppb (MW-3) to 374 ppb (MW105S). While there are no state or Federal MCLs for these detected SVOCs, the concentration of isophorone detected in MW105S exceeds the New Jersey class II-A groundwater quality criterion of 100 ppb. Further, the sum of VOC and SVOC concentrations, including both target and non-target analytes is 1076 ppb in MW105S and as such, exceeds the New Jersey generic class II-A groundwater quality criterion of 500 ppb for total non-carcinogenic synthetic organic chemicals. The concentrations of bis(2-ethylhexyl)phthalate, butylbenzylphthalate, and di-n-octylphthalate detected in MW104S (only bis(2-

ethylhexyl)phthalate detected) and MW106S are below New Jersey class II-A groundwater criteria. There is no class II-A groundwater criterion for naphthalene.

Groundwater samples for inorganic analysis consisted of unfiltered and filtered aliquots. Inorganic analytes were typically present at higher concentrations in the unfiltered aliquot of a sample than in the filtered aliquot. Also, inorganic analytes were often detected in the unfiltered fraction of a sample, but not in the filtered aliquot. Arsenic was detected in unfiltered samples from MW-3 and MW101S at concentrations which exceed the New Jersey class II-A groundwater quality criterion. However, the corresponding filtered samples did not exceed this criterion. There is no state or Federal MCL for arsenic. Chromium was detected in unfiltered samples from MW-3 and MW101S at concentrations which exceed the state and Federal MCLs. As with arsenic, the concentrations of chromium detected in the corresponding filtered samples were below the applicable criterion. Cobalt was detected in the unfiltered samples from MW101S (13.4 ppb), MW102S (8.1 ppb), MW105S (23.7 ppb), and MW106S (9.4 ppb). There is, however, no state or Federal MCL or New Jersey class II-A groundwater standard for cobalt with which to compare these samples. The concentrations of manganese detected in unfiltered samples from eight wells (MW-1, MW-2, MW-3, MW101S, MW102S, MW103S, MW105S and MW106S) as well as the concentrations detected in filtered samples from six of these wells (MW-1, MW-2, MW102S, MW103S, MW105S and MW106S) exceed the New Jersey class II-A groundwater quality criterion. There is no state or Federal MCL for manganese. Lead exceeds the state and Federal MCLs in the unfiltered samples from MW101S, MW103S, and MW106S, but was not detected or detected below the criterion (15 ppb) in the corresponding filtered samples. Nickel was detected at about 140 ppb in both the filtered and unfiltered sample from MW106S and both exceed the state and Federal MCLs. Vanadium was detected in unfiltered samples from eight wells (MW-1, MW-2, MW-3, MW101S, MW103S, MW104S, MW105S, and MW106S) but was not detected in the corresponding filtered samples. There is, however, no state or Federal MCL or New Jersey class II-A groundwater criterion for vanadium with which to compare these samples. Zinc was detected in all shallow well samples, both filtered and unfiltered, at levels below the New Jersey class II-A groundwater criterion. There is no state or Federal MCL for zinc.

Groundwater samples from the shallow wells were also analyzed for the wet chemistry parameters shown in Table 4-14. Total Suspended Solids (TSS) concentrations measured range from 30.3 ppm in the MW-2 sample to 781 ppm in MW103S sample. TSS concentrations are generally higher in the samples from the shallow wells than in samples from the deep wells, in which they range from 23.9 ppm to 50.7 ppm. The higher TSS concentrations in the shallow wells may be attributed to the finer grained deposits (silt and fine sand) of the shallow formation and the slow recharge rates typically associated with those wells, which adversely affected well development efforts.

TDS concentrations measured range from 40 ppm in the sample from MW102S to 470 ppm in the sample from MW104S. Chloride concentrations range from

10.85 ppm in the sample from MW102S to 112.5 in the sample from MW101S. Chloride was not detected in samples from MW-2 and MW103S. The concentration of methylene blue active substances (MBAS), which indicate the presence of detergents (surfactants), is 4.2 ppm in the sample from MW105S. MBAS were not detected in any of the other groundwater samples. It should be noted that groundwater from MW105S foamed when it was withdrawn from the well using a centrifugal pump. The foaming was severe enough to affect the efficiency of the pump.

Nitrate was detected in seven of the nine groundwater samples collected from shallow wells. Concentrations found range from 0.19 ppm in the MW-2 sample to 14 ppm in the MW104S sample. COD was detected in all of the groundwater samples except MW103S and MW104S. Concentrations range from 24.2 ppm in the sample from MW102S to 51.0 ppm in the sample from MW105S. BOD was detected in two of the nine groundwater samples from shallow wells. The BOD concentrations found in the samples are low, 3.9 ppm in the sample from MW105S and 4.3 ppm in the sample MW102S. Petroleum hydrocarbons (TPHC) were not detected in any of the groundwater samples.

4.7.2 Wenonah-Mt. Laurel Aquifer (Deep Monitoring Wells)

Monitoring wells MW101D, MW102D, and MW103D were installed to monitor groundwater quality in the Wenonah-Mt. Laurel Aquifer. These wells are part of three two-well clusters that include the corresponding shallow (Navesink Formation) wells MW101S, MW102S, and MW103S.

With the exception of methylene chloride, a common laboratory contaminant detected in MW102D that was also detected in the method blank associated with the sample, no target or non-target VOCs were detected in samples from the deep monitoring wells. No target SVOCs were detected in the samples from the deep wells. Non-target SVOCs were detected in the samples from MW102D and MW103D at 43 ppb and 35 ppb, respectively.

Groundwater samples for inorganic analysis consisted of filtered and unfiltered aliquots. As expected, detected inorganic analyte concentrations for the filtered sample aliquots are typically lower than the concentrations found in the unfiltered samples.

The chromium concentration of 136 ppb found in the unfiltered sample from MW101D exceeds the Federal MCL of 100 ppb; however, chromium was not detected in the filtered sample. No other inorganic analyte concentrations in the filtered and unfiltered samples from the deep wells exceed the applicable criteria.

Groundwater samples were also analyzed for seven wet chemistry parameters, as shown in Table 4-14. Neither MBAS nor TPHC were detected in any of the deep well samples. TSS concentrations found range from 23.9 ppm in the sample from MW103D to 50.7 ppm in the sample from MW101D, and are lower in these samples than in the shallower Navesink Formation groundwater samples, except for MW-2 (30.3 ppm). The TDS concentration of 660 ppm in the sample from MW101D is the highest of any groundwater sample. Relatively low concentrations of TDS were detected in samples from MW102D (40 ppm) and MW103D (100 ppm). Nitrate-nitrogen (NO_3-N) was detected in the MW102D sample at a concentration of 1.5 ppm, but was not detected in samples from MW101D and MW102D. BOD was not detected in any deep well sample. COD was detected only in MW102D at a concentration of 20.6 ppm.

4.8 Data Validation and Quality Assurance

In accordance with USEPA Region II policy, no data are presented in this report which have not been validated. Validation of TCL organics (volatiles and semivolatiles) data was performed in accordance with SOP No. HW-6 "CLP Organics Data Review and Preliminary Review", Revision #7, March 1990, and Revision #8, January 1992. Validation of inorganics (metals and cyanide) data was performed in accordance with SOP No. HW-2, "Evaluation of Metals Data for the Contract Laboratory Program (CLP)", Revision X, March 1990, and Revision XI, January 1992. Validation of TCLP data incorporate SOP No. HW-7, "TCLP Data Validation", Revision #1, February 1992. Validation of non-CLP data (e.g., petroleum hydrocarbons, wet chemistry, and geotechnical analyses) was based on the professional judgment of the validator, and included review of the laboratory's adherence to the specified method and evaluation of the required QA/QC data in comparison to the method or contract-specified limits.

Field Quality Control (QC) samples, which included field duplicates, field blanks, and trip blanks, which are not included in the Chapter 4 tables but were used in the data validation process, are included in Volume III - Appendix H. It should be noted that the data validation protocols require that these QC samples (as well as laboratory QA samples) be used only to qualify data from other field samples with which they are associated. However, a few general observations are warranted based on a review of the overall data set generated for this RI.

4.8.1 Field Duplicates

Analysis of field duplicates is a measure of both sampling and analytical precision. Field duplicate precision was generally within the acceptable limits. In some cases, the presence of an analyte may have been reported in a duplicate sample, but not in the original field sample, at a concentration greater than the laboratory's detection limit, but less than the concentration of the lowest calibration standard (the CRQL for volatile organics or CRDL for inorganics). This is not unexpected at these low levels of quantitation and is not considered to affect the data quality or usability.

4.8.2 Blank Analysis

Field, trip, and laboratory blank data were evaluated in order to rule out false positives; i.e., reported detections in field samples that have a significant possibility/probability of being artifacts of contamination introduced by the field sampling and analysis process.

Data have been negated or rejected for blank contamination in accordance with the applicable validation guidelines. Organic data associated with contaminated blanks, but not at a concentration sufficient to warrant negation, are shown on the tabulated data with the qualifier "B" (compound also found in associated blank). It is the judgment of TAMS' data reviewers that volatile organic analytes with this qualifier (acetone and methylene chloride) probably are not indicative of field sample contamination; in fact, based on the prevalence of blank contamination with these compounds, other reported detections of these compounds (without the "B" qualifier) should be considered as possible extraneous contamination. TAMS' discussion of the data reflects this evaluation.

The semivolatile organic compound butylbenzyl phthalate was also found in blanks associated with high concentration detections (250,000 to 500,000 ppb) in lagoon sediment samples. Due to the presence of butylbenzyl phthalate at high concentrations (up to 31,000,000 ppb) in other lagoon sediment samples, as well as historical evidence of the presence of this compound at the K&M Site, these data are considered to be representative of environmental contamination (rather than a result of laboratory contamination).

4.8.3 Filtered and Unfiltered Aqueous Sample Metals Analysis

The surface water and groundwater samples analyzed for metals were submitted as both filtered and unfiltered samples, so that both dissolved and total metals concentrations were determined. The filtered and unfiltered concentrations were compared during data validation, and data were qualified or rejected in accordance with the criteria specified in the SOP. In some cases, low concentrations (greater than the instrument detection limit, but less than the lowest concentration calibration standard [CRDL]) were reported in the filtered sample, but not in the unfiltered, or, a higher concentration (but still less than the CRDL) was detected in the filtered sample than the unfiltered sample. Such anomalies are not unexpected at the low end of the analytical quantitation range, and did not cause data to be qualified.

4.8.4 Analytical Completeness

There were 10,666 analytical data points generated in support of this investigation (not including QA/QC samples). Of these, 136 were rejected through the data validation process due to significant quality control problems. This yields an overall rejection rate of 1.3%, or 98.7% data usability. In no case was data for an entire fraction (volatile organics, semivolatile organics, or inorganics) rejected for an individual sample.

The rejection rate can be broken down further into the analytical fractions which represent discrete analytical methodologies. The rejection rate for the volatile organic fraction was 0.75% (20 rejections out of 2660 data points), 0.23%

rejection for the semivolatile organic fraction (11 rejections out of 4940 data points), 2.7% for the Target Analyte List (inorganic) fraction (63 rejections out of 2304 data points), 8.1% for the Toxicity Characteristic Leaching Procedure (40 rejections out of 494 data points), 1.9% for the Total Organic Carbon (1 rejection out of 54 data points), 1.9% for the Total Petroleum Hydrocarbons analysis (1 rejection out of 54 data points) and the wet chemistry had a 0% rejection rate (100% usability) out of 160 data points.

In no case, were all data points for an analyte rejected in every sample from a particular sampling location. For example, the 0.75% overall rejection rate for the volatile fraction was derived from the rejection of 20 out of 35 analytes in one sample collected from the surface water body sediment area. The data from the remaining six samples collected from this area are complete. In the inorganic fraction, the maximum number of data points were rejected for lead, mercury, and sodium, each of which were rejected in four of out of 13 soil samples collected from the marsh area.

5.0 CONTAMINANT FATE AND TRANSPORT

The previous chapter outlines the occurrence of contamination across the site in surface soil, subsurface soil, sediment, groundwater, and surface water. Observed contamination consists mainlv of phthalates, aromatic hydrocarbons, chlorinated VOCs, and petroleum hydrocarbons in lagoon sediments, and phthalates and petroleum hydrocarbons in the surface soils and sediments. Elevated concentrations of metals (cadmium, chromium, copper, zinc and others) occur periodically. Manganese occurs in elevated concentrations in most aqueous (surface water and shallow and deep groundwater) samples.

5.1 Potential Routes of Migration

Several of the environmental media studied have the potential for off-site migration, primarily lagoon sediment and surface soil (see Figure 2-1 for sampling locations). Subsurface soils do not have the potential for off-site transport unless exposed by excavation. Although several contaminants of concern were detected in subsurface soil samples, the mode of transport of these contaminants would be through leaching and subsequent groundwater transport.

Surface soils can migrate or be carried from the site by overland runoff/entrainment (resulting from precipitation), in the form of airborne dust, and by users of the site (via vehicle tires or shoes, for example). In addition, contaminants can move from the surface soils (leaving the soils in place) through leaching by infiltration of precipitation and transport by groundwater, and volatilization to ambient air. Lagoon sediment migration may occur when the lagoon fills with water and overflows, as has happened in the past. Sediments in Barker's Brook and bed soils in the intermittent stream and drainage ditch are subject to waterborne transport. Drainage ditch and intermittent stream bed soils are subject to waterborne transport only after periods of significant rainfall, since these channels are normally dry.

Groundwater from the Wenonah - Mt. Laurel Aquifer is used as a drinking water source in the vicinity of the site and, although the comparatively low hydraulic conductivity associated with the Navesink Formation largely precludes its use as a potable water source, the Navesink Formation is a potential potable water source as well. In contrast to the groundwater samples collected in the shallow wells in which VOCs and phthalates were detected, the groundwater samples collected from the deeper monitoring wells as part of this investigation do not show any apparent contamination attributable to the site. Both the deep and shallow wells exhibit elevated concentrations of manganese which appear to be a local anomaly, as opposed to resulting from site contamination.

Surface water flow consists of discharges from the drainage ditch and intermittent stream and surface runoff from precipitation. Surface water quality appears impacted only in the immediate vicinity of the site, namely, at intermittent discharge locations between the K&M property and Barker's Brook. Dilution or natural renovation occurs downstream of the site, i.e., at Barker's

Brook, so that no discernible effects attributable to the site were observed in surface water samples from Barker's Brook. However, contaminated surface water does represent a potential route of migration from the site.

5.2 Contaminant Distribution and Observed Migration

The following section discusses the contaminant presence across the site, as outlined in Chapter 4, in combination with the migration pathways presented in Section 5.1, to provide an understanding of contaminant persistence and migration at the site. The discussions below are presented with respect to contaminants or contaminant groups. Contaminants observed in the environmental samples collected from the site include VOCs, SVOCs, and inorganics.

5.2.1 Volatile Organic Compounds

While widespread at the site, VOCs are present primarily at low concentrations; although concentrations greater than 10,000 ug/kg (i.e., 10 ppm) were detected in three samples from the lagoon sediments and drainage ditch bed soils. As indicated in Figure 5-1, the highest total VOC concentrations were detected in the lagoon sediments and in the drainage ditch bed soils, both of which were used as discharge points for selected wastewaters generated during K&M operations. Lower concentrations were detected in the site surface soils and marsh soils with the lowest VOC concentrations being detected in the Barker's Brook sediment and the intermittent stream bed. The VOCs detected at the site include aromatic hydrocarbons, chlorinated aliphatics, and ketones.

Aromatic Hydrocarbons

The most commonly detected VOCs on site are the aromatic hydrocarbons benzene, toluene, ethylbenzene, and xylenes, or BTEX compounds. Of the BTEX compounds, xylene and toluene were detected most frequently and in the highest concentrations; benzene was detected in only two samples, and at low concentrations (less than 20 ppb). The BTEX compounds were detected in lagoon sediments and surface soils from the unpaved operations lot, marsh area, and drainage ditch. Low BTEX concentrations (less than 10 ppm) were also detected in surface soils from the washwater collection pit area) and the intermittent stream bed. BTEX compounds were detected in only one aqueous sample, a groundwater sample from the Navesink Formation, at a concentration of 9 ppb total, including 1 ppb benzene; no BTEX compounds were detected in any of the surface water samples.

The principal mechanism for the natural removal of aromatic VOCs is through volatilization (USEPA, 1979). As shown on Table 5-1, vapor pressures (at approximately 20°C) of the aromatic hydrocarbons range from 7 to 76 mm Hg and Henry's Law Constants range from 5.4 x 10-3 to 6.7 x 10-3 atm-m3/mol. The environmental half-life of the BTEX compounds is fairly short (28 days or less) in soil and surface water, but may be substantially longer (up to 1 year for xylenes and 2 years for benzene) in groundwater, where biodegradation is not significant.

The adsorption of BTEX compounds to soil particles is related to the amount of organic carbon in the soil and is represented numerically by the organic carbon partition coefficient (Koc). The BTEX compounds detected at the K&M Site have similar log Koc values, ranging from 1.94 to 2.50. The compounds with higher Koc values would be preferentially partitioned to organic matter in soils and so would be less likely to leach from the soils and transported to the groundwater. These log Koc values indicate a low to moderate tendency of BTEX compounds to adsorb to soils. The aqueous solubility of the BTEX compounds is moderate, ranging from about 150 ppm for xylenes to 1,700 ppm for benzene. However, in the lagoon sediments, the significant presence of other organic compounds, particularly phthalates, may serve to further bind the BTEX compounds to soil/phthalate matrix, thereby reducing the rate of transfer into the groundwater.

Based on the aqueous solubility and Koc values, the BTEX compounds are fairly mobile in soil; however, the Henry's Law Constant and environmental half-life data indicate that soil concentrations are expected to attenuate naturally fairly rapidly. However, any BTEX compounds reaching either the shallow (Navesink) or deep (Wenonah - Mt. Laurel) groundwater would be expected to be fairly persistent and mobile. The data for aromatic hydrocarbons, along with the data for chlorinated VOCs (see below) and SVOCs other than phthalates or PAHs (see Section 5.2.2), suggest that organic contaminants have migrated from the lagoon into the shallow groundwater in the Navesink Formation, and then migrated with the groundwater toward the south or southwest.

Off-site transport by surface runoff of BTEX compounds appears to be occurring at the site, as high concentrations (about 292,000 ppb total) were detected in the drainage ditch bed soil sample adjacent to the site (SD06). BTEX data further downstream in the ditch (SD05) were unusable (rejected); however, no BTEX compounds were detected even further downstream, past the confluence with Barker's Brook (i.e., at SD01).

Chlorinated Aliphatics

Chlorinated aliphatics (trichloroethene, 1,1,1-trichloroethane, 1,2-dichloroethene, tetrachloroethene, and 1,1-dichloroethane) were detected in high concentrations in one lagoon sediment sample (SD15) but, in general, were detected infrequently.

Chlorinated VOCs were not detected in surface water samples, but were detected in two groundwater samples. The highest concentration of chlorinated VOCs detected in a groundwater sample was 131 ppb (including 94 ppb 1,2-dichloroethene and 17 ppb vinyl chloride) at location MW105S; three chlorinated VOCs at a total concentration of 21 ppb (including 15 ppb 1,1,1-trichloroethane) were also detected in MW102S.

Methylene chloride was detected in groundwater and surface water samples. It is assumed to be associated with laboratory blank contamination in all cases (i.e., qualified "B") for the following reasons:

1. Methylene chloride was detected in virtually every trip blank, field blank, and method blank associated with the groundwater and surface water samples.
2. In all but sample GW02 collected from MW102D (Wenonah-Mt. Laurel groundwater sample), the reported concentration of methylene chloride was less than 10 times the maximum concentration detected in the associated blanks. Sample GW02 was analyzed at a 10-fold dilution, and by taking this dilution into account, the detected methylene chloride concentration in GW02 is also less than 10 times the maximum blank concentration. The "Risk Assessment Guidance for Superfund" (USEPA, 1989a) states that a common laboratory contaminant may be excluded if the concentration detected in the sample is less than 10 times the maximum concentration detected in any blank.
3. The detection of methylene chloride in GW02 is anomalous in that it was not detected in the lagoon sediments nor was it detected at greater concentration in the Navesink groundwater samples.

The chlorinated VOCs would exhibit a similar fate and transport pattern to the BTEX compounds. The log Koc values for the chlorinated VOCs detected at the K&M Site are similar to or lower than those of the BTEX compounds; their vapor pressures, aqueous solubilities, and Henry's Law Constants tend to be somewhat higher. Therefore, both volatilization and leaching of chlorinated VOCs would be expected to be at least as rapid as for the BTEX compounds. The detection of trichloroethene in the TCLP analysis of SD15 at a concentration substantially exceeding the regulatory limit (4260 ug/l in the SD15 TCLP analysis, vs. the regulatory limit of 500 ug/l) confirms the mobility of the chlorinated VOCs as well as the potential for migration to groundwater. The environmental half-life of the chlorinated VOCs is also longer, indicating less rapid natural attenuation of these substances in all media (soil, groundwater, and surface water); therefore, the chlorinated VOCs are expected to be fairly persistent, especially in groundwater.

Carbon disulfide was detected in several samples, including three marsh area soil samples, one Barker's Brook sediment sample, and one lagoon sediment sample. Carbon disulfide is soluble in water but was not detected in any groundwater or surface water samples. Carbon disulfide was detected at low concentrations (less than 10 ppb) in the samples from the marsh and Barker's Brook. These low concentrations may be biogenic in origin and are not considered significant. A higher concentration (2500 ppb) was detected in one lagoon sediment sample (SD17). The origin of the carbon disulfide in this sample is uncertain; however, high concentrations of other organic compounds including ketones (4380 ppb total), BTEX (29,500 ppb), and phthalates (586,800 ppb), among others, were also detected in SD17.

Chlorinated VOCs, including a high concentration of 1,2-dichloroethene (total) (27,000 ug/kg) were detected in the drainage ditch bed soil sample adjacent to the site (SD06). However, these chlorinated VOCs were not detected farther downstream in the ditch (sample location SD05) or farther downstream in Barker's Brook (sample location SD01).

As with BTEX compounds, chlorinated VOCs were detected in two shallow wells near the lagoon and downgradient of it (MW105S and MW102S), indicating that the chlorinated VOCs have migrated from the lagoon sediments and into the shallow Navesink Formation groundwater. The absence of chlorinated VOCs from MW-2, which is also downgradient of the lagoon but closer to the lagoon than MW102S, is anomalous. However, available well construction and groundwater elevation data indicate that the top of the shallow groundwater table was probably about five feet above the top of the MW-2 well screen at the time of sampling in March, 1992. It is possible that contaminants may not have been detected at MW-2, which is only 50 feet from the perimeter of the lagoon, due to incomplete vertical (downward) diffusion of the contaminants. It should also be noted that chlorinated VOCs (including trichloroethene at 7 ppb) were detected in previous (1982) sampling at MW-2.

Ketones

Four ketones were detected at the site in various sampled media. Acetone, 2-butanone (MEK), 2-hexanone and 4-methyl-2-pentanone (MBK) were detected in surface and subsurface soil samples. Acetone and 2-butanone are common laboratory contaminants and their presence in low concentrations in any sample should be considered with some reservation. Concentrations of the ketones were generally low (less than 100 ppb); samples in which higher concentrations were reported generally also had significant phthalate contamination (more than 10,000 ppb total phthalates). The only ketone which is a TCLP analyte, 2-butanone, was not detected in the TCLP analysis of any sample.

The ketones detected at the K&M Site are all soluble in water (ranging from 1.9% to infinite solubilities) and, with the exception of 2-hexanone, have low log Koc values (less than 1.0). Coupled with the fairly high vapor pressures of these compounds, the ketones are highly mobile. However, the ketones also have short environmental half-lives in all media (14 days); therefore, rapid natural attenuation of these compounds is expected in soil, surface water, and groundwater. The absence of ketones from monitoring wells downgradient of the lagoon reflects the short anticipated environmental half-lives of these compounds; lagoon sediment contaminants with longer half-lives were detected in downgradient wells.

Relatively low concentrations of ketones (590 ppb acetone and 220 ppb 2-butanone) were detected at SD01, downstream of the confluence of Barker's

Brook and the two discharges (i.e., the intermittent stream and drainage ditch). However, ketones were not detected in any of the discharge sediment samples. This apparent anomaly may be attributable to laboratory contamination, as acetone and 2-butanone were detected in laboratory blanks associated with these samples, although not at concentrations high enough to warrant negation of the ketone results from sample SD01.

Comparison with Previous Data

Previous groundwater sampling data collected by NJDEP (1981, 1982, and 1988) and NUS (contractor to USEPA) in 1985, indicated the presence of methylene chloride (25 ppb) and trichloroethylene (7 ppb) in MW-2 in 1982. No valid detections of other VOCs were reported in the 1981, 1982, or 1985 sampling.

The results of this Remedial Investigation (RI) confirm the previous results (i.e., target VOCs were not detected in MW-1, MW-2, or MW-3). However, data from wells installed for this RI do show the presence of chlorinated VOCs in two samples and BTEX compounds in one sample. The absence of these contaminants from the three deeper wells indicates that there is no evidence as of yet that contamination has migrated into the Wenonah - Mt. Laurel Aquifer. Similarly, the absence of BTEX compounds in soils adjacent to the former washwater collection pit in three of the four samples from this area (low levels - less than 10 ppb total were detected in SB-18), despite their presence in previous aqueous samples from the pit, is not unexpected, based on the fate and transport processes described for these contaminants earlier in this section.

5.2.2 Semivolatile Organic Compounds

Semivolatile organic compounds (SVOCs), especially phthalates, were detected in surface soils, subsurface soils, groundwater, and surface water discharge locations but were not detected in surface water from Barker's Brook. Polynuclear aromatic hydrocarbons (PAHs) were also detected in several samples but less frequently and at lower concentrations than phthalates. As indicated in Figure 5-2, the highest total VOC concentrations were detected in the lagoon sediments and in the drainage ditch bed soils, both of which were used as discharge points for selected wastewaters generated during K&M operations. Lower concentrations were detected in the marsh soils and lagoon berm soils with the lowest total SVOC concentrations being detected in site surface soils and Barker's Brook sediment. The semivolatile compounds, particularly the PAHs, are persistent in the environment due to their chemical nature. Some of the lighter PAHs (e.g., naphthalene and 2-methylnaphthalene, with only two aromatic rings) would be subject to biodegradation or volatilization, but the chemical persistence generally increases with increasing number of aromatic rings. SVOCs are generally characterized by high boiling point, low vapor pressure, and low solubility (except phenols). Physical constants for SVOCs detected at the K&M Site are presented in Table 5-1.

The SVOCs are divided into the following groups for discussion: phthalates; polynuclear aromatic hydrocarbons (PAHs) and naphthalene; and other compounds (phenol, 1,2-dichlorobenzene, carbazole, and isophorone). Total petroleum hydrocarbons (TPHC), although not a discrete fraction of organics, are also discussed in this section for convenience.

Phthalate Compounds

Phthalate compounds were reported in samples from all environmental media collected at the site, although phthalates were not detected in surface water samples from Barker's Brook. Five different TCL phthalates were detected at the site, consisting of butylbenzylphthalate, di-n-octylphthalate, di-n-butylphthalate, bis(2-ethylhexyl)phthalate (BEHP), and diethylphthalate. Of these, butylbenzylphthalate and di-n-octylphthalate were detected most often and at the highest concentrations, with butylbenzylphthalate usually occurring at higher concentrations than di-n-octylphthalate. It should be noted that phthalates are common laboratory contaminants and are widespread in the environment (ATSDR, 1989a; ATSDR, 1989b); therefore, some low concentration detections, especially of BEHP, may be suspect. However, the high concentrations detected in many samples, coupled with the known use and presence at phthalates at the site, indicates that these phthalate detections are attributable to environmental contamination at the site. The phthalate esters are distributed in the environmental samples from the site as follows:

- Surface soil samples distributed across the site.
- Subsurface soil samples from the lagoon and one monitoring well boring.
- Groundwater samples from two shallow monitoring wells, but at low concentrations (less than 5 ppb total phthalates).
- Water and bed soil samples from discharge locations (i.e., the ditch and intermittent stream).
- Sediment from all three Barker's Brook sample locations.
- Trace concentrations in two (one on-site and one off-site) downgradient surface water samples.

The occurrence of phthalate esters is widespread across the site, including presumed background sample locations. They generally exhibit low solubility and high Koc, and so would not be particularly amenable to water transport except in suspension as solid-bound phthalates. This is consistent with the site data, which show the phthalates primarily in sediment and soil samples. However, control of phthalate migration from the site would require control of sediment and soil migration, as well as discharges from the lagoon.

The data from Barker's Brook sediment and discharge location bed soil samples suggest that some migration of phthalates has occurred. High phthalate concentrations were detected in the drainage ditch opposite the lagoon (4,200 ppm total phthalates in SD06). The phthalate concentration detected about 550 feet farther downstream in the ditch (SD05) is an order of magnitude lower (423 ppm). Phthalates were also detected at much lower concentrations in the Barker's Brook sediment sample downstream of the ditch (1.56 ppm in SD01).

Polynuclear Aromatic Hydrocarbons

PAHs, including naphthalene and 2-methylnaphthalene, were detected at concentrations up to 120,000 ppb in one lagoon sediment sample (SD15). Detections in other areas of the site were at lower concentrations, with the next highest concentration of PAHs detected in the surface soil sample intended as the background sample (4649 ppb total PAHs in SS01). PAHs generally have a very low solubility (30 mg/l or less). The Koc values of PAHs are generally greater than 1,000 ml/g (log Koc greater than 3.0), with many greater than 100,000 ml/g (log Koc greater than 6.0). This indicates that PAHs readily adsorb to organic carbon in soils. This accounts for their virtual absence from the groundwater and surface water samples.

Naphthalene, which has the highest aqueous solubility and lowest Koc of all the PAHs detected at the site, was detected at a low concentration (1 ppb) in one shallow groundwater sample (MW105S); no PAHs were detected in any of the surface water samples or in any of the other groundwater samples.

PAHs are readily adsorbed onto particulates (Callahan et al., 1979). Biodegradation is expected to play a significant role in the fate of PAHs which accumulate onto sediments (USEPA, 1979). PAHs were present in one sediment sample collected from the lagoon, two surface soil samples from the marsh, all three sediment samples from Barker's Brook, three surface soil samples from the unpaved operations lot, and the surface soil sample from the septic system area. PAHs and naphthalene were not detected in the bed soil samples from discharge locations (although the detection limits were high [19,000 to 440,000 ppb]), surface soil samples from the washwater collection pit, drum, or spoils areas, or in subsurface soils from the UST area or unpaved operations lot. Since PAHs are present in asphalt and tars, as well as particulates from vehicles exhaust, PAHs detected in surface soil samples, including background sample SS01, may be due to roadway runoff. With the exception of SD15, PAH concentrations detected at the K&M Site are within the range (4 to 13 ppm) total PAHs reported as background in areas not influenced by industrial or urban activities (ATSDR, 1990).

Other Semivolatile Organic Compounds

Other SVOCs detected in the environmental samples include phenol, 1,2-dichlorobenzene, carbazole and isophorone. These compounds appear in isolated occurrences, showing no apparent pattern. Although present in on-site surface and subsurface soils, groundwater, surface water, surface waterbody sediments, and surface water discharge locations, they do not appear in surface water or sediment samples collected downgradient of the site (i.e., from Barkers Brook).

Phenol is more soluble in water than other SVOCs and displays a relatively low volatility (the vapor pressure of phenol is less than the aromatic hydrocarbons but slightly greater than naphthalene; the Henry's Law Constant for phenol is much less than that of naphthalene). Based on the relatively low Koc and high solubility of phenol, it would not tend to adsorb to soils and sediment organic matter; but would tend to leach from soil into groundwater. Phenol was detected in subsurface soil, groundwater, surface water and sediment samples. The apparent absence of phenol from surface soil may be due to its solubility (leaching potential) or biodegradability (Callahan et al., 1979).

Phenol was detected at a very low concentration (1 ppb) in two surface water (discharge) samples from the ditch, but phenol was not detected in any other on-site or off-site surface water samples. Phenol was also detected in one sediment sample downgradient of the site.

Isophorone was detected at a low concentration (41 ppb) in the deepest subsurface lagoon soil sample, and at a higher concentration (570 ppb) in a shallow groundwater sample from the monitoring well immediately downgradient of the lagoon (MW105S). Although isophorone was not detected in any of the lagoon sediment samples, this may have been due to the high detection limits (14,000 to 74,000 ppb) for isophorone in these samples. Isophorone has a high aqueous solubility (12,000 ppm) and a fairly low Koc (log Koc 1.49); therefore, vertical transport from the lagoon sediments, through the underlying soils and into the groundwater, is likely and the data suggest that this has, in fact, occurred.

Carbazole was detected at a low concentration (83 ppb) only in the surface soil sample intended as background (SS01); no significance is attached to this finding. The only detection of 1,2-dichlorobenzene was at 15 ppm in the most contaminated lagoon sediment sample (SD15). This finding is also not considered significant.

Total Petroleum Hydrocarbons

Total petroleum hydrocarbons (TPHC) analysis was conducted on all surface and subsurface soil samples, on the sediment samples, and on the surface water and groundwater samples. Petroleum hydrocarbons include numerous volatile and semivolatile hydrocarbons, including both aliphatics and aromatics. Some target analytes, including the BTEX compounds and PAHs, are found in various petroleum products.

Based on the site history and age, the petroleum hydrocarbons remaining on site would be expected to be the less volatile, higher molecular weight constituents. These compounds would also be expected to have relatively low water solubilities and moderate to high Koc values. The distribution of observed TPHC confirms these assumptions. Petroleum hydrocarbon concentrations are highest in the surface soils; concentrations are much lower in the subsurface soils. For example, the geometric mean TPHC concentration in the five lagoon sediment samples is about 8600 ppm, but the concentration is much lower in the subsurface sample from the 2 to 4-foot interval (272 ppm in SB02), and lower still (48 ppm) in the 10 to 12-foot sample (SB02A).

The absence of detectable concentrations of petroleum hydrocarbons in groundwater samples is consistent with both the expected and observed behavior of these compounds. The observed attenuation of TPHC concentration with depth, along with the expected Koc values and low aqueous solubilities of these compounds, would indicate that migration of these compounds into groundwater is not likely to be significant.

High TPHC concentrations (85,400 ppm) were detected in the drainage ditch bed soil sample adjacent to the site (SD06); significant, though lower, concentrations (57,200 ppm) were also detected in SD05, about 550 feet downstream of SD06. These data indicate that petroleum hydrocarbons are probably being transported to the ditch and then downstream toward Barker's Brook via surface water transport of entrained (suspended) contaminated soils or sediments. The detection of petroleum hydrocarbons at lower concentrations (5,360 ppm) in Barker's Brook sediments at location SD01, about 50 feet downstream of the confluence of the ditch with Barker's Brook, is difficult to evaluate. Although the data are consistent with continued migration of TPHC from the ditch, location SD01 is also subject to the influence of contamination from Jobstown-Juliustown Road; how much each of these sources (i.e., site-related contamination and roadway-related contamination) contributes cannot be determined.

High TPHC concentrations (21,000 ppm) were also detected in bed soils of the intermittent stream originating near the southeast corner of the lagoon (SD04), indicating the probable influence of previous lagoon overflows or overland contaminant transport. Sediment TPHC concentrations at Barker's Brook in the vicinity of its confluence with the intermittent stream do show an increase in TPHC contamination in the downstream sample (131 ppm in SD02) as compared to the upstream sample (83 ppm in SD03).

Comparison with Previous Data

No valid detections of SVOCs were reported in previous groundwater sampling data collected by NJDEP (1981, 1982, and 1988) and NUS (contractor to USEPA) in 1985. Low concentrations of phthalates were detected in MW-2 and MW-3 in 1985, and in 5 residential wells (2.7 to 9.1 ppb di-n-butylphthalate and 11.0 to 23.4 ppb bis(2-ethylhexyl)phthalate) in 1988. These detections may be attributable to field or laboratory contamination.

Previous data indicated high concentrations of phthalates in aqueous samples from the lagoon and washwater collection pit (Environics, 1986) as well as sediments from the lagoon (Environics, 1986; NJDEP, 1985). In general, the results of the RI are consistent with these results, both in terms of the identity and concentration of the analytes detected. The presence of phthalates in soil samples taken adjacent to the former washwater collection pit during the RI is as expected, based on the concentrations previously detected in aqueous samples from the pit.

5.2.3 Pesticides and PCBs

The site history and previous data did not suggest the presence of PCBs or pesticides at concentrations of concern at the K&M Site; therefore, samples collected for the RI were not analyzed for these compounds. If present, several PCBs and pesticides would have been detected as non-target Tentatively Identified Compounds (TICs) in the semivolatile organics analysis; however, no TIC pesticides or PCBs were reported.

5.2.4 Inorganic Analytes

The presence of numerous inorganic analytes was reported in Chapter 4. Many metals have an affinity for soils (particularly clay particles and organic matter in soils) which reduce their mobility. Under low pH conditions, most metals can be rendered mobile. The presence of the inorganic analytes, particularly the naturally occurring elements, must be examined in the context of background concentrations for the site, as discussed in Chapter 4. The analytes which appeared elevated above soil background evaluation criteria in one or more samples are: chromium, copper, cadmium and zinc. Antimony, beryllium, manganese, selenium, vanadium and cyanide were also detected in concentrations exceeding the soil evaluation criteria. As is evident in Figure 5-3, the highest concentration of total inorganics (not including crustal abundant elements - aluminum, calcium, iron, potassium, magnesium, and sodium) was detected in the drainage ditch bed soils. Relatively high total inorganics concentrations were also detected in one site surface soil sample and one lagoon sediment sample. However, the total metals concentrations detected in the majority of the sediment and soils samples collected were comparable and are likely representative of background conditions. The distribution of these analytes is discussed below.

Soil and Sediment

- Chromium was detected at concentrations above the background criterion (41.4 ppm) in one or more surface soil samples from the lagoon berm, the former washwater collection pit area, the UST area, the marsh, the intermittent stream bed and the drainage ditch bed. In addition, chromium was detected above background criterion in subsurface soils collected from the lagoon, the unpaved operations lot, the septic system area, MW101S, and MW103D. Chromium was also detected above the background criterion in two lagoon sediment samples.

- Copper was detected at concentrations above the background criterion (11.1 ppm) in one or more surface soil samples from the former washwater collection pit area, the unpaved operations lot, the excavation spoils area, the marsh, and the drainage ditch. Copper was also detected above background criterion in the lagoon sediment and in subsurface soil samples from MW103D.

- Cadmium was detected at concentrations above the background criterion (0.26 ppm) in surface soil samples from the unpaved operations lot, the drainage ditch, and the marsh. Cadmium was also detected above background criterion in the lagoon sediments.

- Zinc was detected above background concentrations in the lagoon sediments as well as in surface soil samples collected from the unpaved operations lot, the drainage ditch, and the marsh.

- Beryllium, selenium, and vanadium were also detected at concentrations which exceed background criteria. The highest concentrations of these metals on site were detected in the marsh soil. Vanadium was also detected at levels slightly above background in surface soil collected from the UST area and the drainage ditch as well as in subsurface lagoon soil. Selenium was detected above background levels in the intermittent stream bed, the drainage ditch, and the subsurface lagoon soil. There were no other detections of beryllium which exceed the corresponding background criterion.

- Antimony was detected above background criterion in the drainage ditch and the subsurface lagoon soil. Manganese was detected above background criterion in one surface soil sample from the unpaved operations lot.

- Cyanide is assumed not to occur naturally at detection concentrations in soils; therefore, the detection of cyanide in the surface and subsurface soils from various areas exceeds background.

As noted above, four metals (chromium, cadmium, copper, and zinc) were detected in the lagoon sediments at concentrations which exceed the background criteria. However, migration of inorganics in soils, even from lagoon sediments, is not expected to be important. While chromium is present at elevated levels as compared to background criterion, there is no obvious pattern in its distribution that suggests migration of chromium off site. The highest concentration of chromium was detected in the marsh soil and was more than twice the maximum chromium concentration detected in the lagoon sediments. Although chromium exceeds the background criterion in several surface and subsurface soil samples, these exceedances are generally less than twice the background criterion. Further, there is no evidence of chromium migration into surface water (based on Barker's Brook surface water sample data) or into groundwater (based on filtered sample data from both the Navesink Formation and Wenonah - Mt. Laurel Aquifer).

Cadmium was also detected in the lagoon sediment, the drainage ditch, the marsh and the unpaved operations lot at levels which exceed the background criterion. However, as with chromium, there is no obvious pattern in its distribution which suggests migration off site. While the highest cadmium concentration was detected in lagoon sediment sample SD-15, it was not detected in the remaining four lagoon sediment samples nor was it detected in the lagoon berm soils or the subsurface lagoon soils. The cadmium concentrations detected in three marsh samples are comparable to the single surface soil detection in a sample from the unpaved operations lot. While relatively high levels of cadmium were detected in the drainage ditch, there is no evidence of cadmium migration into surface water (based on Barker's Brook surface water sample data) or into groundwater (based on unfiltered sample data from both the Navesink Formation and Wenonah - Mt. Laurel Aquifer).

Copper and zinc were also detected in lagoon sediment sample SD-15 at concentrations which exceed their respective background criterion. However, as with cadmium and chromium, there is no obvious pattern in distribution which suggests migration off site. While copper was detected in one other lagoon sediment sample at a level which is just slightly greater than the background criterion, no other elevated levels of copper or zinc were detected in the lagoon sediment, lagoon berm or lagoon subsurface soil samples. Elevated levels of copper and zinc were detected in surface soil and marsh samples and copper was detected above background in one subsurface sample. The concentration of copper detected on site is generally comparable to concentrations detected in the marsh samples. Both copper and zinc were detected at elevated levels in the drainage ditch. However, concentrations of copper and zinc measured in Barker's Brook and both the Navesink Formation and Wenonah - Mt. Laurel Aquifer do not exceed applicable criteria.

Groundwater and Surface Water

- Manganese was detected in concentrations exceeding the applicable criterion (50 ppb) in filtered and unfiltered surface water samples from Barker's Brook; in eight of nine unfiltered and six of nine filtered shallow groundwater samples; and in all six (three filtered and three unfiltered) deep groundwater samples.
- Chromium, arsenic, and lead detections exceed the applicable criteria in a few unfiltered groundwater samples, but were detected at less than the applicable limits in the filtered samples.

Manganese concentrations exceed NJ FW-2 surface water quality criteria in Barker's Brook; however, the concentration detected in the two valid Barker's Brook analyses (about 90 ppb) is similar to that detected in other aqueous (shallow and deep groundwater) samples collected during the RI.

Comparison with Previous Data

Due to the variations in sampling locations, analyses performed, and data reporting formats, it is difficult to compare previous data with data generated for the RI in order to assess trends or evidence of migration. However, limited comparisons can be made with previous groundwater data (NJDEP 1983; NJDEP, 1985) as summarized on Table 1-3, as well as lagoon and washwater collection pit sediments (NJDEP, 1985; Environics, 1986) summarized on Table 1-2, and lagoon sediments and surface soil data (NJDEP, 1985), summarized on Table 1-5.

Previous analyses of the lagoon sediments are consistent with the data generated during this RI. Due to the apparent non-homogeneity of the lagoon sediments (as evidenced by the wide range of contaminant concentrations in samples collected during the RI), only a qualitative comparison can be made. Similarly, the previous surface soil data are consistent with the RI data, but differences in sample locations and reporting formats preclude conclusions regarding trends.

Groundwater data from the RI consistently show elevated concentrations of manganese (greater than 50 ppb). Previous data reports show that manganese was detected in groundwater samples, but listed as detected at an estimated concentration, without specifying the numerical value of that estimated concentration. Therefore, it cannot be determined whether the elevated concentrations of manganese detected in the RI represent a new phenomenon, or confirm historical conditions.

5.3 Fate and Transport Summary

Three major contaminant transport pathways have been identified at the site, based on the data generated during the RI. These are:

1. Vertical migration of mobile organics from the lagoon sediments through the underlying soil and into the shallow groundwater in the Navesink Formation, and subsequent migration of contaminated water. Chlorinated aliphatics and BTEX compounds have been detected in shallow groundwater samples from monitoring wells near the lagoon. However, there is no evidence to date of further horizontal or vertical migration of these contaminants to the deeper aquifer or to off-site wells.

2. Transport of contaminants from the lagoon (by sediment or water) under overflow or breaching of the lagoon berm to the marsh immediately adjacent to the lagoon. Phthalates, especially di-n-octylphthalate, were detected in high concentrations from marsh samples adjacent to the lagoon. Although phthalates, were also detected in several other samples from the marsh, the concentrations decreased significantly with distance from the lagoon.

3. Overland transport of contaminants via surface flow (stormwater runoff contaminated by contact with site soils and contaminated soils entrained in the runoff) to the drainage ditch and intermittent stream, followed by potential or actual transport of contaminated sediments to Barker's Brook. High concentrations of phthalates, petroleum hydrocarbons, unidentified semivolatile organics, and to a lesser extent, BTEX compounds and chlorinated aliphatics were detected in the drainage ditch adjacent to the

unpaved operations lot. Many of these contaminants were also detected farther downstream in the ditch and in Barker's Brook sediments, although at lower concentrations. Phthalates, unidentified semivolatile organics, and petroleum hydrocarbons were also detected at high concentrations in the intermittent stream connecting the marsh and Barker's Brook though the concentrations are not as high as those in the ditch samples.

6.0 BASELINE RISK ASSESSMENT

A baseline risk assessment associated with the contaminants at the K&M Site has been prepared to address the potential impact to human health in the event that the No Action alternative is selected. Potential current and future risks, in the absence of any remedial (corrective) action are addressed pursuant to Section 200.68(f) (ii) of the National Contingency Plan. In general, the procedures used in this risk assessment are consistent with USEPA guidelines for risk assessments and Superfund sites (USEPA, 1989a), and RI/FS activities (USEPA, 1988a).

Risk Assessment Methodology

Methods used in this assessment are in accordance with the USEPA "Risk Assessment Guidance for Superfund", Vol. I, Human Health Evaluation Manual (USEPA, 1989a). It also incorporates more recent guidance from USEPA on specific portions of the risk assessment (USEPA, 1991b, 1992, 1995). The following six step methodology was used to conduct this risk assessment:

1. Identify compounds of concern;
2. Define human exposure pathways;
3. Assess contaminant toxicity;
4. Estimate exposure point concentrations;
5. Assess human contaminant intakes; and
6. Characterize the human health risks.

A brief summary of this methodology is presented below.

Identify Compounds of Concern - Identification and selection of site-specific "compounds of concern" for each medium of the K&M Site were based on analyses of analytical results including:

- frequencies of occurrence;
- compound concentrations;
- concentration-toxicity screening;
- risk-based concentration screening;
- historic records of site use;
- the historic data base of contamination at the site; and
- the toxicological, physical and chemical characteristics of the compounds detected.

Although frequency of occurrence was considered, it was not used as a specific criterion in the selection process due to the limited number of samples available for most site media. Compounds of concern were independently selected for each media, to provide a more accurate estimate of potential exposure for each exposure pathway.

The selection criteria for a compound to be retained as a compound of concern for quantitative evaluation were: (1) it was detected above the applicable analytical detection limit; (2) toxicological data were available for the compound; (3) the toxicity screening analysis showed that the compound contributed more than one percent to the total risk (ingestion pathways only); and (4) risk-based concentration screening levels were exceeded (USEPA, 1993a).

Define Human Exposure Pathways - subsequent to selecting the compounds of concern the potential human exposure pathways for the site were defined. Exposure pathways were determined based on observations made during site visits and possible future uses of the site. Each potential pathway was then evaluated by examining site-specific conditions to determine if the pathway was complete. The demography and land use characteristics were taken into consideration when the pathways were developed (see Section 6.2). If a pathway was complete, it was retained for further evaluation. A complete exposure pathway generally consists of the following four elements (USEPA, 1989a): (1) a source and mechanism of chemical release; (2) a transport medium; (3) a point of potential human contact with the contaminated medium (referred to as the exposure point); and (4) an exposure route (e.g., ingestion, inhalation) at the contact point.

Assess Compound Toxicity - The compounds detected in site media were reviewed for human toxicity. Data on compound toxicity were obtained from USEPA's on-line information service, the Integrated Risk Information system (IRIS; January, 1995), from the 1994 Health Effects Assessment Summary Tables (HEAST) and supplements (USEPA, 1994a, 1994b, 1994c). On the basis of USEPA classifications, compounds were separated into two groups: those exhibiting noncarcinogenic effects (noncarcinogens) and those with carcinogenic effects (carcinogens). Although the compounds detected in site media were reviewed for toxicological effects, only those compounds with USEPA-promulgated toxicity criteria were considered for quantitative evaluation.

Estimate Exposure Point Concentration - Estimation of high-end risk exposure point chemical concentrations was based on the estimated 95 percent Upper Confidence Limit (UCL) on the arithmetic mean, or the maximum detected concentration if it was less than the UCL. The calculations of the UCL included the non-detect occurrence generally at a value of one half of the detection limit. In some cases, the high concentrations of tentatively identified phthalate compounds raised reported detection limits for TCL compounds and a smaller fraction of the detection limit was used. Estimates of central tendency exposure point concentrations were obtained using arithmetic means. Airborne concentrations were estimated using USEPA -supported models.

Assess Human Compound Intakes - A quantitative assessment of human contaminant intakes associated with each potential exposure pathway was developed. Human exposure levels for chronic and subchronic compound intakes were considered for each contaminant, site area and medium through the use of exposure scenarios. Exposure scenarios are plausible sets of human exposure pathways that help to define the intake levels of compounds in site media. Scenarios were developed for both on-site and off-site receptors. The high-end risk exposure scenario employed the UCL exposure point concentration and reasonable maximum exposure circumstances. This scenario was intended to be used as a screening tool to identify and remove from further consideration those site media and pathways that pose potential health risks below target levels of concern. Average, or central tendency estimates, were calculated for pathways where the high-end risk exposure calculated potential health risks in excess of target levels in order to provide some measure of the uncertainty.

Characterize Human Health Risks - The final step in this risk assessment was the actual health risk characterization (Section 6.5). Risk characterization combines the compounds of concern, human exposure pathways, compound toxicity, exposure point concentrations and human compound intake evaluations to calculate risk estimates.

Quantitative estimates of risk were calculated to determine the potential noncarcinogenic and carcinogenic risks to the exposed population. Average risk estimates were calculated for pathways that exceeded target risk levels under the high-end risk assumptions. Finally, the uncertainties inherent in various parts of the risk assessment process were identified and discussed.

6.1 Identification of Compounds of Concern

The data from the RI were evaluated in order to select compounds of concern. First, samples were grouped into media according to anticipated exposure pathways. Compounds in each medium were then evaluated using blank, background and toxicity data to select medium-specific compounds of concern. These procedures are described below.

6.1.1 General Considerations

The analytical data used in this assessment passed validation according to current USEPA Region II criteria as specified in SOP No. HW-2 Revision 11, "Evaluation of Metals Data for the Contract Laboratory Program (CLP)" for inorganic data, and as specified in SOP No. HW-6, Revision 7, "CLP Organics Data Review and Preliminary Review" for organic data. They have received final approval from USEPA Region II. All available data collected for the site during this remedial investigation were considered in the compounds of concern selection process.

The data were grouped according to anticipated exposure pathways for various site areas as follows:

1. Surface Soils (0 to 2 ft in depth): Soil samples from the K&M property, including composite samples, collected at depths less than two feet below grade, excluding the lagoon. Fourteen sampling locations were included in all.

2. Subsurface Soils: Soil and sediment samples collected as part of the investigation at depths greater than two feet below grade. A total of 15 samples were collected.

3. Lagoon Sediments: The five sediment samples from the lagoon at depths less than two feet below grade. The lagoon berm samples were not included in this group, as they were collected from locations around, rather than within, the lagoon.

4. Ditch, Marsh, and Intermittent Stream Soils: Soil samples from the adjacent marsh and intermittent stream on the eastern portion of the site, and the drainage ditch on the western edge of the site were included in this group. Twelve marsh, two ditch, and one intermittent stream sample were collected for a total of 15 samples. All samples were collected less than two feet below grade. For the remainder of this chapter, this sample group is referred to as "ditch and marsh soils".

5. Ditch and Intermittent Stream Surface Water: The three surface water samples collected from the drainage ditch and intermittent stream on the western and eastern boundaries of the site, respectively.

6. Barker's Brook Sediments: The three sediment samples collected from Barker's Brook.

7. Barker's Brook Surface Water: The two downstream-most surface water samples collected from the brook. The sampling point farthest upstream was considered to be background.

8. Navesink Marl Groundwater (all shallow wells): The nine shallow groundwater samples collected from the Navesink Marl Formation.

9. Wenonah - Mt. Laurel Groundwater (three deep wells): All three groundwater samples collected from the Wenonah-Mt. Laurel aquifer.

The above media were considered in compiling the list of compounds of concern. In the evaluation of detected compounds for the selection of compounds of concern, the following general rules were applied to each medium.

1. Compounds detected in associated method, trip, or field blanks, (e.g., methylene chloride) were not retained for further evaluation.

2. Compounds detected at levels comparable to site background were not retained.

3. For inorganic analytes in aqueous media, analytes found at levels below the CRDL and less than 2 times the average reported instrument detection limit were not retained. (This criterion was not applied to solid media.)

4. Analyte results from duplicate analyses showing poor agreement (differences greater than 2x the lower value) were not considered in selecting a compound, although the values were used when calculating compound concentrations.

5. Aluminum, calcium, iron, magnesium, potassium, and sodium were not considered in the selection of compounds of concern, since these essential nutrients are major soil components.

The nature and extent of contamination found on the K&M Site and the associated fate and transport processes were described in detail in Chapters 4 and 5, respectively. Compounds were found in the site soils and sediments from all three TCL/TAL analyte classes analyzed (i.e., volatile organics, semivolatile organics, and inorganics). The dominant class of compounds in terms of total contaminant mass was the semivolatile organics, specifically phthalate compounds. In addition to the TCL-listed phthalates, tentatively identified phthalate (compound) derivatives (TIC phthalates) represented a substantial portion of the contaminant mass. The remaining two classes of TCL compounds and analytes (volatile organics and inorganics) had a large number of detected compounds but the frequency of detection and the compound concentrations were generally lower than those for the semivolatile organics. Tentatively identified compounds other than the phthalate derivatives were also detected in a substantial portion of the site soils and sediments. One lagoon sediment sample contained elevated concentrations of several polycyclic aromatic hydrocarbons (PAHs). This sample constituted most of the PAHs detected, as neighboring samples had few or no detections.

In aqueous media, the levels of contamination were substantially lower than those found in site soils. This is expected since the dominant site chemicals, phthalate compounds, tend to adsorb to soils and generally exhibit low solubility. In aqueous media, inorganic analytes were frequently detected. Both filtered and unfiltered results for inorganic analytes were obtained and examined for use in this assessment. Volatile organics were detected only in groundwater from the Navesink Marl formation, the uppermost stratigraphic layer underlying the site. Semivolatile organics were found in two of the four aqueous media, the Navesink Marl groundwater and surface water from the drainage ditch and intermittent stream.

Site media were not analyzed for pesticides and PCBs.

6.1.2 General Considerations for Site Soils, Site Sediments, and Related Background Levels

Metal concentrations measured in the surface soil, subsurface soil, marsh area soil, lagoon sediment, and surface water sediment sample at the K&M Site were first compared with literature background metals concentrations to screen out those metals that are not site related. Table 6-1 lists background metals concentrations from New Jersey soils (NJDEPE, 1993 and Tedrow, 1986), Eastern United States (US) soils (Shacklette and Boerngen, 1984), US sandy soils and clay soils (Kabata-Pendias and Pendias, 1984) and general US soils (Dragun, 1988 and McClanahan, 1986). Use of literature values was necessary because of the absence of site samples that unequivocally represent site background conditions. Aluminum, calcium, iron, magnesium, potassium, and sodium were not considered as potentially site-related owing to their respective abundances in the earth's crust.

Metals concentrations measured at the Site were compared to background metals concentrations in New Jersey soils as reported by the New Jersey Department of Environmental Protection and Energy (NJDEPE), with the exception of barium and cobalt, which were not reported in the NJDEPE study. Cobalt was compared to the background concentration for cobalt in New Jersey reported by Tedrow (1986) and barium was compared to the maximum background concentration in the eastern US, as determined by Shacklette and Boerngen (1984). Samples were compared to the maximum metals concentrations measured at five sampling locations in the vicinity of the K&M Site as well as to maximum concentrations measured at 35 rural sampling locations throughout New Jersey. The five sampling locations were selected due to their proximity to the K&M Site as well as their similarities in soil type as compared to soil in the immediate vicinity of the Site. Two of the five samples are classified as rural and were taken in Monmouth County, and the remaining three are classified as suburban and are located in Burlington County.

A metal was considered to be site related if it occurred at a concentration that exceeded twice the local sample background metal concentration in more than five percent of the samples. Antimony, beryllium, cadmium, chromium, copper, lead, selenium, vanadium and zinc were found to exceed this criterion (Table 6-2). Cyanide was also considered to be site related as no background levels of cyanide were found in the literature.

Although antimony exceeded the screening criterion, all of the antimony detections were below the method detection limit, resulting in being qualified as estimated values. Because the three detections occurred in samples taken from the lagoon, the marsh, and the brook (a potential pathway for contaminant migration off-site), antimony may be site related.

For organic analytes, background levels were considered to be below detection levels with the exception of the PAHs, which are considered to be fairly ubiquitous in the environment. Background levels range from 1.3 to 13 mg/kg total PAHs in eastern US soils (Edwards, 1983). Although acetone was found in the associated field blanks, it was retained for further evaluation owing to elevated concentrations in the lagoon sediments.

After an initial review of background levels, the sediments of Barker's Brook were excluded from further consideration in the risk assessment. The few analyte levels detected in these samples were generally close to detection limits or typical of soils of New Jersey and the US. For two organic compounds detected at levels above background levels in Barker's Brook sediment (di-n-butylphthalate and diethylphthalate), levels found in the ditch and marsh soils were comparable or higher. Thus, exposure to these compounds will be covered as a part of the ditch and marsh soils exposure scenarios.

6.1.3 General Considerations for Aqueous Media and Related Background Levels

Background levels for all aqueous media were based on the upstream Barker's Brook surface water sample (SW03). This sample was located above the two known site-related influents, the intermittent stream and the drainage ditch. No organic analytes were detected in this sample and it was considered to be free of site contamination. For nearly all inorganic analytes, the unfiltered results from SW03 were the lowest levels detected and were used as background

levels. In general, these levels were at or below the Contract Required Detection Limits (CRDLs). The inorganic results for many of the surface water samples were somewhat ambiguous in that filtered analyte levels were sometimes substantially higher than the more turbid unfiltered results. In these cases, however, the analyte levels were still below the CRDL and therefore have a high level of uncertainty associated with their quantitation and are considered to be estimated values.
Thallium was reported in the shallow and deep groundwater samples. However, the reported concentrations were difficult to quantify at levels well below the CRDL. Thallium was not found in any site medium other than groundwater and has no historical association with the site. For these reasons, thallium was not retained for further consideration as a compound of concern.

In evaluating the aqueous inorganic results for groundwater, the unfiltered results were considered in selecting compounds of concern, even though unfiltered results were turbid and contained suspended solids. The high suspended solids levels found in most groundwater samples typically result in high inorganic analyte levels that are not reflective of drinking water conditions.

Two of the aqueous media, the Barker's Brook surface water and the drainage ditch/intermittent stream, were excluded from further evaluation in this risk assessment based on several considerations. The surface water in Barker's Brook was excluded based on the absence of compound detections above site background levels (SW03). The surface water from the drainage ditch and intermittent stream were excluded based on incomplete pathways for these media. Although the surface water was shown to contain chemicals above background, the pathways by which a human receptor could be exposed to the media were not complete, (i.e., the receptor could not be exposed to the contaminants by ingestion, inhalation, or dermal contact).

For the surface water from the drainage ditch and intermittent stream, the quantity of water available to human receptors was quite small, since these locations samples were small, shallow puddles. These puddles had insufficient volume to support a regular exposure, thereby making the exposure pathways incomplete. In addition, the small volume of these puddles probably also resulted in the inclusion of a substantial portion of fine-grained sediments in the surface water samples, potentially resulting in elevated levels of chemicals found there. Lastly, the more probable exposure scenario for these areas, exposure to sediments, will be evaluated as part of this risk assessment and should provide a sufficient basis to examine risks to receptors in the site area. The lack of a complete pathway for these site media is further discussed in Section 6.2 of this report.

In the case of the Navesink Marl Formation groundwater, the formation yield is insufficient to supply a residential well (see Section 1.1). This assessment was based on the results of the field investigation where both the yield and the permeability of the formation were examined. The hydraulic conductivity tests indicate that while the Navesink does provide recharge to the Wenonah-Mt. Laurel Aquifer in the vicinity of the site, the rate of recharge is relatively slow compared to the rate of lateral flow in the Wenonah-Mt. Laurel Aquifer (Section 3.7.3). However, the Navesink Marl Formation groundwater was still considered to be a complete pathway and included in the risk assessment, in the event that local residents use shallow, hand dug wells.

6.1.4 Concentration-Toxicity Screening and Risk-Based Concentration Screening

The first review of the data provided an initial list of more than 40 chemicals detected in the site media. For most sites, baseline risk assessments are dominated by a few compounds and a few routes of exposure (USEPA, 1993a). To effectively concentrate on the compounds presenting potential health risks, a dual screening procedure was used to select compounds of concern for all ingestion pathways. This two-step screening procedure entailed first a concentration-toxicity screening and second a Risk-Based Concentration screening (RBC). Compound screening for inhalation pathways was limited to RBC screening upon the direction of USEPA.

Concentration-toxicity screening examines two of the most important factors that determine the potential effect of a chemical, its measured concentration and its toxicity. It screens compounds on the basis of relative risk using available toxicity data. Compounds are selected for further evaluation when they contribute more than one percent of the risk associated with exposure to a given medium. The toxicity criteria for the screening calculations were obtained from the January 1995 diskette version of the IRIS database (USEPA, 1995a), the current HEAST guidance (USEPA, 1992c), and the most recent RBC Table (USEPA, 1995b) that includes withdrawn and provisional values. Concentration-toxicity screens were performed for all ingestion pathways.

As part of the concentration-toxicity screening, a "risk factor" was calculated for each chemical using the following equation (USEPA, 1989a):

$$Rij = (Cij)(Tij)$$

where: Rij = risk factor for contaminant I in medium j
Cij = maximum detected concentration of contaminant I in medium j; and

Tij = toxicity value for ingestion for contaminant I in medium j (i.e., the slope factor or 1/RfD)

The total risk factor (Rj) was calculated for each medium by summing the factors for all analytes detected in the medium and then calculating the ratio of the chemical-specific risk factor to the total risk factor (Rij/Rj).

On this basis, the contaminants detected in each medium were evaluated for their contribution to the total carcinogenic risk and total noncarcinogenic risk resulting from exposure to that medium. Concentration-toxicity screening calculations are presented in Appendix J, Tables J-1a to J-1f. Contaminants were selected for further evaluation when they contributed more than 1 percent of the total carcinogenic or noncarcinogenic risk in a given medium. On the basis of these calculations, 17 compounds were selected in surface soil, 11 compounds were selected in subsurface soils, if compounds in lagoon sediments 13 compounds in the ditch and marsh soils, 13 compounds in the Navesink Marl groundwater and 3 compounds in the Wenonah-Mt. Laurel groundwater.

Chromium was separated into 85% chromium III and 15% chromium VI, based on the assumption that the ratio of chromium III to chromium VI is 6:1 (IRIS, 1995). Therefore, chromium is presented as chromium III and chromium VI in all.

Two other compound groups, tentatively identified (TIC) phthalates, and TIC benzene derivatives are included in the list because of their presence in many samples throughout the site. Although these groups lack toxicological criteria, they represent an important portion of site contamination. These groups are discussed qualitatively in Section 6.4.3.

Lead currently has no promulgated criteria, but a recent directive from USEPA (1994d) recommends using a residential screening level for Superfund and RCRA sites of 400 ppm in soil and dust. Based on this criterion lead was eliminated as a COC from soil and sediment pathways. It was not retained for any groundwater pathways because it lacks any promulgated toxicological criteria, and the detections in groundwater may be linked to suspended sediments contained therein.

The concentration-toxicity screen retained a large number of compounds. Some of these compounds may not contribute significantly to the overall risk. To increase the efficiency of this risk assessment an effort was made to further reduce the number of COCs and focus on dominant compounds and exposure routes. A Risk-Based Concentration (RBC) table, developed by USEPA Region III (USEPA, 1995b) was used to screen the remaining compounds and analytes.

Tables 6-3a to 6-3f present the results of the risk-based screening of the compounds selected by the contaminant- toxicity screening for each of the six media examined. For ingestion pathways 10 compounds of concern (COCs) were selected for surface soils, 3 COCs were selected for subsurface soils, 10 COCs were selected for lagoon sediments, 8 COCs were selected for ditch and marsh soils, 8 COCs were selected for the Navesink Marl groundwater, and 1 COC was selected for the Wenonah-Mt. Laurel groundwater. These totals include TIC benzene derivatives and TIC phthalates, which could not be quantified. COCs for each medium are discussed in the following paragraphs.

RBCs screen data by using an absolute comparison of risk. USEPA has developed a table of nearly 600 chemicals in air, drinking water, fish tissue, and soil that correspond to a systematic hazard quotient of 1 or a lifetime cancer risk of 10^{-6}. The risk-based concentrations were developed using protective default exposure scenarios suggested by USEPA (1991b) and the best available reference doses and carcinogenic potency slopes. They represent relatively protective environmental concentrations at which USEPA would not typically take action. As a further protective measure, a safety factor of 10 was applied to RBCs, which raised the screening an order of magnitude to a hazard quotient of 0.1 or a lifetime cancer risk of 10^{-7}. The reference doses and carcinogenic potency slopes used for calculating the RBCs for nearly 600 chemicals were obtained from the Integrated Risk Information System (IRIS) through January 1, 1995, the Health Effects Assessment Summary Tables (HEAST) through March 1994, the Superfund Health Risk Technical Support Center and other USEPA sources.

For inhalation pathways, 2 COCs were selected for surface soils, 1 COC was selected for subsurface soils, 7 COCs were selected for lagoon sediments, 6 COCs were selected for the Navesink Marl groundwater, and no COCs were present in ditch and marsh sediments and the Wenonah-Mt. Laurel groundwater.

Table 6-4 lists compounds of concern for each medium at the K&M Site. In several cases, a compound is not evaluated in every medium in which it was detected. This is because in these cases the compound concentration was below the RBC, or the compound is not particularly toxic in comparison to other compounds found in that medium.

Compounds of Concern in Site Surface Soils

A total of 14 soil samples was considered in the evaluation of site surface soil contamination. The set of samples included three composite samples from the unpaved operations lot, ten surface soil samples from various site locations and two samples from the lagoon berm. The final RBC screening for site surface

soils is presented in Table 6-3a. Of the 16 compounds determined to constitute more than 1% of the total risk by the concentration-toxicity screening (Table H-1a), 8 were selected based on RBCs for residential soil ingestion as COCs. These compounds are beryllium, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, di-n-octylphthalate TIC phthalates and TIC benzene derivatives (Table 6-3a). The TIC benzene derivatives and TIC phthalates are only discussed qualitatively.
Beryllium and chromium were selected as COCs for inhalation pathways.

Compounds of Concern in Subsurface Soils

Fifteen subsurface soil samples were used in the evaluation of subsurface soil contamination. These subsurface soils included on-site and off-site boring samples representing depths from 2 to 12 feet. A total of 18 organic compounds were detected above applicable background levels in these samples, representing volatile and semivolatile organic compounds. Six inorganic analytes were detected above background in these samples. These 24 compounds were screened in an initial concentration-toxicity screening (Table J-1b), which reduced the number of potential COCs to 11.

The RBC screening results narrowed the selection down to 2 inorganic analytes and 2 semivolatile organic compounds (Table 6-3b). For the ingestion pathway antimony was selected for quantitative evaluation and TIC benzene derivatives and TIC phthalates were selected for qualitative evaluation. Chromium was the only COC selected for the inhalation pathway.

Compounds of Concern in Lagoon Sediments

The database for the evaluation of lagoon sediment samples consisted of five sediment samples. These samples represented surface sediments only. Deeper soil samples from the lagoon were included in the subsurface soil medium evaluation. Chemicals from the three analytical groups tested (i.e., inorganic, semivolatile organic, and volatile organic analytes) were found to exceed applicable background levels in the lagoon sediments and evaluated in a concentration-toxicity screening (Table J-1c). A total of 27 chemicals was initially screened for the ingestion pathway.

Of the 27 compounds, 10 were evaluated in the RBC screening for the ingestion pathway and all were retained as compounds of concern (Table 6-3c). The ten compounds of concern consist of six volatile organic compounds (1,2-dichloroethene (total), 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, toluene and ethylbenzene), two semivolatile organic compounds (butylbenzylphthalate and di-n-octylphthalate), TIC phthalates, and TIC benzene derivatives.

The inhalation pathway screened eight volatile organic compounds and 10 semivolatile organic compounds (Table 6-3c). All ten volatile compounds except xylenes were selected as COCs for on-site receptors (1,1-dichloroethane, 1,2-dichloroethene (total), 1,1,1-trichloroethene, trichloroethene, tetrachloroethene, toluene, ethylbenzene). 1,2-Dichloroethene (total), 1,1,1-trichloroethene, trichloroethene, tetrachloroethene, and xylens were selected as COCs for off-site receptors. No semivolatile organics were selected for the inhalation pathway.

Compounds of Concern in the Drainage Ditch and Marsh Soils

Surficial sediment samples from the drainage ditch on the western edge of the site, the marsh on the eastern edge of the site, and the intermittent stream that drains the marsh were grouped together to evaluate surface sediment contamination for the purposes of this risk assessment. This grouping was based on the fact that all three areas were subject to site releases and generally exhibited similar contamination patterns. In addition, the exposure scenarios for the areas were judged to be the same.

A total of 15 samples was used to evaluate contamination in the ditch, marsh, and stream sediments. The concentration-toxicity screening evaluated 33 chemicals (Table J-1d). Based on the screening calculation, 12 chemicals underwent further RBC screening for the sediment ingestion pathway (Table 6-3d). Eight compounds of concern were selected for quantitative evaluation. These compounds are: antimony, beryllium, vinyl chloride, butylbenzylphthalate, bis-(2-ethylhexyl)phthalate, di-n-octylphthalate, TIC phthalates, and TIC benzene derivatives.

Compounds of Concern in Groundwater from the Navesink Marl Aquifer

The nine shallow well unfiltered groundwater samples contained 20 chemicals above background levels (Table J-1e). The concentration toxicity screening reduced the number of compounds to 12 for the ingestion pathway. The RBC screening selected three inorganics (beryllium, chromium VI and vanadium), four volatile organics (1,2-dichloroethene, tetrachloroethene, trichloroethene and vinyl chloride), and one semivolatile organic (isophorone) for the ingestion pathway (Table 6-3e).

Six volatile organics were selected for the inhalation pathway using the RBC screening. These compounds are: 1,1-dichloroethane, 1,2-dichloroethene, tetrachloroethene, trichloroethene, vinyl chloride, and benzene (Table 6-3e).

Compounds of Concern in Groundwater from the Wenonah-Mt. Laurel Aquifer

The evaluation of contamination in the groundwater from the Wenonah-Mt. Laurel aquifer was based on the results from the three deep wells screened in the aquifer. The groundwater samples were analyzed for inorganic analytes in both unfiltered and filtered water samples. The unfiltered samples contained high levels of suspended solids, which would not be present in most wells developed for use. However, to evaluate maximum exposure to contaminants in the groundwater, unfiltered samples were used in this assessment. Water samples were evaluated for inorganic compounds of concern. Five chemicals, all inorganic analytes, were detected above background and underwent contaminant toxicity screening (Table J-1f). No organic analytes were detected in the samples except for methylene chloride, which has been excluded from consideration due to its detection in associated blanks (see discussion in Section 4.7).

Three compounds were selected for further RBC screening (Table 6-3f), and chromium VI was the only compound of concern selected through RBC screening for the Wenonah-Mt. Laurel groundwater. It is important to note that the major compound groups in the other media under consideration (i.e., lead, phthalates, benzene derivatives, and volatile organics) are not present in this groundwater.

6.1.5 Summary of Compounds of Concern

The final list of compounds of concern to be evaluated quantitatively is given by medium in Table 6-4 and is summarized below:

<u>Inorganics</u>

- Antimony
- Beryllium
- Chromium (III and VI)
- Vanadium

<u>Volatile Organics</u>

- 1,1-Dichloroethane
- Vinyl chloride
- 1,2-Dichloroethene (total)
- 1,1,1-Trichloroethane
- Trichloroethene
- Tetrachloroethene
- Toluene
- Benzene
- Ethylbenzene

Semivolatile Organics

- Benzo(a)pyrene
- Benzo(a)anthracene
- Di-n-butylphthalate
- Butylbenzylphthalate
- Dibenzo(a,h)anthracene
- TIC benzene
- Bis(2-ethylhexyl)phthalate
- Di-n-octylphthalate
- Isophorone
- Benzo(b)fluoranthene
- Indeno(1,2,3-c,d)pyrene
- TIC phthalates

6.2 Identification of Exposure Pathways

This step of the risk assessment involves defining and characterizing the populations at risk and determining the circumstances and levels of exposure. To estimate the levels of exposure for populations likely to be at risk, several current- and future-use scenarios depicting activities of residents, site workers, trespassers, and construction workers have been developed.

Each potential exposure pathway is evaluated to determine whether it is complete or not. A complete pathway is defined as having (1) a source or chemical release from a source, (2) a transport medium; (3) an exposure point where contact can occur, and (4) an exposure route at the contact point (USEPA, 1989a). Only complete pathways are considered for further evaluation. Exposures that have a low probability of occurring and associated low risks were eliminated if another pathway with higher associated risks involving the same medium was evaluated.

6.2.1 Characterization of Potentially Exposed Populations

The characteristics of the potentially exposed population were determined through demographic and health statistics, as discussed below.

Demographic Characteristics of the Study Area Population

The 1980 and 1990 census results obtained from the New Jersey Department of Labor were examined for Burlington County using the State of New Jersey as a comparative baseline (Table 6-5). No unusual age distribution patterns were detected. The median ages given in the 1980 census results indicate that the average ages for males and females in Burlington County are 27.8 and 29.2, respectively, versus averages of 30.7 and 33.5 in the State of New Jersey. Examination of the age distribution patterns confirmed that Burlington County had a higher percentage of individuals under 25 years of age than in New Jersey overall (Table 6-5).

Background Health Statistics Survey for Burlington County

Mortality rates of diseases that may be aggravated by exposure to contaminants were examined to determine whether a preexisting "sensitive population" exists in Burlington County. If an above-average incidence rate of a disease potentially affected by hazardous contaminants is detected, modifications may be made in the risk assessment to account for the presence of a sensitive population.

Data were obtained from the New Jersey Center for Health Statistics in order to determine whether a sensitive population may be present near the K&M Site. Four causes of death were examined: 1) malignant neoplasms; 2) benign and unspecified neoplasms; 3) congenital anomalies; and 4) early infant mortality. An examination of age distribution showed the first two diseases to occur primarily in individuals 45 years of age or older, while the later two occurred mainly in children under one year of age.

A review of the data indicated that mortality rates for malignant neoplasms, benign neoplasms, congenital anomalies, and early infant mortality did not differ significantly between the State of New Jersey and Burlington County (Table 6-6).

Available information on the Springfield Township was reviewed to determine if any sensitive subpopulations were present in the vicinity. The only subpopulation identified that may be at increased risk are the children living in the vicinity of the site.

6.2.2 Current-Use Exposure Scenarios

Based on the site evaluation and on the demographic data presented above, the populations likely to be exposed at the present time include residents living in the vicinity of the K&M site, site workers, and local teenagers trespassing on the site. Each of these groups and their potential pathways of exposure will be discussed. Table 6-7 outlines the potential exposure pathways considered at the K&M Site.

Residential Exposure to Contaminated Media

Residential Exposure to Contaminated Soil

Elevated levels of beryllium, chromium, PAHs, and phthalates were detected in on-site surface soils. Residents are expected to have no direct contact with surface soils, as the K&M Site is surrounded by a locked fence, but may inhale fugitive dust particles carried from the Site. Emissions may originate by wind erosion of soils, vehicles traveling over unpaved roads, or a combination of the two.

Organic compounds undergo volatilization and can be carried to residential areas. Generally volatilization of chemicals at uncontrolled hazardous waste sites occurs at covered landfills, spills and leak areas, and lagoons (USEPA, 1988b). Since surface soil does not fall into these categories and the main chemicals detected (e.g., phthalates and PAHs) are unlikely to volatilize owing to their low Henry's Law constants, this pathway is considered to be incomplete.

Currently, residents are not expected to contact subsurface soil chemicals, because of the absence of excavation and remediation activities.

Residential Exposure to Contaminated Lagoon Sediments

Residents are not expected to have any direct contact with lagoon sediments. However, several volatile organics were detected in lagoon sediments at concentrations up to 3,100 ppm. Organic compounds may volatilize and be transported to residential areas. Therefore, the inhalation of volatile organics originating from lagoon sediments was evaluated.

Residential Exposure to Contaminated Groundwater

Springfield Township does not have a public water supply system. The majority of residents have wells placed in the Wenonah - Mt. Laurel Aquifer. Some individual home owners may have placed wells in the shallow Navesink Marl aquifer. Since the precise current and future usage of all residents in the Site vicinity is unknown, groundwater pathways for both aquifers were evaluated as a combined current/future scenario.

Although the shallow Navesink Marl Formation is unlikely to be used for a residential well, the potential for wells being developed in Navesink Marl exists. Inorganics, volatile organics and semivolatile organics were selected as compounds of concern in the shallow aquifer. Pathways of exposure via ingestion and inhalation of volatile organics are considered. Contaminants in the Navesink Marl Formation have permeability constants (K_p) less than 0.1, which is the point at which a dermal dose may exceed an ingested dose. Because risks from ingested doses were calculated, dermal exposure risks were not determined for this pathway.

Inhalation of vapors from the Navesink Marl Formation groundwater use was also evaluated. Inhalation of volatiles while showering and during normal household use (e.g., dishwashing, laundry) was evaluated.

Elevated levels of chromium were detected in the Wenonah-Mt. Laurel aquifer at the K&M Site; however, no inorganic or organic contamination has been detected in local residential wells. The potential for exposure to contaminated groundwater via ingestion exists and is evaluated in this assessment. Inhalation of volatiles while showering is considered to be an incomplete exposure pathway, because chromium is not considered a volatile compound.

USEPA (Schaum et al., 1992) concluded that where the same water supply is used for drinking and bathing, dermal exposure while showering or bathing is not important to consider for most contaminants, but may be important for the small percentage of compounds which permeate fastest. As chromium has a low permeation constant, dermal exposure while showering or bathing was not considered for this pathway.

Residential Exposure to Ditch and Marsh Soils Surface Water

It is assumed that local residents will not trespass in the ditch and marsh areas, and therefore this pathway was not evaluated. Risks for trespassers are calculated as discussed in the trespasser exposure section.

Surface water may also be used as a source of drinking water. Barker's Brook is the closest body of water to the K&M Site. No contamination was detected in Barker's Brook surface water, rendering this pathway incomplete. Therefore, ingestion of surface water will not be considered in this assessment.

Residential Ingestion of Contaminated Fish

Individuals may fish in the tributary of Barker's Brook that lies south of the site. This stream is classified by the New Jersey Department of Environmental Protection and Energy (NJDEPE) as FW2-NT (non-trout production) waters. However, no compounds were detected in water from the stream. In addition, the stream is not considered large enough to support regular sport fishing use. On this basis, this pathway was precluded from further consideration.

Residential Ingestion of Contaminated Home-grown Produce

This pathway may only be relevant for a small number of chemicals, such as some inorganic chemicals and pesticides (USEPA, 1991b), owing to the metabolic and uptake mechanisms of plants. Pesticides are not associated with historic site use. Two inorganic analytes, beryllium and chromium, were selected as compounds of concern in surface soil. However, there are no current residents using site soils for home-grown produce (the Site is not developed for residential use), hence this pathway is precluded from further evaluation. In addition, the exposure resulting from the soil ingestion pathway considers all other soil chemicals and provides an alternate means of evaluating soil-related risks.

Trespasser Exposure to Contaminated Media

Trespasser Exposure to Contaminated Soils and Sediments

Although the K&M Site is enclosed by a locked fence, the possibility exists that trespassers, most likely adolescents, may climb over the fence and enter the site. Trespassers are assumed to be local residents, owing to their proximity to the site. Accordingly, any trespasser activity would be in addition to residential exposures and those pathways will not be repeated here. Trespassers may be exposed to ingestion and dermal contact with surface soil, ditch and marsh sediments, lagoon sediments and surface water, in addition to residential pathways.

Trespassers who enter the site and the nearby stream and marsh areas may incidentally ingest and dermally contact site soils, lagoon sediments, and stream and marsh soils. Exposure to surface water in the drainage ditch and intermittent stream was considered an incomplete pathway because there is insufficient water to permit a regular exposure. Exposure to surface water in the marsh could not be evaluated in this risk assessment due to the absence of data on marsh surface water. However, it should be noted that trespassers are unlikely to come into contact with marsh surface water, unless an individual accidentally falls into the marsh. This is not likely to be a regularly occurring scenario. Dermal contact with sediments could not be evaluated due to the lack of sufficient data on dermal absorption. Therefore, the sediment ingestion pathway was retained, while the surface water pathways were considered to be incomplete.

Site Worker Exposure to Contaminated Media

At the current time, no workers are present at the K&M site. Over the last several years, site workers have been active on site. The site is currently zoned as "Neighborhood Commercial," which makes it unlikely that site workers will return, but a small possibility exists. Therefore, worker exposure is examined as a combined current/future scenario as a conservative exposure pathway, using the default parameters recommended by USEPA (1989c ;1991b).

Site Workers Exposure to Contaminated Soils and Lagoon Sediments

Site workers may come into contact with soils and sediment during daily activities. Individuals engaged in physical outdoor work are more likely to contact contaminated soils and sediments than individuals working indoors. Workers may incidentally ingest soil during activities such as eating or smoking.

Site workers may also inhale soil and dust particles, especially during periods of heavy wind activity, vehicular activity, construction, or excavation.

During work activities, soils may contact exposed body areas. Many compounds of concern in site soils and lagoon sediments are phthalates and PAHs. Permeability constants have not been calculated for phthalates (USEPA, 1992b), owing to their relatively low permeation potential. USEPA (1991b) considers the major pathways of soil exposure under commercial/industrial land use to be direct ingestion, inhalation of volatile from the soil, and inhalation of particles from the soil. The USEPA does not consider the data available on dermal exposure and permeability for the chemicals detected on the site to be sufficient to evaluate the dermal pathway. Due to the absence of sufficient data to evaluate the dermal exposure pathway, it will not be evaluated in this risk assessment.

Volatile organics may emanate from the lagoon, therefore inhalation of volatile organics on site will be considered.

Site Worker Exposure to Contaminated Groundwater

Currently the water supply well on the K&M Site is placed in the aquifer below the Wenonah-Mt. Laurel aquifer. Contamination has not been detected in this aquifer. However, to provide a conservative estimate of risk, Site Workers were assumed to ingest groundwater from the Navesink Marl and Wenonah-Mt. Laurel aquifers.

6.2.3 Future-Use Exposure Scenarios

The future-use scenario under consideration is the development of the K&M site for residential housing units. Under the present zoning (i.e., "Neighborhood Commercial" use), this exposure scenario depicts a maximum future-use. Residential groundwater use and site workers have already been discussed under a combined current- and future-use scenario, and the development of the site would preclude the potential for trespassing.

Residential Exposure to Contaminated Media

Future site use for residential purposes assumed that all site soils and lagoon sediments remained on the site as is, effectively representing two soil media for exposure. Residents may be exposed to chemicals in site soils and lagoon sediments during activities such as playing and gardening. During these activities individuals may incidentally ingest soil, contact soil on their skin surfaces, and inhale dust particles. Volatile organics may volatilize or degrade by the time residential units are completed, but the inhalation of volatile pathway was evaluated.

Housing developments on Site may install groundwater wells in the Wenonah-Mt. Laurel aquifer, or individual private owners may install a hand-dug well in the Navesink Marl Formation. Future use of groundwater is combined with current use and was discussed previously.

Although it would be inadvisable to place a well in the Navesink Marl Formation, it is possible that some individuals may install a well in the shallowest aquifer possible. Using this assumption the potential for future use of the Navesink Marl Formation groundwater exists and, therefore, drinking water ingestion and the inhalation of volatile while showering pathways are evaluated.

Construction Worker Exposure to Contaminated Media

If the K&M Site is developed for residential housing units, construction workers would actively work on site during the building of housing units. They would be exposed to both surface and subsurface soils via ingestion and inhalation of fugitive dust particulates. If the lagoon area is converted to housing units, workers would come into contact with lagoon sediments. They may also be exposed to volatile organics, if they have not volatilized or degraded by the time residential units are constructed. Groundwater ingestion was also considered to be a pathway of concern, in the event that workers install a well in the Navesink Marl and Wenonah-Mt. Laurel aquifers rather than bringing their own drinks, or utilizing the well present in the deeper aquifer on site.

6.2.4 Summary of Exposure Pathways

The following pathways are considered to be complete and will be evaluated.

Current-Use:

Local Residents

- Inhalation of fugitive dust particulates from surface soil
- Inhalation of volatile organics emanating from the lagoon
- Ingestion of Wenonah-Mt. Laurel groundwater
- Ingestion of Navesink Marl groundwater
- Inhalation of Navesink Marl volatiles while showering
- Whole house inhalation of Navesink Marl volatiles

Trespassers (in addition to local resident exposure)

- Ingestion of site soil and lagoon sediments
- Ingestion of ditch, marsh and intermittent stream sediments

Current- and Future-Use:

Site Workers

- Ingestion of surface soil
- Ingestion of lagoon sediments
- Inhalation of surface soil fugitive dust particulates
- Inhalation of volatile organics emanating from the lagoon
- Ingestion of Navesink Marl groundwater
- Ingestion of Wenonah-Mt.Laurel groundwater

Future-Use:

Local Residents

- Ingestion of site soils
- Ingestion of lagoon sediments
- Inhalation of surface soil fugitive dust particulates
- Inhalation of lagoon fugitive dust particulates
- Ingestion of groundwater from the Wenonah- Mt. Laurel Aquifer
- Ingestion of groundwater from the Navesink-Marl Aquifer
- Inhalation of volatile organics from the Navesink-Marl Aquifer while showering
- Inhalation of Navesink-Marl volatile organics, whole house exposure

Construction Workers

- Ingestion of subsurface soil
- Ingestion of lagoon sediments
- Inhalation of subsurface soil particulates
- Inhalation of volatile organics from the lagoon
- Ingestion of Navesink Marl groundwater
- Ingestion of Wenonah-Mt. Laurel groundwater

6.2.5 Uncertainties Associated with Exposure Pathways

Exposure pathways were selected after a careful review of contaminated media, local conditions and activities, and possible future scenarios. Receptor populations were selected based on field visits, but there is no verification of trespassers on site. In addition, no workers are currently on site, which means that risks to present/future workers may be lower than calculated. Future exposure pathways are based on providing an estimate of maximum use and development of the site. These uses may not occur in the future as the K&M site is located in a rural area, and the demand for land may not be high enough for the K&M Site to be converted into a residential development.

The overall degree of uncertainty associated with current scenarios is moderate, while for future exposure pathways it is significantly greater. If the site is developed for residential housing, it is likely that the lagoon will be cleaned up for aesthetic and health reasons. In addition, current regulations require the buyer of property to assume liability for any hazardous materials found on the property. Therefore, it will be difficult for the current owner to find a buyer, and a developer willing to address concerns of local, state and federal governments prior to the site being classified as uncontaminated. There is a conservative bias present in future-use scenarios to consider maximum site utilization, which brings a high degree of uncertainty with it.

6.3 Exposure Factors

This section discusses exposure factors chosen for use in the exposure scenarios and the basis for their selection. Assumptions used for both receptor parameters and exposure point concentrations are discussed.

A single estimate of the high end exposure was used initially for exposure assumptions expected to occur under current and future land-use conditions. USEPA (1992a) defines the high end exposure as follows:

> "The high-end risk descriptor is a plausible estimate of the individual risk for those persons at the upper end of the risk distribution. The intent of this descriptor is to convey an estimate of risk in the upper range of the distribution, but to avoid estimates which are beyond the true distribution. Conceptually, high-end risk means risks above the 90th percentile of the population distribution, but not higher than the individual in the population who has the highest risk."

For exposure scenarios that had calculated risks above target levels, average, or central tendency, parameters were also developed to provide estimates representing average exposures.

Exposure assumptions were primarily taken from RAGS (USEPA, 1989a), the Exposure Factor Handbook (USEPA, 1989b), and Supplemental Guidance to RAGS (USEPA, 1991b). In instances where more than one exposure factor was provided, factors from the most recent guidance available (USEPA, 1991b) were used. Table 6-8 outlines high-end risk exposure assumptions used in this risk assessment and Table 6-9 presents the central tendency risk assumptions used.

6.3.1 Residential Exposure Assumptions

The exposure frequency (EF) of residents is presumed to be 350 days per year, for both the high-end risk and central tendency exposure scenarios. This is based on the assumption that residents take two weeks of vacation a year spent away from home (USEPA, 1991b). In terms of exposure duration (ED), residents are assumed to live in the same house for 30 years for the high end exposure scenario. This value has been calculated as the 90th-percentile value of time spent at one residence (USEPA, 1989b). For average exposure scenarios an exposure duration of 9 years was used, which represents the national median time at one residence (50th percentile value). These values represent owner-occupied housing units, which generally have longer residence times than rental units (USEPA, 1989b). Most houses in the vicinity of the K&M Site are owner-occupied units.

Groundwater Pathways

Adult risks were calculated for residential exposure pathways via groundwater, per USEPA guidance. For the high-end risk scenarios, adults were assumed to ingest 2 liters per day. This quantity is used by the Office of Water in setting drinking water standards and is close to the 90th percentile for drinking water ingestion (USEPA, 1989b). Based on five independent studies, the average drinking water consumption rate for adults was calculated to be 1.4 liters per day (USEPA, 1989b) and this value was used in the central tendency analysis.

The body weight (BW) of an adult is assumed to be 70 kg, which is consistent with USEPA guidance (USEPA, 1989a). Groundwater ingestion for children was calculated based on a body weight of 15 kg and a consumption rate of 1 liter of water per day. The exposure duration for a child was estimated to be 6 years (i.e., 0-6 years of age).

Owing to the lack of compound-specific absorption efficiencies in an aqueous medium, an absorption efficiency of 1.0 (100%) was used.

Inhalation of volatile organic emissions from groundwater usage at home was also considered a potential pathway. Volatile compounds may be emitted during showering or bathing and from household water usage such as dish washing, laundry, and toilet flushing. Emissions from both showering and whole house exposure were modeled and discussed in Section 6.3.6.

Soil and Sediment Pathways

Individual ingestion rates are used for children and adults. USEPA (1989c) recommends using an ingestion value of 200 mg per day of combined soil and dust for children 1 through 6 years of age, and 100 mg per day for all other age groups. After reviewing the current literature USEPA (1991b) considers these values to represent upper-bound values for soil and dust ingestion, and, therefore, these values were used.

Because children and adults have different ingestion rates and body weights, both populations were examined for noncarcinogenic effects. Carcinogenic effects were only evaluated for adult (30 year) exposures due to the large uncertainty associated with long term exposures with respect to soil concentrations and exposure assumption parameters. As for the groundwater pathways, the body weight used was 15 kg for children and 70 kg for adults. An absorption value of 100% was used for this pathway in the absence of compound-specific data. TCDD (dioxin) is the only compound for which extensive oral bioavailability studies exist for soil exposures. These studies (e.g., Lucier et al., 1986; McConnell et al., 1984; and Poiger and Schlatter, 1980) found bioavailability of TCDD in soil to be approximately 50%. Therefore, the oral absorption of 100% used in this assessment is considered to be conservative.

The frequency of exposure to site surface soils and lagoon sediments was assumed to be 350 days/year under the future-use scenario. This value is based on the assumption that a home will be built directly on the site and that surface soils will be present in the immediate vicinity of the home. The lagoon was assumed to be left on site essentially intact, with residential housing constructed around it. Thus, the potential for exposure would be present year-round. Note that the rate of soil and sediment ingestion was assumed to be the same for both ingestion scenarios, effectively doubling the total daily amount of soil ingested when a receptor is exposed to both the home (site) soils and the lagoon sediments. This assumption is considered conservative but it permits the evaluation of the exposure to each medium on a separate basis.

Residents may also be exposed via inhalation of soil fugitive dust and volatile organics. The estimation procedure given in "Guidelines for Predictive Baseline Emissions Estimation Procedures for Superfund Sites (USEPA, 1992d) was used to calculate upper-bound values for volatilization of organic compounds from the lagoon. Procedures in "Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites" (Cowherd et al., 1985) were used to calculate fugitive dust emissions. The assumptions used to obtain fugitive dust and volatile organic emissions are outlined in Section 6.3.6.

Absorption of particulates is assumed to be 15% based on the assumption that a proportion of the particulates will enter the digestive system after being removed from the lungs. Particulates in the lungs are assumed to be minimally absorbed.

The inhalation rate for residents was assumed to be 20 m^3/day, based on USEPA's standard default value (USEPA, 1991b). This value is intended to represent the highest percentile among weekly averages for both home and work exposures. This provides a moderate overestimate of inhalation intake for individuals who work away from home.

An inhalation rate of 20 m^3/day was also used to estimate inhalation rates of children 1 to 6 years of age, using inhalation rates found in USEPA guidance (1988b).

6.3.2 Trespasser Exposure Assumptions

Site trespassers are assumed to be local adolescents (ages 12 through 18). Trespassers were assumed to enter the K&M Site twice a week during the summer (26 days/year) for a period of 10 years for the high end exposure scenarios and once a week during the summer (13 days/year) for 5 years for the central tendency exposure scenario.

The body weight used for adolescents is 55 kg, based on the weights for various age-groups provided in Anderson et al. (1984). Since the 200 mg/day soil ingestion rate applies only to children 1 to 6 years of age, the adult soil ingestion rate of 100 mg/day was used.

Trespassers were also considered to be exposed to all residential pathways. Adult default assumptions were used, as residential exposure is calculated on a long-term basis.

6.3.3 Site Workers Exposure Assumptions

Workers are anticipated to work 5 days per week, 50 weeks per year, for a total of 250 days per year. The number of years worked at the same location for the high end exposure is considered to be 25 years, based on the 95th percentile time period (Bureau of Labor Statistics, 1990). The central tendency exposure is considered to be 10 years.

The incidental ingestion of soil and lagoon is assumed to be 50 mg per day of each medium, based a study by Calabrese, et al. (1990). This is an interim value currently being used by USEPA (1991b).

For inhalation of fugitive dust and volatile organic emanating from the lagoon, workers are assumed to have an upper-bound inhalation rate of 20 m^3 per 8-hour workday. This value represents the highest among weekly average patterns that were derived by coupling "worst case" activities with "average" adult inhalation rates (USEPA, 1991b). This inhalation rate was used for both high-end risk and central tendency exposures.

In the event that site workers install a well in the Navesink Marl or Wenonah-Mt. Laurel aquifers, groundwater ingestion risks were calculated for these pathways. Standard USEPA (1989a) groundwater ingestion assumptions were used, consisting of a 70 kg adult ingesting 2 liters/day under the high-end risk scenario and 1.4 liters/day under the central tendency scenario. Absorption efficiencies were assumed to be 100%.

6.3.4 Construction Worker Exposure Assumptions

Construction workers were assumed to work at the K&M Site during the hypothetical building of residential housing units. Construction time was assumed to last for approximately 6 months for both high-end risk and central tendency scenarios, with employees working normal 5-day weeks during that period. Owing to the nature of the job, workers were assumed to ingest 480 mg/day of soil (Hawley, 1985). All soil was assumed to be subsurface soil, due to the excavation required for house construction. Construction workers were also assumed to ingest 50 mg of lagoon sediment a day, because of contact with lagoon sediment during construction.

Construction workers were assumed to be exposed to the same fugitive dust and organic volatile emissions as future on-site residents. However, it was assumed that the construction workers were exposed to fugitive dust originating from subsurface soil. An inhalation rate of 20 m^3/workday was used, based on the assumption the assumptions that workers are in the vicinity of the site for a shorter period than residents, but are more physically active during that period. The average adult body weight of 70 kg was used for workers.

Ingestion of groundwater from the Navesink Marl and Wenonah-Mt. Laurel aquifers by workers during construction was also evaluated.

6.3.5 Estimation of Exposure Point Concentrations

Estimates of exposure point concentrations are needed as part of the quantitative risk evaluations, since these estimates are used along with the exposure scenarios to estimate chronic daily intake and subsequent human health risks.

Estimation of exposure point concentrations for the ingestion and inhalation pathways are based on measured concentrations of the compounds of concern. For the ingestion pathways, the exposure point concentrations were calculated directly from the data sets without any modeling, since the concentration measured in the soils and sediments represents the concentration at the exposure point. For the inhalation pathways, the exposure point concentrations were modeled as airborne transport affects the concentration at the exposure point. This discussion of calculation of inhalation exposure point concentrations is presented in Section 6.3.6. No exposure point concentrations were estimated for dermal exposure pathways because they were not be examined in this risk assessment based on current USEPA guidance (USEPA, 1991b).

For high-end pathway exposures to site media, the representative exposure point concentrations were taken as the 95 percentile upper confidence limits (UCL) about the arithmetic mean for the measured contaminant levels. In the event that the UCL exceeded the maximum measured concentration, the maximum value was used in place of the UCL. The method of calculation of the UCL was selected based upon an analysis of the data distribution for the compound in question, following the guidelines described in USEPA, 1992c. For compounds exhibiting normal distribution characteristics the UCL was calculated as follows:

$$\mathrm{UCL} = \overline{X} + t * \frac{s}{\sqrt{n}}$$

where: $\overline{X}$ = arithmetic mean of the sample data set for the compound of concern

s = standard deviation of the sample data set for the compound of concern

t = the Student's t statistic for the 95 percent confidence interval for a two tail distribution; t is a function of the number of samples collected

n = the number of samples in the data set

In instances where the data set exhibited log-normal distribution characteristics, the UCL was calculated by taking the natural log transform of all sample values and using the following formula:

$$\mathrm{UCL} = \mathrm{EXP}\left[\overline{X} + 0.50s^2 + \frac{Hs}{\sqrt{n1}}\right]$$

where: $\overline{X}$ = the arithmetic mean of the natural log transformed data
s^2 = the variance of the transformed data
s = the standard deviation of the transformed data
H = the t-value for the transformed data. The H value differs from the t-values because the formula is designed to estimate the UCL on the basis of log transformed data
n = the number of samples in the data set

Both calculations include all analyses for a given compound in a given medium with the non-detect analyses set at one-half of the Contract Required Detection Limit (CRDL) with the exception of all semivolatile compounds and volatiles in the lagoon and marsh sediments. For these compounds the detection limits were frequently much higher than the CRDL, primarily because of the dilution required to quantitate the high levels of TIC phthalates in the semivolatile component and TIC benzene derivatives in the volatile component of the lagoon and marsh sediments. Although the reported detection limits were quite high in some samples, the data also showed that in these cases the laboratory was able to detect contaminants down to 10 percent of the reported detection limit. On this basis, it was decided that the estimation of the UCL would be based upon one-half of the effective detection level or 5 percent of the reported detection limit for samples with high reported detection limits and 50 percent of the reported detection limit if it was close to the standard CRDL for low level contaminated samples.

The type of data distribution exhibited by a compound of concern in a medium (specifically, normal or log-normal) was evaluated based on a calculation of the W test statistic developed by Shapiro and Wilk (1965). This test is designed to examine the likelihood that the underlying population is normally distributed based on a random sample set containing less than fifty samples. This test was applied to each compound of concern in each medium.

A detailed explanation of the W test statistic calculation is given below.

1. Compute the denominator d of the W test statistic, using the n data.

$$d = \sum_{i=1}^{n} (x_i - \overline{X}) = \sum_{i=1}^{n} x_i^2 - \frac{1}{n}(\sum_{i=1}^{n} x_i)^2$$

where: n = number of samples

x_i = individual measurements of the compound of concern

$\bar{X}$ = mean value of the data set

2. Order the n data from smallest to largest to obtain the sample order statistics $x_{[1]} \leq x_{[2]} \leq \ldots \leq x_{[n]}$.

3. Compute k where:

$$k = \frac{n}{2} \text{ if n is even}$$

$$k = \frac{n-1}{2} \text{ if n is odd.}$$

4. Obtain the coefficients $a_1, a_2, \ldots, a_n$ for the observed n from the reference table (Gilbert, 1987).

5. Then compute:

$$W = \frac{1}{d}\left[\sum_{i=1}^{k} a_i \,(x_{[n-i+1]}\ \ x_{[i]})\right]^2$$

Values for W lie between 0 and 1. The closer the W value is to 1.0, the more normally distributed the data set is. The test criteria for W was set at the two percent significance level for testing for a normal distribution (i.e., the population was taken to be normally distributed as long as there was at least a two percent probability that a random sampling could produce the actual sample data set obtained). In these instances, the exposure point concentration was then estimated using Equation 1 given above. When the test failed for the normal distribution assumption, the data were natural log transformed and the test was repeated on the transformed values. In this instance, the assumption of log-normality was made if the W test statistic met or exceeded the threshold value for the 2 percent significance level. In addition, if the W test statistic of the log-transformed data showed a substantial change toward the threshold value relative to the W test statistic for the untransformed data, the underlying population was assumed to be log-normally distributed. In these instances, the exposure point concentration was calculated using Equation 2 given previously.

In the limited number of instances where no improvement occurred in the W test statistic after the log transform, the data set was reviewed and assigned as normally or log normally distributed. The exposure point concentrated was calculated using the appropriate formula. Tables 6-10a to 6-10g list the compounds of concern by medium, along with several statistics to quantify the data distribution. These tables also include the calculated W test statistics, the method of calculating the exposure point calculation and the actual exposure point value. As noted previously in this discussion, if the calculated UCL exceeded the maximum values measured for a compound of concern in a given medium, the maximum value was used as the exposure point concentration. Statistics were calculated for combined surface soils and lagoon sediments (Table 6-10e) for evaluation of trespasser risk.

Arithmetic means, provided in Tables 6-10a to 6-10g, were used to calculate exposure concentrations for the central tendency analyses. In a few cases the arithmetic mean was greater than the maximum detection, because the maximum concentration detected was less than half the detection limit of the remaining samples. In these instances the maximum concentration detected was used, so as not to overestimate the central tendency risk.

6.3.6 Exposure Point Concentration Modeling

For current and future pathways that involve exposure via the inhalation of site contaminants, contaminant release and transport models were employed to estimate airborne concentrations at receptor locations. The following four separate inhalation exposures were evaluated: 1) exposure to fugitive dust generated from site soils; 2) exposure to volatile contaminants emanating from the lagoon sediments; 3) exposure to volatile organics while showering; and 4) indoor exposure to volatile organics form indoor water uses (whole house model).

For these scenarios, the two receptor populations examined were local residents and site workers. Under the future-use scenario, exposure point concentration were also developed for construction workers. To evaluate potential risks to each of these populations, a set of exposure point concentrations was developed.

For fugitive dust emissions, concentrations were calculated using USEPA guidance (Cowherd et al., 1985; USEPA, 1992d). Estimates were made of the annual average concentration at the center of the source. Dust was assumed to exist solely of site soils, thus site soil contaminant exposure point levels were use as estimates of the contaminant concentrations in the dust.

Future-use residential dust exposure point concentrations were assumed to be identical to those for the present-use on-site scenario, since there is insufficient information to develop a specific dust level estimate for this scenario.

Residential, site worker, and construction worker exposure to volatile organic emissions from the lagoon exposure were estimated using volatilization and air transport models developed by USEPA (1992d).

It is important to note that the fugitive dust and volatile organic emissions air transport modeling done for this risk assessment provides an estimate of contaminant concentration in ambient <u>outdoor</u> air at the receptor locations. For the purposes of the risk assessment, the outdoor air concentrations are conservatively assumed to represent indoor air concentrations. Indoor air is expected to represent the bulk of the air inhaled by the residential receptors. This assumption is conservative in that it is expected that indoor air concentrations of site contaminants would be lower due to settling of fugitive dust upon entry to the house, and the conservative nature of the airborne transport models. For the site worker scenarios, outdoor air is the media for exposure and no additional assumptions are necessary.

All ambient air concentrations for groundwater volatilization pathways were modeled for indoor exposures. These pathways are discussed later in this section.

Fugitive Dust Emissions

Fugitive particulate emissions from the K&M Site were calculated to estimate potential residential and worker exposure to contaminated soils via inhalation of particulates. Equations developed by Cowherd et al. (1985) were used to calculate particulate emissions for wind erosion releases and releases associated with vehicular traffic. Although this model was developed as a rapid assessment technique, USEPA (1988b) rates the degree of accuracy attained using this model as consistent with simplified quantitative estimation procedures.

The K&M Site was examined to determine the appropriate model for use. As the site is sparsely vegetated, the potential for erosion exists at exposed areas. Bisal and Ferguson (1970) determined that if more than 60% of the soil passes a 1-mm sieve, the "unlimited reservoir" (i.e., infinite availability of erodible material) model will apply; if not, the "limited reservoir" (i.e., finite availability of erodible material) will apply. Greater than 60% of each surface soil sample analyzed at the K&M Site passed through a 1-mm sieve, therefore the unlimited reservoir model was applied.

The first step of the model is to determine the emission rate. The form of the equation used is as follows:

$$E_{10w} = 0.036 * (1 - V) * ([u]/u_t)^3 * F(x)$$

where: E_{10w} = PM_{10} emission factor, i.e., average annual emission rate of suspended matter less than 10 μm in diameter per unit area of contaminated surface (mg/m^2-hr)

V = fraction of contaminated surface area covered by continuous vegetative cover or paved areas (0 for bare soil); (assumed to be 0.1 for the K&M Site)

$[u]$ = mean annual wind speed (m/s) (2.5 m/s, from McGuire Air Force Base, National Climactic Data Center records NOAA, 1974)

u_t = threshold of wind speed at 7 m above the ground surface (the standard monitoring height) (m/s)

x = $0.886\ u_t/[u]$ = dimensionless ratio

$F(x)$ = function plotted in Cowherd et al. (1985)

The threshold wind speed at 7 m (u_t) was found to be 6.7 m/s, based on an assumed roughness height of 5 centimeters. Hence the equations were solved as follows:

x = 0.886 (6.7m/s)/(2.5m/s) = 2.4

$F(2.4)$ = 0.08 (from Cowherd et al., 1985)

E_{10w} = $0.036\ (1-0.10)\ (2.5/6.7)^3\ (0.8)$

= 1.35×10^{-4}g/hr/m^2

Emission rates (R_{10v}) from vehicle traffic was calculated from the following emission equation. It was assumed that approximately ten large vehicles (10 wheels, 26 Mg [28 tons]) would enter and leave the facility each day. Truck parameters were based on the upper-range default values given in Cowherd et al. (1985). Trucks are assumed to travel an average distance of 600 feet (0.2 kilometers) each way into and out of the facility.

$$E_{10v} = 0.85\ (s/10)\ (S/24)^{0.8} (W/7)^{0.3} (w/6)^{1.2} (365 - p)/365$$

where: E_{10v} = PM_{10} emission factor, i.e., the quantity of PM_{10} emissions from an unpaved road per vehicle-kilometer of travel

s = silt content of road surface material (17% from field samples)

S = mean vehicle speed (8 km/hr; default industrial, from Cowherd et al., 1985)
W = mean vehicle weight (26 Mg [28 tons] Cowherd et al., 1985)
w = mean number of wheels (10)
p = number of days with at least 0.254 mm (0.01 in.) of precipitation per year (135, from Cowherd et al.; 1985)

E_{10v} was calculated to be:

$$E_{10v} = 0.85\ (17/10)\ (8/24)^{0.8}\ (26/7)^{0.3}\ (10/6)^{1.2}\ (365-135)/365$$
$$E_{10v} = 1.03 \text{ kg/VKT}$$

The fugitive dust emission rates (R_{10}) are determined from the above emission factors (E_{10v}, E_{10w}) using the following equation:

$$R_{10} = E_{10} * A$$

where: R_{10} = emission rate of dust as PM_{10}
A = source extent (for a specified averaging time in the case of vehicle resuspension)

For wind erosion, the source is the K&M owned property (13,900 m^2), excluding the lagoon and the building. The lagoon was excluded because fugitive dust particulate suspension is unlikely to occur in a moist area. The building area was excluded because erosion can not occur at this location. The marsh area was not considered as a source of fugitive particulate emissions because it is completely vegetated.

Thus, the equation for wind erosion was solved as follows:

$$\begin{aligned} R_{10w} &= E_{10w} * A \\ &= (0.135 \text{ mg/m}^2\text{-hr})\ (13{,}900 \text{ m}^2) \\ &= 1{,}877 \text{ mg/hr or } 0.52 \text{ mg/sec} \end{aligned}$$

In the case of mechanical resuspension resulting from vehicular traffic on unpaved surfaces, the source extent is defined as the product of the contaminated travel length and the daily traffic count. At the K&M site, no vehicles are currently active, but based on previous patterns of use an estimate of 10 vehicles driving a round trip distance of 0.4 kilometers was assumed. The following equation was used:

$$R_{10V} = E_{10V} * \frac{\text{Vehicles}}{\text{day}} * \text{Distance Traveled}$$

$= 1.03$ kg/vkt * 10 vehicles/day * (0.4km)/vehicles

$= 4.12$ kg/day

$= 47.7$ mg/sec

The total emission rate (R_{10T}) is then the sum of the wind erosion and vehicular traffic terms:

$$\begin{aligned} R_{10T} &= R_{10w} + R_{10v} \\ &= 0.5 \text{ mg/sec} + 47.7 \text{ mg/sec} \\ &= 48.2 \text{ mg/sec or } 0.048 \text{ g/sec} \end{aligned}$$

Once the total emission rate was calculated, an atmospheric dispersion model (USEPA, 1992d) was used to predict ambient deposition concentrations at receptors of interest (i.e., residents and site workers). The receptors were considered to be at the edge of the area source. Hence the following steps were followed:

1. The natural logarithm of the horizontal dimension of the subject area source (118 meters) was determined [ln(118)= 4.77].

2. This value was entered into the following polynomial equation to produce the natural logarithm of the normalized concentration.

$$\ln(C/Q_T) = 13.0 - 0.261(\ln X) - 0.24(\ln X)^2 + 0.0124(\ln X)^3$$

where: C = concentration
Q_T = total source emission rate (g/s)

This equation was solved as follows:

$$\begin{aligned} \ln(C/Q_T) &= 13.0 - 0.261(4.77) - 0.24(4.77)^2 + 0.0124(4.77)^3 \\ \ln(C/Q_T) &= 7.62 \end{aligned}$$

3. The exponential of this value was then taken to produce the normalized concentration:

$$C/Q_T = e^{\ln(C/QT)}$$
$$C/Q_T = 2{,}031$$

4. The final step consisted of multiplying the normalized concentration by the emission rate to produce the long-term (annual average) concentration in ug/m^3.

$$C = (C/Q_T) \times Q_T$$
$$C = 2{,}031 \times 0.048 \text{ g/sec}$$
$$C = 97.5 \text{ ug/m}^3$$

Based on these calculations the long-term concentration of fugitive dust was estimated to be 97.5 ug/m^3.

Volatilization of Organic Compounds to the Air from Lagoon Sediments

The presence of volatile organic contaminants of concern in the sediments of the lagoon suggests that these chemicals may be released to the air over time. There is, therefore, a potential concern with inhalation exposure to these compounds for both onsite and offsite receptors in both the present and future-use scenarios. In order to roughly assess the magnitude of these risks, a model of the volatile emission rate was employed to estimate the release rates of volatile organics from lagoon sediments.

Volatilization rates from the lagoon sediments were estimated using the method developed by Farino et al. (1983) as described in "A Workshop on Air Pathway Analysis at Superfund Sites" (USEPA, 1992d). The emission rate E_i for the organic contaminant I in soil can be estimated using the equation:

$$E_i = D_i * C_{si} * A * (P_t)^{4/3} * M_i / d_{sc}$$

where:

D_i = diffusion coefficient of contaminant in air (cm^2/sec)

C_{si} = saturation vapor concentration of contaminant i (g/cm^3)

A = source area (cm^2)

P_t = total soil porosity (dimensionless)

M_i = mole fraction of contaminant i in the waste (g mole/ g mole)

d_{sc} = effective depth of soil cover (cm)

For this assessment, contaminants were assumed to exist in a "free-phase" within the sediment vadose zone rather than existing in solution with available sediment moisture and adsorbed to sediment particles within the sediment matrix. This assumption is based on the high concentrations of oil-phase constituents including total petroleum hydrocarbons (TPHC - maximum concentration of 249 parts per thousand - 24.9%), butylbenzylphthalate (maximum concentration of 31 parts per thousand - 3.1%), and di-n-octyl phthalate (maximum concentration of 4.4 parts per thousand - 0.4%) measured in the lagoon sediment samples.

Diffusion coefficients (Di) for the organic contaminants were obtained from the Superfund Exposure Assessment Manual (USEPA, 1988b) assuming an ambient soil-air temperature of 15 °C.

The saturation vapor concentration in g/cm^3 was estimated as:

$$C_{si} = \frac{p * MW_i}{R * T}$$

where:
p = vapor pressure of contaminant I at 15°C (mm Hg)
R = molar gas constant (6.236 x 10^4 mm Hg-cm^3/mole-°K)
T = absolute ambient temperature (°K)
Mw_i = molecular weight of contaminant I (g/mole)

For this assessment, all releases were assumed to occur at a sediment/air temperature of 15°C (288°K), and possible decreases in release rates caused by saturation or freezing of the surface sediments, coverage by water, or snow cover were not considered.

The area of release (A) was estimated to be 3,064 m^2 which corresponds to the area of the lagoon. This assumption provides a conservative estimate of contaminant volatilization since the lagoon is often partially filled with water, which would decrease the emission rate.

The mole fraction of contaminant I in the waste was estimated as:

$$M_i = \frac{(\text{Mass of Compound}_i / \text{Mass of Waste}) * MW_i}{\sum_{i=1}^{j} (\text{Mass of Compound}_i / \text{Mass of Waste}) * MW_i}$$

where: MW_i = molecular weight of contaminant i (g/mole)

Total soil porosity (P) was estimated to be 0.55, typical of dry, non-compacted soils (USEPA, 1988b). Because the emission rate E_i varies linearly with the effective soil cover (d_{sc}), the mean emission rate corresponds to one-half the mean sediment depth. Therefore, the effective soil cover was assumed to be one-half the mean sediment depth which is approximately 15.25 cm.

Once emission rates were calculated for the organic contaminants in the lagoon sediments, ambient air concentrations were calculated for the on-site and off-site receptors using atmospheric dispersion models obtained from USEPA 1992d.

For off-site receptors, the ambient air concentration was estimated as:

$$C_i = Q_i * x/Q_i$$

where:
C_i = Ambient air concentration of contaminant I (kg/m^3)
Q_i = Total source annual emission rate per square meter (kg/m^2-yr)
x/Q = 16 x 10^{-9} yr/m from function plotted in USEPA 1992d corresponding to downwind receptor distance of 76 meters.

The total source emission rate was estimated as:

$$Q_i = \frac{E_i * 31,536}{A}$$

where:
Q_i = Total source annual emission rate per square meter (kg/m^2-yr)
E_i = Emission rate for contaminant I (g/s)
A = source area (m^2) - 3,064 m^2

For on-site receptors, the ambient air concentration was estimated as:

$$Ci = (C/Q_T)\ Q_T$$

where:
C_i = Ambient air concentration of contaminant I (ug/m^3)
Q_T = Total source emission rate (g/s)
C/Q_T = normalized ambient air concentration

The normalized ambient air concentration (C/Q_T) can be estimated from the following equation (USEPA, 1992d):

$$\ln C/Q_T = 13 - 0.261*\ln X - 0.241*(\ln X)^2 + 0.0124*(\ln X)^3$$

where:
X = nominal width of the source area (m) - assumed to be 55.4 m for the lagoon

Ambient air concentrations were calculated for the eight volatile organic compounds detected in the lagoon sediments (Table 6-3c). For off-site receptors, four compounds (1,1,1-trichloroethane, 1,2-dichloroethene, trichloroethene, and tetrachloroethene) exceeded their respective Risk Based Concentrations (RBCs) as reported in the RBC table developed by USEPA-Region III. For on-site receptors, seven compounds (1,1-dichloroethane, 1,2-dichloroethene, ethylbenzene, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, and toluene) exceed their respective RBCs. However, the time to depletion, assuming the mean concentration of the volatile organics in the lagoon sediments best represents the inventory of the entire lagoon, is less than seven days and, therefore, does not represent chronic exposure.

The time required to deplete the inventory of volatile organic compounds in the lagoon sediment at emission rates corresponding to their respective RBCs was also calculated. At emission rates which yield ambient air concentrations for off-site receptors equal to the RBCs for the volatile organics detected in the lagoon sediments, the entire inventory of volatile organics, with the exception of trichloroethene, will be depleted in a matter of days. Trichloroethene will be depleted in less than 1.5 years. Therefore, if it takes longer than 1.5 years to deplete the lagoon inventory of volatile organics, it will be at an ambient air concentrations which do not exceed the respective RBCs. Conversely, if it takes less than 1.5 years to deplete the lagoon inventory, it will be at an ambient air concentration that exceeds the RBC for trichloroethene but it will not represent a chronic exposure (greater than two years) for any of the volatile organic compounds detected in the lagoon sediment.

At emission rates which yield ambient air concentrations for on-site receptors equal to the respective RBCs for volatile organics detected in the lagoon sediment, the inventory of 1,1-dichloroethane, ethylbenzene, 1,1,1-trichloroethane, 1,2-dichloroethene, and tetrachloroethene will be depleted in 0.4 days, 10 days, 13 days, 41 days, 230 days, and 580 days, respectively. Therefore, even for on-site receptors, none of the volatile organics represents a chronic exposure. However, at the RBC emission rate, the inventory of trichloroethene will be depleted in approximately 67 years and, therefore, represents a chronic exposure.

It is important to note that the potential relative error associated with this model may span an order of magnitude. This analysis assumes that the volatile organics detected in the lagoon sediments are "free-phase" and not dissolved in available soil moisture or adsorbed to sediment particles within the sediment matrix. While this is an appropriate assumption given the significant presence of TPHC and phthalate oil in the lagoon sediment, this analysis also assumes that the lagoon is not filled with water and there is no water in any of the sediment pore spaces. In reality, diffusion from the lagoon is through an aqueous phase and there is likely no air-filled pore space. These assumptions should result in a calculated emission rate which is greater than the actual emission rate and hence this model provides a conservative estimate of risk. It is also important to note that the assumption that sample SD-15 represents 20 percent of the lagoon sediment concentration is also likely an overestimation given the large discrepancies in organics concentrations between this sample and the remaining four sediment samples.

While it is apparent that volatilization does not represent chronic exposure for off-site receptors, the magnitude of the exposure for on-site receptors is unclear. At the present time, there are no on-site receptors exposed to the diminishing concentration of contaminants in the lagoon.

Inhalation Exposures from Domestic Water Use

USEPA's method (Schaum et. al, 1992) for estimating indoor air concentrations of volatile chemicals from residential water usage was used to model exposure concentrations of volatile organic compounds detected in Navesink Marl Formation. Two pathway were modeled; exposure to volatile organics while showering and exposure to volatile organics via water use (whole house exposure). These exposures are discussed in the following paragraphs and summaries of the parameters used for these models are provided in Tables 6-12a and 6-12b.

Showering Exposure

The first step in the modeling was to estimate the equilibrium partitioning that occurs between the water and air phases using the Henry's law constant. This provides the maximum possible concentration of a contaminant in air, as a result of volatilization from water. The equilibrium level in air was estimated using the following equation:

$$C_a = C_w H$$

Where: C_a = Concentration of contaminant in air (mg/m^3)
C_w = Concentration of contaminant in water (mg/L) x 1000L/m^3
H = Henry's law constant (unitless)

The unitless Henry's Law Constant was calculated by using the following equation:

$$H = \frac{H'}{RT}$$

Where: H' = Henry's Law Constant (atm-m^3/mol)
R = Gas constant (atm-m^3/mol - °K)
T = Temperature (°K)

These calculations are found in Table 6-12a.

In the second step a simple model is applied to treat the bathroom as one compartment and yields an air concentration averaged over the time of both the actual shower and time spent in the bathroom subsequent to the shower. The model was derived by assuming: 1) contaminants volatilize at a constant rate; 2) contaminants instantly mix uniformly with the bathroom air; and 3) ventilation with clean air does not occur. This implies that contaminants in the air increase linearly from zero to a maximum at the end of the shower and remain constant during the time an individual spends in the bathroom immediately after the shower. *The concentration of each contaminant was calculated as follows:*

$$C_a = \frac{(C_{aMAX}/2)t_1 + C_{aMAX}t_2}{t_1 + t_2}$$

Where: C_a = Concentration of contaminant in air (mg/m^3)
C_{aMAX} = Maximum concentration of contaminant in air (mg/m^3)
t_1 = Time of shower (hr)
t_2 = Time after shower (hr)

C_{aMAX} was estimated as follows:

$$C_{aMAX} = \frac{C_w f F_w t_1}{V_a}$$

Where: C_{aMAX} = Maximum air concentration in bathroom (mg/m^3)
C_w = Water concentration (mg/L)
f = Fraction volatilized (unitless)
F_W = Water flow rate (L/hr)
V_a = Bathroom Volume (m^3)

Concentrations of contaminants in water were taken from the UCL or maximum concentrations detected for the high-end risk scenarios and from the arithmetic mean for central tendency scenarios (Table 6-12a). Calculation of air concentrations are provided in Tables J-2b for the scenarios. The most conservative of the default assumptions provided by USEPA (Schaum et al.,

1992) were selected for water flow rate, bathroom volume, shower time, and time after shower in the bathroom. These assumptions include a water flow rate of 1000L/hr, a bathroom volume of 6m^3, a 20 minute shower, and 30 minutes spent in the bathroom after the shower.

The mass fraction volatilized of each contaminant (f_i) was predicted using a ratio of each contaminant's overall mass transfer coefficient to that of a compound for which the fractional volatilization has been experimentally determined. The mass fraction volatilized was calculated as follows:

$$f_i = f_j \times (K_i/K_j)$$

Where:
f_i = volatilization fraction for compound I
f_j = volatilization fraction for compound j
K_i = mass transfer coefficient for compound I
K_j = mass transfer coefficient for compound j

Once the concentration was calculated, the carcinogenic and noncarcinogenic risks were evaluated. Residents were assumed to be exposed for 0.8 hours/day for the high-end risk scenario and 0.6 hours/day for the central tendency scenario.

Whole House Exposure

The whole house model employed a similar model to the shower model (Schaum et al., 1992). Water uses that can contribute volatile organics to the air include dish washing, laundry and cooking. Showering and bathing were handled separately in the previous section. This model provides an estimate to represent a spatial average over the house, rather than providing air concentrations at the point of water use. The air concentration was estimated using the following equation:

$$C_a = \frac{WHFC_w f}{HVERMC}$$

Where:
C_a = Concentration in air (mg/m^3)
C_w = Concentration in water (mg/L)
f = Fraction of contaminant that volatilizes (unitless)
WHF = Water flow rate in whole house (L/day)
HV = House Volume (m^3)
ER = Exchange rate (air changes/day)
MC = Mixing coefficient (unitless)

Maximum and arithmetic mean contaminant concentrations were used to estimate water concentrations, as was done for the shower model (Table J-2c). The fraction of the contaminant that volatilizes was the same as calculated for the shower model. Conservative default factors were selected for the remaining parameters from USEPA (Schaum et al., 1992). The water flow rate was assumed to be 890 L/day, house volume was taken at 200 m^3, and the exchange rate was presumed to be 10 changes per day. The mixing coefficient, which represents how well mixed the contaminant is in the household air (1.0 represent perfect mixing and 0 represents a complete lack of mixing) was selected to be 0.7.

The calculated air concentrations (Table 6-12b) were then used to calculate potential health risks to local residents. Residents were assumed to be indoors 24 hours/day for both the high-end risk and central tendency scenarios.

6.3.7 Uncertainties Associated with Exposure Factors

Exposure durations are considered to accurately reflect upper-range values. Estimates, such number of days per year exposed, are considered to have a high degree of reliability, while others, such as a 30-year exposure duration, tend to be more conservative. Estimates for the time spent exposed to volatiles via showering and household uses of water are quite conservative, assuming that residents do not leave the house and regularly take long showers. The degree of uncertainty associated with estimates of exposure durations ranges from low to moderate.

Physical parameters were developed by USEPA (1991b) after careful consideration. These estimates are considered to provide realistic mid- and upper-range estimates for use in risk assessment. Therefore, associated uncertainties are considered to be low.

Estimation of exposure point concentrations from measurements of site contaminants are considered to accurately reflect upper range site conditions. However, in many cases, the UCL value exceeded the maximum detected value, indicating that the data were badly skewed. In these cases, the maximum detected value was used, introducing an upward bias since it is unlikely that all human exposures would occur at the maximum contaminant levels.

The models used to predict concentrations of emissions of volatile organics from the lagoon, fugitive dust particulates and inhalation of volatiles from showering and household water uses have uncertainty associated with them due to their inherent conservative assumptions, a lack of site-specific data and a shortage of fine-tuned models.

As the future-use of the K&M site has not be determined, it is difficult to accurately predict future site uses. The scenarios selected in this assessment provide maximum use of the site area, which encompass generally conservative assumptions. In addition, the site contaminant levels were assumed to remain constant and not decrease with time as would be expected. These factors increase the degree of uncertainty concerning future-uses, which is considered to be high.

6.4 Toxicity Assessment

This section summarizes the procedures used to obtain toxicity values for noncarcinogenic and carcinogenic compounds, and discusses associated uncertainties. Toxicological profiles providing specific information on each compound are found in Appendix I.

6.4.1 Health Effects Criteria for Noncarcinogens

Noncarcinogenic compounds are believed to have a "threshold" or tolerance limit. Consequently organisms may tolerate exposure ranging from zero to a finite value, with essentially no chance of adverse effects (USEPA, 1989a). The upper bound of this threshold level used in risk assessments is referred to as the reference dose (RfD) and incorporates uncertainty and modifying factors. In general, the RfD is an estimate, with incorporated uncertainty, of a daily exposure to humans (including sensitive subgroups) that is likely not to have an appreciable risk of deleterious effects during a lifetime (USEPA, 1995b). RfDs are divided into subchronic and chronic values. Subchronic values are calculated for exposures during a portion of a lifetime (as a Superfund guideline, two weeks to seven years), while chronic risk are calculated for longer periods or an entire lifetime (USEPA, 1989a). The RfD is expressed in units of mg contaminant/kg body weight-day.

For inhalation pathways an inhalation Reference Dose (RfD_i) is used, which accounts for differences in respiratory anatomy, physiology, and physicochemical characteristics. The RfD_i is given as a concentration in air (mg/m^3), rather than in a inhaled dose (mg/kg/day). RfDs may be converted to an inhaled dose by dividing by body weight, multiplying by an inhalation rate and adjusting by an appropriate absorption factor. USEPA does not advocate individuals to make this conversion owing to potential uncertainties introduced by the assumptions in the conversion (USEPA, 1994a). Therefore, only compounds with inhalation reference doses were evaluated quantitatively for this assessment.

Prior to calculating an RfD, the sources of uncertainty in the toxicity assessment are determined and quantified. Uncertainty factors may include a 10-fold safety factor to account for each of the following uncertainties: variation in human sensitivity among populations, extrapolating from animal to human data, extrapolating from a Lowest-Observed-Adverse-Effect-Level (LOAEL) to a No-Observed-Adverse-Effect-Level (NOAEL), and when extrapolating from a subchronic to chronic exposure (USEPA, 1994a). In order to reflect professional assessment of the study and databases, an additional uncertainty factor or a modifying factor ranging from zero to ten is applied. The default value for this factor is one. Tables 6-13a and 6-13b list the RfD of each compound of concern, the confidence level, critical effect, basis and source, and the uncertainty and modifying factors for oral and inhalation exposures, respectively.

Oral and inhalation RfDs provide benchmarks against which estimated doses can be compared. The Chronic Daily Intake (CDI) is divided by the RfD to obtain a ratio of the dose to the benchmark. Doses that produce a ratio greater than one (unity) may indicate that an inadequate margin of safety exists for exposure to a compound and an adverse health effect could occur.

6.4.2 Health Effects Criteria for Carcinogens

Carcinogenesis is considered to be "nonthreshold response", because there is believed to be no level of exposure to a carcinogenic compound that does not pose a probability, however small, of generating a carcinogenic response (USEPA, 1989a). In estimating carcinogenic risks an effects threshold cannot be determined. Instead a two-part evaluation is done, where first each substance is assigned a weight-of-evidence classification and then a slope factor based on the best available data is calculated. Tables 6-14a and 6-14b lists the compounds identified as potential carcinogens at the K&M Site, their weight-of-evidence classification, and their slope factors for oral and inhalation exposures, respectively.

The weight-of-evidence classification determines the likelihood that a compound is a human carcinogen. Groups are classified from A (known human carcinogen) to E (evidence of noncarcinogenicity for humans). Evidence is characterized separately for human and animal studies, but a review of both data sets provide the basis for a provisional weight of evidence, which may be adjusted upward or downward.

The slope factor is calculated based on the relationship between dose and response. When several studies are used, the geometric mean of the slope may be adopted as the SF. Generally, the 95-th percent confidence interval of the slope of the dose-response curve is calculated for use in risk assessments. This value is expressed as $(mg/kg\text{-}day)^{-1}$.

To obtain an excess individual lifetime cancer risk the CDI is multiplied by the Slope Cancer Factor (SF) of a contaminant. Cancer risks are quantified as occurrences per million individuals exposed under defined circumstances. This is equivalent to a per-capita risk expressed as the odds per million that a hypothetical exposed individual will contract cancer as a result of exposure to contaminants at the K&M Site over a lifetime. A risk of 1 x 10^{-6} is equivalent to one excess cancer occurrence in a million individuals. The general range of acceptable cancer risks at Superfund sites is between 10^{-4} and 10^{-7} To calculate exposure to multiple contaminant exposure, the excess lifetime cancer risk from each compound is summed to provide an estimate of total cancer risks. USEPA guidelines (1986b) advocate this policy in the absence of specific information on combinations of chemicals. This approach considers neither synergistic (positive) or interference (negative) interactions between compounds.

6.4.3 Uncertainties in the Toxicity Assessment

Uncertainties in the toxicity assessment may result from a lack of toxicity values for some contaminants present at the site, as well as from uncertainties inherent in determining quantitative values for those contaminants having toxicity values. The effect of these uncertainties on the toxicity assessment is discussed below.

Compounds Lacking Toxicity Values

This section will briefly discuss compounds for which no toxicity values (i.e., neither carcinogenic nor noncarcinogenic) are available. In this analysis no toxicity values were available for 1,1,1-trichloroethane, trichloroethene, several PAHs (benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene and indeno(1,2,3-c,d) pyrene), TIC phthalates, and TIC benzene derivatives. The toxicity value for vanadium pentoxide was used, as no value was available for vanadium.

The lack of toxicity values limits the risk analysis to a qualitative discussion on the potential adverse effects of these compounds that could be experienced by individuals exposed to these compounds. This introduces a moderate to high level of bias, where the risk is likely to be biased downward owing to the inability to calculate risk estimates without toxicity values.

1,1,1-Trichloroethane

1,1,1-Trichloroethane (1,1,1-TCA) is not classifiable as to human carcinogenicity (USEPA, 1995a). The animal carcinogenicity data are inadequate and there are no data for human exposures. For noncarcinogenic effects the oral RfD was withdrawn from IRIS on August 1, 1991, and an inhalation RfD is under review by a USEPA work group. The maximum contaminant level (MCL) for 1,1,1-TCA is 0.2 mg/L based upon a drinking water effect level of 1.0 mg/L and an assumed drinking water contribution of 20%. The drinking water effect level was based on liver toxicity in mice (inhalation study). 1,1,1-TCA was selected as a COC for lagoon sediments only. The mean concentration detected was 320 mg/kg, which results in an ambient air concentration of 110 $\mu g/m^3$ for off-site receptors and 4,900 $\mu g/m^3$ for on-site receptors (Table 6-11). Chronic exposure to elevated levels of 1,1,1-TCA may result in adverse effects.

Trichloroethene

The carcinogenicity assessment for trichloroethene (TCE) was withdrawn on July 1, 1992 based on a new carcinogen summary that is being prepared by the CRAVE work group (USEPA, 1992b). Animal studies have shown significant increases in the incidence of liver tumors, malignant lymphomas and pulmonary adenocarcinomas in mice. USEPA has classified TCE as a B2 carcinogen, which indicates sufficient evidence in animals and inadequate evidence in humans. Based on these studies, adverse effects are probably associated with TCE. However, they cannot be quantified at this time, owing to the absence of a reliable cancer slope factor.

Noncarcinogenic effects of trichloroethene (TCE) are presently under review by a USEPA work group (USEPA, 1992b) for both the oral and inhalation RfDs.

The maximum contaminant level for trichloroethene is 0.005 mg/L. Trichloroethene was selected as a COC for the lagoon sediments and the Navesink Marl groundwater. The arithmetic mean concentration in sediment was 620 mg/kg, which results in an ambient air concentration of 120 $\mu g/m^3$ for off-site receptors and 5,400 $\mu g/m^3$ for on-site receptors (Table 6-11). The exposure point concentration for TCE in the Navesink Marl groundwater was calculated to be 8.5 $\mu g/L$, above the MCL.

PAHS

The following five PAHs were selected as compounds of concern for this risk assessment: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and ideno(1,2,3-cd)pyrene. Only one of these compounds, benzo(a)pyrene (BAP) has a USEPA approved toxicity value. Data for the other PAHs are largely unsuitable for the calculation of quantitative risk estimates by conventional methods for one or more of the following reasons: 1) data were from exposures not typically used in deriving quantitative estimates for oral or inhalation exposure (e.g., skinpainting or subcutaneous exposure); 2) study populations were too small; 3) studies were done at only one exposure level; and 4) dose-response data were not reported (USEPA, 1993b).

USEPA quantitative risk estimates for mixtures of PAHs have often assumed that all carcinogenic PAHs are equipotent to BAP, and that the carcinogenic effect of the mixture can be estimated by the sum of effects of each individual PAH. Some PAHs are less carcinogenic than BAP, so use of this procedure may result in an overestimation of the effect of those PAHs. On the other hand, PAH mixtures may contain carcinogenic PAHs that are not considered indicator compounds and thus would not be measured. Some PAHs may also be more potent animal carcinogens than BAP. Although the need for toxicity equivalency factors (TEF) exists, not all the guiding criteria have been met for their establishment. USEPA has issued an estimated order of potential potency for the carcinogenic effects of seven PAHS. There is no support for the additivity, or lack of it, for PAH mixtures. The estimated order of potential potency is not an Agency consensus, but rather an Office of Health and Environmental Assessment (OHEA) recommendation.

The estimated order of potencies for the PAHs in this assessment, provided as orders of magnitude, is as follows:

COMPOUND	RELATIVE POTENCY
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

PAHs were selected as contaminants of concern in the lagoon sediments. Trespassers may be exposed to lagoon sediments and future residents may be exposed to lagoon sediments if they are mixed with site soils. Using the relative potencies in relation to BAP to estimate risk, risks to trespassers are below target levels. However, future residents may be exposed to unacceptable levels of PAHs in site soils.

TIC Phthalates

A large number of unknown phthalates were detected in many soil and lagoon samples. The identified phthalates that were included as contaminants of concern have primarily noncarcinogenic properties. Adverse effects include increased organ weight and testicular lesions in rats exposed to butylbenzylphthalate in their diet; increased mortality in rats fed diets containing dibutylphthalate; weight loss and growth retardation in rats fed diethylphthalate; and increased liver weights in female guinea pigs fed diets containing bis(2-ethylhexyl)phthalate (BEHP). Confidence in the oral RfDs ranged from low to medium (USEPA, 1995a).

Carcinogenic effects have only been reported for bis(2-ethylhexyl)phthalate. Rats and mice were fed diets ranging from 0 to 12,000 ppm BEHP in their diet. No clinical signs of toxicity were observed; however a statistically significant increase in the incidence of hepatocellular carcinomas and adenomas were observed in female rats and mice of both sexes (NTP, 1982 as cited in USEPA, 1995a). Guinea pigs and dogs were fed BEHP with no observed carcinogenic effects (Carpenter et al., 1953 as cited in USEPA, 1995a). Because the animals were not sacrificed after the study, the only evaluation made was of a below-average survival period.

It is difficult to evaluate potential adverse health effects of unknown phthalates in light of the diversity of the group. The most probable effects would be related to the hepatic system; however, no data are available to evaluate the magnitude of the risk.

TIC Benzene Derivatives

Unknown compounds were also detected in many soil and lagoon samples. Benzene related compounds may induce both carcinogenic and noncarcinogenic health effects. A brief outline of the health effects of benzene, toluene, and xylene is given in order to provide an overview of potential effects of benzene compounds.

Benzene is a class A human carcinogen, with several studies documenting an increased incidence of nonlymphocyctic leukemia from occupational exposure (USEPA, 1995a). Animal studies, both oral and inhalation, have resulted in the development of neoplasia.

Toluene has been shown to induce adverse noncarcinogenic effects in rodents. Rats were found to exhibit increased mortality, and organ weight increases (NTP, 1989 as cited in USEPA, 1995a). No significant effects were noted for inhalation exposures. Confidence in this study is high, yielding a medium level of confidence in the oral RfD. Data are inadequate to determine possible carcinogenic effects.

Xylene studies have shown a dose-related increase in mortality in male rats and hyperactivity, a manifestation of central nervous system toxicity. There is a medium level of confidence in the oral RfD. The existing animal carcinogenicity data is inadequate to classify xylene as a carcinogen.

Based on studies of related compounds, benzene compounds may induce carcinogenic or noncarcinogenic adverse health effects. Quantification of these effects is not possible with the existing data.

Uncertainties in the Toxicity Values

The RfDs and slope factors contain inherent uncertainties owing to the difficulties associated with deriving toxicity values. Most values are derived from animal studies because few epidemiological studies are available for human populations. Human epidemiological studies, when available, often examine potential toxic effects *a posteriori* rather than *a priori*. The means that even if human data exist, there are still difficulties with confounding factors, exposure periods and levels, and possible genetic predispositions. Animal studies, although controlled more carefully, have the problem of extrapolating between species. This area has a large amount of associated uncertainty, because toxicity is not necessarily uniform among species. Toxicity values are usually based on a minimum of three points, consisting of a no dose, medium dose, and high dose level. Actual exposure doses may be significantly below the high dose level and may not produce the same effects seen at the high doses.

Toxicologists are aware of the inherent uncertainties in deriving toxicological values and include uncertainty factors and modifying factors to provide a measure of safety in the estimate. Toxicity values tend to be conservative in order to protect sensitive individuals; however, until more is known about specific compounds, no definitive conclusions may be drawn about the level of uncertainty for each specific compound.

Oral RfD values are generally more available for use in human health risk assessments than inhalation RfD values. USEPA cautions risk assessors against extrapolating from oral concentrations to inhalation dosage (USEPA 1994a), due to the many uncertainties associated with it. Therefore, no extrapolations were made from oral RfDs to inhalation RfDs. This potentially biases the risk assessment downwards; however, a decision was made not to proceed with the extrapolation in the absence of data.

Finally, one potentially exposed population, construction workers, was considered to be exposed under subchronic conditions. However, for the contaminants of concern in this exposure, no subchronic toxicity criteria were available. In this case, chronic toxicity criteria were used instead, introducing an upward bias to the estimates of risk for future construction workers.

6.5 Risk Characterization

This section quantitatively estimates and characterizes the potential human cancer risks and the potential for noncancer adverse health effects associated with current- and future-use scenarios at the K&M Site. Chronic Daily Intakes (CDIs) of contaminants were calculated for each pathway based on estimated exposure point concentrations and exposure parameters. The estimated CDIs were then combined with health effects criteria (slope factors and reference doses for carcinogens and noncarcinogens, respectively) to calculate potential carcinogenic and noncarcinogenic risks.

Equations used to calculate CDIs for the pathways selected in Section 6.2.4 are given in Tables 6-15a through 6-15d. More complex modeling pathways, such as the inhalation of fugitive dust, inhalation of volatiles from the lagoon, and inhalation of volatiles from showering and household water usage, are discussed in Section 6.3.6.

Exposure point concentrations for use in the equations in Tables 6-15a through 6-15d are given in Tables 6-10a through Table 6-10g. Other parameters used in these equations are provided in Table 6-8, for high-end risk exposures, and Table 6-9, for central tendency exposures.

For noncarcinogens, exposure pathways were evaluated by comparing calculated CDIs to acceptable RfDs, for each exposure pathway. Exposure pathway and medium-specific intake (exposure) rates of contaminants of concern were calculated to generate a pathway model. In some instances RfDs were not available for a quantitative assessment.

Potential concerns for noncarcinogenic effects are evaluated as the ratio of the Chronic Daily Intake (CDI) to the Reference Dose (RfD). The sum of all of the CDI:RfD ratios for the selected chemicals of concern is called the Hazard Index (HI) and is calculated as shown below:

$$HI = \sum_{i=1}^{n} \frac{CDI_i}{RfD_i}$$

where:
HI = Hazard index
CDI_i = Chronic daily intake for contaminant I (mg/kg/day)
RfD_i = Reference dose for contaminant I (mg/kg/day), and

n = Number of contaminants of concern in the medium under consideration.

A hazard index less than 1.0 is unlikely to be associated with health risks, while a hazard index greater than 1.0 indicates the potential for adverse effects. As a rule, the greater the hazard index, the greater the level of concern. However the level of concern does not increase linearly as unity (1.0) is approached or exceeded, because the RfDs, upon which they are based do not have equal accuracy or precision and are not based on the same severity of toxic effects. For the purposes of the following discussions, the threshold hazard index for unacceptable noncarcinogenic effects is taken as unity (1.0), based on current USEPA guidance (USEPA, 1989a).

Carcinogenic effects were evaluated in terms of excess lifetime cancer risks. Excess lifetime cancer risk is defined as the additional probability that an individual will develop cancer as a result of exposure to carcinogenic contaminants. This probability is in addition to the expected probability of cancer development in the exposed population. Current USEPA guidance for Superfund sites (USEPA, 1989a) states that acceptable excess cancer risk levels for exposure to site contaminants fall in the range of 10^{-4} to 10^{-7} (a chance of one in ten thousand to one in ten million). For the purposes of this risk assessment a value of 10^{-6} was used as the threshold, or target risk level, above which cancer risks were considered unacceptable.

For carcinogens, the potential for excess lifetime cancer risk due to exposure to a specific carcinogenic compound is calculated by multiplying the compound specific CDI by its slope factor (SF) as follows:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where: CDI = Chronic daily intake of the chemical (mg/kg/day), and
SF = Slope factor for the chemical $(\text{mg/kg/day})^{-1}$

This formula is appropriate for excess risk levels less than 10^{-2}.

At cancer risk levels higher than 10^{-2}, the following equation is applicable:

$$\text{Risk} = 1 - \exp(-\text{CDI} \times \text{SF})$$

Slope Factors are defined by USEPA's Carcinogen Assessment Group (CAG) and obtained from HEAST and IRIS. Based on USEPA guidance (1986b), cancer risks for exposure to multiple carcinogenic contaminants were assumed to be additive.

Potential sources and areas of uncertainty in the risk assessment are discussed in Section 6.6. A discussion summarizing the pathways identified as posing a potential health risk and the specific chemical constituents of concern within each pathway is provided in Section 6.7.

6.5.1 Calculation of Exposure Risks

Values determined in the contaminant of concern, exposure assessment and toxicity assessment sections were used to calculate risk estimates. Calculated risks are discussed by receptor population, time frame (current or future) and media. The actual calculations for the CDI's and the exposure risks are provided in Appendix J. Summaries for each receptor group are provided in Tables 6-16 to 6-19. The discussions below summarize the results of the calculations.

The residential scenarios were a combination of current/future and future scenarios, site worker scenarios were combined current/future scenarios, trespasser exposures were only current scenarios, and construction worker exposure was limited to future scenarios.

6.5.2 Current Scenarios

Current carcinogenic and noncarcinogenic risks were calculated for residents, trespassers and site workers.

Residential Exposure

Current residential exposure includes: inhalation of fugitive dust from surface soil particulates; ingestion of groundwater (Navesink Marl and Wenonah Mt. Laurel Formations); and, inhalation of volatiles from household use of groundwater (Navesink Marl Formation). Inhalation of volatile organics from the lagoon is an inappropriate pathway, as discussed in Section 6.3.6.

The high end adult carcinogenic risk calculated for fugitive dust inhalation was 4.6×10^{-7}, or 5 excess cancer cases in 10 million individuals (Table 6-16). This values is below the target risk level of 1×10^{-6}, or one excess cancer case in a million individuals. The calculations for this exposure scenario are provided in Appendix J, Table J-3.

Noncarcinogenic risk calculations were not quantifiable for contaminants found in fugitive dust, as no reference doses are available for beryllium or chromium.

The current exposure pathway for high-end exposure scenario ingestion of groundwater from the Navesink Marl yielded a carcinogenic risk of 3.2 x 10^{-4} (Table J-4a). Vinyl chloride, beryllium, and isophorone each individually exceeded the target risk level of 1 x 10^{-6} with individual risks of 2.2 x 10^{-4}, 9.4 x 10^{-5}, and 2.4 x 10^{-6}, respectively. The central tendency scenario calculated an excess cancer risk of 4.5 x 10^{-5}, or approximately 5 excess cancer cases in 100,000 (Table J-4b). Vinyl chloride and beryllium each individually exceeded the target risk level with risks of 3.2 x 10^{-5} and 1.3 x 10^{-5}, respectively.

The high end exposure adult groundwater ingestion scenario for adults had a calculated hazard index of 3.3 x 10^{-1} (Table J-4c), below the target level of 1.0. The hazard index for children was calculated to be 7.8 x 10^{-1} (Table J-4d), also below the target level. Vanadium pentoxide and 1,2-dichloroethene each contributed over 30% of the risk and chromium VI contributed about 20% of the risk.

The carcinogenic risk from the inhalation of volatile organics released from Navesink Marl groundwater while showering was calculated to be 2.7 x 10^{-6} (Table J-5a) for the high-end risk scenario and 5.6 x 10^{-7} (Table J-5b) for the central tendency risk. All of the calculated risk was attributed to benzene, as it was the only compound detected in the groundwater with an inhalation cancer slope factor.

The hazard index for noncarcinogenic risks from volatile organic inhalation while showering was calculated to be 6.3 x 10^{-3} for adults (Table J-5c) and 2.9 x 10^{-2} for children (Table J-5d), both well within target risk levels. All of the noncarcinogenic risk was derived from 1,1-dichloroethane, which was the only compound with an inhalation reference dose.

Carcinogenic risks from the inhalation of volatile organics released from Navesink Marl groundwater during household water usage (e.g., laundry or dish washing) were calculated to be 1.3 x 10^{-6} for the high-end risk scenario (Table J-6a) and 3.8 x 10^{-7} for the central tendency risk scenario (Table J-6b). Noncarcinogenic risks were not quantified, because 1,1- dichloroethane was not selected as a compound of concern for the whole house exposure (Table 6-3e).

The only compound of concern selected for the Wenonah-Mt. Laurel aquifer was chromium. There is no cancer slope factor associated with chromium, so only noncarcinogenic risks were calculated. The hazard indices for high-end risk adults and children were calculated to be 1.1 x 10^{-1} and 2.7 x 10^{-1}, respectively (Tables J-7a and J-7b). Both these values were below the target level of unity, so a central tendency scenario was not modeled.

The total current resident lifetime excess cancer risk was calculated to be 3.2 x 10^{-4}, or 3 excess cancer cases in 10,000 individuals (Table 6-16). The majority of the risk came from the ingestion of Navesink Marl groundwater; however each of the Navesink Marl groundwater inhalation pathways (showering and whole house exposure) also exceeded the target level of 1 x 10^{-6}. Central tendency scenario risks were then calculated for carcinogenic compounds. Risks for inhalation of volatiles while showering and during whole house exposure no longer exceeded the target risk level, however the risk of groundwater ingestion was 4.5 x 10^{-5}, above the target risk level.

The total high-end risk scenario hazard index for current residential exposure from all pathways evaluated to contaminants from the K&M Site was calculated to be 3.4 x 10^{-1} and 8.1 x 10^{-1} for adults and children, respectively (Table 6-17). As these levels unlikely to cause any adverse health effects, no calculations were performed for noncarcinogens under the central tendency scenario. Additionally, in order to provide a conservative estimate of risk, the shallower, more contaminated Navesink Marl Formation was assumed to be used as a groundwater source, rather than the deeper, less contaminated Wenonah-Mt. Laurel aquifer.

These results indicate under the current conditions there are not expected to be any adverse effects to residents from noncarcinogens, but use of the Navesink Marl for drinking and other household uses may result in excess cancer risks above the target level.

Trespasser Exposure

Trespassers on the K&M Site are expected to be local residents. Therefore, trespassers will be exposed to incidental ingestion of surface soil/lagoon sediments and ditch/marsh sediments in addition to the pathways evaluated in the previous section. This scenario is considered conservative but reasonable, since it is likely that site trespassers would live in the immediate site vicinity.

The total carcinogenic risk for ingestion of site soils and lagoon sediments was calculated to be 1.5 x 10^{-7} for the high-end risk scenario (Table J-8a). The noncarcinogenic hazard index was calculated to be 5.4 x 10^{-2} (Table J-8b). As both the carcinogenic and noncarcinogenic risks were below target levels for these pathways, no central tendency exposures were calculated.

The high end exposure excess cancer risk from ingestion of ditch and marsh sediments was calculated to be 3.3 x 10^{-7} (Table J-9a). The noncarcinogenic hazard index for high end ingestion of ditch and marsh sediments was calculated to be 1.3 x 10^{-2}, (Table J-9b). As risks for these pathways were also below target risk levels, no central tendency exposures were calculated.

The total hazard risk index for trespasser exposure to noncarcinogens from trespassing and residential activities under the high-end risk scenario was calculated to be 4.1 x 10^{-1} (Table 6-17). The total excess cancer risk from all exposure pathways under the high-end risk scenario was calculated to be 3.2 x 10^{-4} (Table 6-17). The majority of this risk is derived from ingestion of Navesink Marl groundwater, as was true for the residential exposure. Using central tendency assumptions, the excess cancer risk was calculated to be 4.6 x 10^{-5}, still above the target risk level due to risks from ingestion of the Navesink Marl groundwater.

Site Workers

Site workers were assumed to be exposed to site contaminants via the following pathways: 1) incidental ingestion of site soils; 2) site soils fugitive dust inhalation; 3) lagoon sediment ingestion; 4) lagoon volatiles inhalation; 5) ingestion of Navesink Marl groundwater; and 6) ingestion of Wenonah-Mt. Laurel groundwater.

Lifetime cancer risks from ingestion of site soils were calculated to be 1.3 x 10^{-6} and 2.6 x 10^{-7} for the high-end risk and central tendency scenarios, respectively (Tables J-10a and J-10b). No compound individually exceeded the target limit under the high end scenario. The noncarcinogenic hazard index for ingestion of site soils was calculated to be 1.4 x 10^{-2} (Table J-10c) for the high-end risk scenario. As this hazard index well below the target level of 1.0, no calculations were performed for the central tendency risk exposure.

The high end carcinogenic risk associated with inhalation of fugitive dust from site soils was calculated to be 1.8 x 10^{-6} (Table J-11a). Most of this risk was attributed to chromium VI, which had an individual risk of 1.5 x 10^{-6}. Because the high end exposure scenario slightly exceeded the target level of 1 x 10^{-6}, the central tendency scenario risk was calculated, which provided a value of 4.5 x 10^{-7} (Table J-11b). As there were no reference doses available, noncarcinogenic risks were not quantified.

Lagoon sediments had no cancer slope factors associated with any of the compounds detected therein, and therefore only noncarcinogenic risks were evaluated. Noncancer risks to site workers from incidental ingestion of lagoon sediments was calculated to be 2.7 x 10^{-1} (Table J-12). Inhalation of volatile organics emanating from lagoon sediments yielded a hazard index of 1.3 (Table J-13), slightly above unity. Toluene was the main contributor to the risk, and individually exceeded the target level with a CDI/RfD ratio of 1.2.

The lifetime cancer risk associated with ingestion of Navesink Marl groundwater (high-end risk scenario) was calculated to be 1.9 x 10^{-4} (Table J-14a). As in the residential groundwater scenario, beryllium, vinyl chloride, and isophorone each individually exceeded the target risk level. Vinyl chloride contributed approximately 70% of the risk. The central tendency analysis for Navesink Marl groundwater ingestion also exceeded target risk levels with a total risk of 3.6 x 10^{-5} (Table J-14b). Vinyl chloride and beryllium each individually exceeded the target level, contributing about 70% and 30% of the risk, respectively. The noncarcinogenic hazard index for high-end risk ingestion of Navesink Marl groundwater was 2.4 x 10^{-1} (Table J-14c), below the target level.

The Wenonah-Mt. Laurel groundwater ingestion pathway contained no carcinogens, and therefore only noncarcinogenic risks were calculated. The hazard index was calculated to be 8.0 x 10^{-2} (Table J-15).

Site workers under the high-end risk and central tendency risk scenarios were calculated to have total cancer risks of 1.9 x 10^{-4} and 3.6 x 10^{-5}, respectively (Table 6-18). Both scenarios exceeded the target risk level. Ingestion of Navesink Marl groundwater contributed the bulk of risk in both scenarios. The hazard index for noncarcinogens under the high end scenario was calculated to be 1.8, slightly above the target level. Inhalation of volatile organics from lagoon sediments contributed over 70% of the risk, and was the only pathway to individually exceed the hazard index. Noncarcinogenic risks were only calculated for the high end exposure scenario, because the lagoon volatile inhalation pathway was not quantifiable for the central tendency exposure.

6.5.3 Future-Use Exposure Scenarios

Future-use exposure scenarios were calculated for residents living on the K&M Site and construction workers building the residential housing units.

As a future-use scenario, risks were calculated for residents who move into housing directly on the K&M Site. Residents may be exposed to: 1) all the current exposure pathways; 2) site soils ingestion; and 3) lagoon sediment ingestion. The calculations for all groundwater pathways and the fugitive dust inhalation are the same as for the present use scenarios and are not repeated here.

Ingestion of site soils yielded a 4.2 x 10^{-6} lifetime cancer risk for the high-end risk scenario (Table J-16a). Beryllium and benzo(a)pyrene each individually exceeded the target risk level, with risks of 2.1 x 10^{-6} and 1.6 x 10^{-6}, respectively. The central tendency scenario produced a risk of 6.7 x 10^{-7} (Table J-16b). The hazard indices for noncarcinogens were calculated to be 3.9 x 10^{-2} and 3.6 x 10^{-2} for adults and children, respectively (Tables 16-c and 16d), well below the target level of one.

The lagoon sediment ingestion and inhalation risks were only quantified for noncarcinogens, as there were no slope factors available for carcinogens. Ingestion of sediments by adults under the high-end risk scenario was below unity at 7.5 x 10^{-1} and the central tendency risk was 3.1 x 10^{-1} (Tables J-17a and J-17b, respectively). Noncarcinogenic risks for incidental ingestion of lagoon sediments by children exceeded the target level for both the high-end risk scenario and central tendency scenario, with hazard indices of 7.0 and 1.5, respectively (Tables J-17c and J-17d). Di-n-octylphthalate, butylbenzyl phthalate, and 1,2-dichloroethene each individually exceeded the target level under the high-end risk scenario. No compound had a CDI/RfD ratio greater than one under the central tendency assumptions.

Calculation of inhalation of volatile compounds from the lagoon was only quantifiable for noncarcinogens using the high-end risk scenario. The hazard indices for adults and children were 2.0 and 9.4, respectively. Toluene contributed about 85% of the risk, and individually exceeded the target ratio of one for both adults and children.

The total excess cancer risks for future residents living on the K&M Site under the high-end risk scenario was calculated to be 3.3 x 10^{-4} (Table 6-16), or 3 excess cancer cases in 10,000. This risk was largely due to ingestion of vinyl chloride in the Navesink Marl groundwater. However, all other Navesink Marl groundwater pathways and the site soils ingestion pathway also exceeded the target limit.

The high-end risk noncarcinogenic hazard index for adults was calculated to be slightly over unity at 3.1 (Table 6-16). The hazard index for children was calculated to be above unity at 18. Ingestion and inhalation of di-n-octylphthalate, butylbenzylphthalate and 1,2-dichloroethene in lagoon sediments were the prime contributors to this risk and most of the individual lagoon pathways exceeded target risk levels. A central tendency hazard index of 2.6 was calculated for children, while for adults the risk was under unity at 6.9 x 10^{-1}.

Construction Workers

Future risks were calculated for construction workers building the hypothetical residential housing units on site (Table 6-19). Only noncarcinogenic risks were able to be quantified for the ingestion of subsurface soil scenarios. The high-end risk scenario for incidental ingestion of subsurface soil by construction workers was calculated to 1.9 x 10^{-2} (Table J-19), well below the target level of one.

Subsurface soil inhalation exposure could only be calculated for cancer risks. The excess cancer risk from inhalation of subsurface soil fugitive dust was calculated to be 9.5×10^{-9} (Table J-20), well below the target level.

The ingestion and inhalation pathways for lagoon sediments could also only be quantitated for noncarcinogens. The high end ingestion of lagoon sediments pathway calculated a hazard index of 1.3×10^{-1} (Table J-21), and the inhalation of volatile organics from lagoon sediments high-end risk scenario calculated a hazard index of 6.5×10^{-1} (Table J-22). Both these hazard indices are within acceptable limits.

Use of Navesink Marl groundwater was also evaluated. The groundwater ingestion pathway had lifetime cancer risks of 3.8×10^{-6} and 1.8×10^{-6} for the high end and central tendency scenarios, respectively (Tables J-23a and J-23b). Approximately 70% of the risk came from vinyl chloride, which individually exceeded the target risk level for both scenarios. The noncarcinogenic risk from ingestion of Navesink Marl groundwater by construction workers provided a hazard index of 1.2×10^{-1} (Table J-23c).

Only noncarcinogenic risks were quantified for ingestion of Wenonah-Mt. Laurel groundwater. The hazard index was calculated to be 4.0×10^{-2} (Table J-24), below the target risk level.

Total carcinogenic risks for future construction workers at the K&M Site were calculated to be 3.8×10^{-6} and 1.8×10^{-6} for the high-end risk and central tendency scenarios, respectively. Over 99% of these risk came from ingestion of Navesink Marl groundwater. The total hazard index for the high-end risk noncarcinogenic compounds was 8.9×10^{-1}, below the target level of one.

6.6 Uncertainties in the Risk Assessment

This section addresses potential sources of uncertainty in the risk estimates, possible impacts of the various sources of uncertainty, and potential bias in the risk estimates. This discussion provides a context in which the significance and limitations of various risk estimates can be understood, to evaluate the overall potential health impacts associated with the K&M Site.

This risk assessment follows the most current risk assessment guidance issued by USEPA (1989a, 1992a). Hence, a qualitative approach identifying and discussing the level of uncertainty in specific aspects of the models was taken. Table 6-20 summarizes the various sources of uncertainty, the degree of uncertainty, and likely direction of bias introduced.

6.6.1 Uncertainties Associated with Physical Setting

Identification and Quantification of Pollutants of Concern

Samples were collected from various media present on site (see Section 4). Since sampling locations were biased toward areas suspected of being contaminated, the possibility that any significant contaminants were missed is considered to be low. The selection of compounds of concern examined the frequency of detection, detection concentration, and toxicity prior to eliminating compounds from consideration. Concentrations of inorganic compounds were compared to background levels in soil to limit the risk assessment to site-related contaminants. This procedure improved the level of confidence in the compounds of concern, and, therefore, the uncertainty associated with them is low.

The concentrations of contaminants used in the high-end risk assessment are the 95 percent upper confidence limits calculated according to the distribution of the data for each contaminant or the maximum detected levels, whichever value was lower. The concentrations were calculated to represent the reasonable maximum exposure, hence, there tends to be a bias to represent the upper range of concentrations of compounds to which an individual may be exposed. The compound concentrations used in this evaluation may introduce a large degree of uncertainty into the risk assessment because of the magnitude of the range of values detected in the media. In order to address this issue, the arithmetic mean concentration of compounds of concern that exceeded target risk levels under the high-end risk scenarios were calculated and used in central tendency scenario analyses.

6.6.2 Uncertainties Associated with Exposure Assessment Methods

Uncertainties Associated with Exposure Pathways

The receptor populations identified have a relatively high degree of certainty associated with them. Exposure pathways included all plausible scenarios.

Current land use scenarios have a relatively high degree of confidence because they were based on observations made by TAMS employees during the field sampling and on a cultural resources survey. An exception to this is the use of the Navesink Marl Formation as a groundwater source, since it is unlikely to produce a sufficient yield for residential use on a regular basis.

One source of uncertainty is the site worker scenario under current-use conditions; the site was initially occupied by workers, but by late 1991, workers were no longer active on site. The possibility that the site may once again be employed for industrial uses and that workers may be exposed to on-site compounds is low, since the site is now zoned "Neighborhood Commercial" and an industrial use such as that during K&M Site operations would not longer be allowed (although the exact site use is unknown). In this respect, the site worker exposure scenario is considered conservative since exposures are assumed to occur daily over an extended period of time.

The future-use scenario is based on placing residential housing units on the K&M Site, which would be a permissible use based on current site zoning. However, given the liabilities associated with the Site, it is unlikely it would be purchased for development prior to remediation. This scenario is conservative in assuming maximum site use with no remediation. It is also conservative in assuming that wells would be placed in the shallow Navesink Marl Formation, which provides an unreliable water source, rather than one of the deeper, more productive aquifers. The associated uncertainties are considered to be high for these assumptions.

Uncertainties Associated with Exposure Factors

Physical parameters are considered to accurately represent the local population, and have little systematic bias. Estimates of contaminant contact rate and intake factors were developed for high-end risk and central tendency individuals, and a moderate degree of uncertainty is associated with them.

The models used for fugitive dust soil emissions (particulates) and emissions of volatile organics encompass a great deal of uncertainty. No models specifically applicable to conditions at the K&M Site were found, and therefore the best available models (Cowherd et al., 1985 and USEPA, 1992d) were used for these pathways. Without field confirmation, the accuracy of these models is unknown. Therefore, a high degree of uncertainty is associated with them.

The groundwater volatilization models (Schaum et al., 1992) used for showering and whole house exposures are also considered to be conservative in their assumptions, such as the rate of air exchange between indoors and outdoors.

6.6.3 Uncertainties Associated with Toxicological Methods

The RfDs and slope factors contain inherent uncertainties owing to the difficulties associated with deriving toxicity values. Most values are derived from animal studies and lack evidence of toxicological effects on humans. Animal studies, although controlled more carefully, also have the problem of extrapolating between species. This is an area of great uncertainty, because toxicity is not necessarily uniform among species.

Toxicologists are aware of the inherent uncertainties in deriving toxicological values and include uncertainty factors and modifying factors to provide a measure of safety in the estimate. Toxicity values tend to be conservative in order to protect sensitive individuals. However, until further information is available concerning the specific compounds no definitive conclusions may be drawn about the level of uncertainty for each specific compound.

Risks may be underestimated for compounds with no current toxicological values or when values could not be extrapolated from one pathway to another (i.e., oral reference doses cannot be extrapolated to inhalation reference doses). The effects of potentially toxic compounds, such as trichloroethene and 1,1,1-trichloroethane, whose toxicity values are being reviewed by USEPA, were not estimated owing to the lack of toxicity values, which may result in an underestimate of overall risk.

6.6.4 Uncertainties Associated with High-End Risk and Central Tendency Scenarios

The high-end risk scenarios represent the plausible upper end of exposure an individual is likely to receive. Therefore, if noncarcinogenic and carcinogenic risks do not exceed target risk levels for high-end risk scenarios, baseline (no action) risks are considered to fall within acceptable levels.

Target risk levels were exceeded for current and future residential scenarios for carcinogenic risks from use of the Navesink Marl Formation (ingestion, showering and whole house inhalation pathways). For future residential scenarios carcinogenic target levels were exceeded for site soils and noncarcinogenic target levels were exceeded for lagoon sediment ingestion and lagoon sediment volatile inhalation. These pathways were then evaluated using a central tendency analysis.

A central tendency analysis is designed to provide some measure of the mean or most likely exposure circumstances, as opposed to the high-end risk scenario which is designed to examine plausible, but less likely exposure circumstances. In this manner, the central tendency analysis provides a means to examine the range of expected human health risks resulting from site related exposures. Central tendency analyses were performed where high-end risk scenarios yielded risks exceeding the target level. When a high-end risk scenario falls below the target level, the central tendency risk analysis will also do so.

Applying the central tendency assumptions, only carcinogenic risks from ingestion of Navesink Marl groundwater by current and future residents and noncarcinogenic risks from ingestion of lagoon sediments by future resident children (ages 1 to 6 years) were exceeded. Lagoon sediment volatilization was not quantifiable for the central tendency exposure. Risks from groundwater ingestion are derived primarily from vinyl chloride and beryllium. Each of these compounds individually exceeded the target level for both high end and central tendency scenarios. In addition, the carcinogen assessment has been withdrawn for both trichloroethene and tetrachloroethene that were both found in the Navesink Marl groundwater.

The main risk from lagoon sediment ingestion comes from ingestion of di-n-octylphthalate and butylbenzylphthalate. Neither of these compounds individually exceeded target levels. However, they both target the same organ, the liver (Table 6-13a). The majority of risk from inhalation of volatile organics emitted from the lagoon is from toluene.

Additional trespasser pathways did not exceed any target risk levels, limiting concern of trespasser exposure to contaminants they are exposed to at home (i.e., residential exposure).

Site workers exceeded target risk levels under the high end scenarios for carcinogenic risks from site soils ingestion and fugitive dust inhalation, Navesink Marl groundwater ingestion, and noncarcinogenic risks from lagoon sediments volatile inhalation. When central tendency assumptions were applied, only the ingestion of Navesink Marl groundwater exceeded target levels. As for residents, this risk was due to elevated concentrations of vinyl chloride and beryllium, both of which individually exceeded target levels. The central tendency scenario may provide a more accurate estimate of risks for site workers than the high-end risk scenario, because there are currently no workers on sites and the zoning of the K&M Sites has been changed to neighborhood commercial.

Future risks to construction workers were exceeded for ingestion of the Navesink Marl groundwater for both the high-end risk and central tendency scenarios. However, as construction workers are only expected to work for six months on-site, it is questionable whether they would use and install groundwater wells during construction.

6.6.5 Uncertainties Associated with Pathways and Contaminants Not Considered

Several pathways and contaminants of concern could not be completely evaluated due to the lack of sufficient toxicological data or exposure parameters. These pathways included dermal exposure to all soil and sediment media for residential and worker populations, and exposure to marsh surface waters by trespassers. However, it is unlikely that dermal exposures, which involve transport through the skin, would yield higher CDIs than those for direct ingestion. Thus, since most soil and sediment ingestion exposures fell below target risk levels, it is not expected that dermal exposures would yield risks exceeding the target level assuming similar toxicological effects by either absorption route.

Risks resulting from exposure to marsh surface water by trespassers could not be quantified due to the lack of appropriate data. However, based on the absence of substantive risk resulting from exposures to marsh, ditch, and stream sediments, it is unlikely that exposures to marsh surface water would pose unacceptable human health risks. This hypothesis is based on the relatively high sediment-to-water partition coefficients (K_{oc} values, as shown on Table 5-1) of the main marsh contaminants, the phthalate compounds, and on the absence of organic contamination in the surface waters downstream of the marsh (Barker's Brook). Additional information on the partition coefficients is given in Section 5 of this report. The result of a high partition coefficient is to yield a marsh water concentration orders of magnitude below the sediment concentration, assuming equilibrium between the phases. The assumption of equilibrium provides an upper bound on the water concentration since much of the sediment contamination lies just below the sediment-water interface and would not be available to maintain a true water-sediment equilibrium. In addition, the absence of downstream surface water contamination would suggest those surface water exposures do not pose substantive risks.

In addition to the pathways not evaluated, there were several contaminants of concern which could not be evaluated, specifically the TIC (tentatively identified compounds) phthalates, TIC benzene derivatives several PAHs, 1,1,1-trichloroethane, and trichloroethene. The chronic daily intakes for the compounds listed above, with the exception of the TICS, were quantified in the calculation tables provided in Appendix J. This was done to provide some measure of their intake relative to other contaminants with appropriate toxicity criteria.

While it is not possible to assess the individual toxicological effects of these compounds, it should be noted that the resulting intake rates are comparable to the contaminants whose risks could be quantified.

6.7 Summary of Risk Assessment

The human health risk assessment for the K&M Site examined plausible current and future exposure scenarios to determine whether the contaminants present posed unacceptable risks to exposed populations. A total of eighteen contaminants of concern was examined in the six distinct media present. Exposures to site surface soils, site subsurface soils, lagoon sediments, ditch, intermittent stream and marsh sediments, Navesink Marl groundwater and Wenonah-Mt. Laurel Aquifer groundwater were considered.

The quantitative risk assessment compared risks for current and future scenarios against target levels for both carcinogenic and noncarcinogenic exposures (1 x 10^{-6} and 1.0, respectively). The dominant risk at the K&M site is from ingestion of contaminated groundwater from the Navesink Marl for all receptors evaluated. Carcinogenic risks were calculated consistently above the target level of one in a million for all exposures. This risk is primarily from vinyl chloride and beryllium present in the water, although isophorone also contributes some risk. However, there are problems in maintaining a sustainable well in the Navesink Marl Formation, and this pathway may be incomplete.

Future residents may be exposed to noncarcinogenic risks above target levels from lagoon sediment ingestion and inhalation of volatiles from the lagoon sediment, if the lagoon is left as is prior to site development. Risks are primarily from phthalates and toluene. In addition, future residents may be exposed to elevated cancer risks due to ingestion of PAHs in site soils.

Site workers exceeded target risk levels for site soils ingestion and inhalation of fugitive dust, inhalation of volatile organics from lagoon sediment in addition to risks from ingestion of Navesink Marl groundwater. Lagoon sediments may emit volatile noncarcinogenic compounds that produce a hazard index slightly above unity, which may potentially affect site workers. Inhalation and ingestion of surface soils under the high end scenario may result in cancer risks above the target level. Approximately half the risk for the ingestion scenario is derived from beryllium, with benzo(a)pyrene and bis(2-ethylhexyl)phthalate contributing the remainder of the risk. The risk for the inhalation of site soils is primarily due to chromium VI, which exceeds the target risk level independently in the high-end risk scenario.

Unregulated use of the K&M Site and associated aquifers may result in carcinogenic and noncarcinogenic risks above target levels.

7.0 ENVIRONMENTAL ASSESSMENT

7.1 Purpose of Environmental Assessment

This environmental assessment discusses potential adverse ecological impacts of contaminants at the K&M site on local biota. The technical guidance for this assessment comes primarily from the Interim Final Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual (USEPA,1989a). This assessment focuses on a general description and characterization of potential impacts to local aquatic and terrestrial resources, providing a qualitative, rather than quantitative assessment.

The primary objectives of this assessment were to: 1) describe the exposed biological resources; 2) determine the significant pathways/routes of exposure; and 3) estimate the potential impacts of exposure to compounds of concern on biological resources.

7.2 Ecological Setting

TAMS ecologists conducted field investigations during the periods of August 26-30 and October 21 and 29, 1991. These investigations provided baseline information on the biological resources of the K&M study area. Four community types or habitats were identified within the study area: open field; riparian woodlands; marsh; and stream. A search was performed for records of existence of threatened, rare or endangered species or habitats in the K&M Site area. Information obtained from the NJ Natural Heritage Program indicated that there were no records of such species or habitats within the study area.

The only area of apparent contaminant-related stress seen during the field investigation was an isolated portion of the marsh. Yellow, withered vegetation and vegetation covered with petroleum-based products were apparent in the area immediately adjacent to the lagoon where the lagoon had overflowed into the marsh. The results of the ecological investigation are described in detail in Section 3.9 and the methods and results are presented in Volume III - Appendix G.

7.3 Receptors, Pathways and Toxicity Evaluation

7.3.1 Selection of Compounds of Concern

Compounds of concern for the environmental assessment were determined by analyzing data from four exposure media: 1) marsh soils (not considered sediments because the area in the marsh where samples were collected are not subject to predominantly aqueous conditions); 2) surface soil; 3) Barker's

Brook sediments; and 4) Barker's Brook surface water. Media for each habitat were selected based upon the habitat use of potentially exposed receptors. Data were grouped according to potential ecological exposure pathways for each community type. The media examined in each community type include:

Stream

- Barker's Brook Surface Water: The three surface water samples collected from the brook.
- Barker's Brook Sediments: The three sediment samples collected from Barker's Brook.

Marsh

- Marsh Soils: Soil samples from the adjacent marsh along the eastern portion of the site (not considered sediments because the area in the marsh where samples were collected are not subject to predominantly aqueous conditions). Samples included in this assessment were collected less than two feet below grade. No surface water samples were taken in the marsh.

Open Field

- Surface Soils (0 to 2 ft in depth): Soil samples from the site including composite samples collected at depths less than two feet below grade; but not including sediment samples from the ditch or intermittent stream.

Riparian Woodlands

- No soil samples were collected from the riparian woodland habitat adjacent to Barker's Brook. This community type is, therefore, not considered further.

To evaluate the potential for biological effects of selected sediment-sorbed inorganics and polynuclear aromatic hydrocarbons (PAHs), National Oceanic and Atmospheric Administration (NOAA) effects range guidelines were used for screening contaminants. Data from the National Status and Trends (NS&T) Program were used to identify contaminant concentrations associated with biological effects. The lower 10 percentile and median concentrations were identified as Effects Range - Low (ER-L) and Effects Range-Median (ER-M), respectively (NOAA, 1990; Table 4-13). The ER-L was used to screen contaminants for the selection of compounds of concern. For compounds without any biological effects guidelines, the frequency and concentration of each compound was examined to determine if it should be retained as a compound of concern.

Compounds of Concern in the Stream Habitat

No volatile organic compounds, with the exception of one contaminant also found in the blank, methylene chloride, were detected in the Barker's Brook surface water samples. As discussed in Section 5.2, the detection of methylene chloride is assumed to be the result of laboratory contamination. Thus, Barker's Brook surface water is eliminated as a medium for environmental exposure.

Sediment samples taken in Barker's Brook (see Table 4-13) were found to contain detectable levels of a number of contaminants. The volatile organic compounds detected, methylene chloride, acetone, and 2-butanone, are common laboratory contaminants. Acetone and 2-butanone were detected in all three of the Barker's Brook sediment samples as well as in the soil samples collected from the intermittent stream and drainage ditch. Due to the associated blank contamination, the reported detections of these two compounds were negated during data validation in sediment and soil samples except in samples SD01 and SD02. Although the concentrations reported in samples SD01 and SD02 exceeded 10 times the concentration in the associated blanks, the reported detection of these common laboratory contaminants is unlikely to represent site-related contamination. Rather, the prevalence of acetone and 2-butanone in lab, trip, and rinsate blanks indicates a high likelihood that laboratory-reported detections are artifacts of the sampling and analytical process. In addition, the presence of acetone and 2-butanone is not consistent with the site-related VOCs (i.e., 1,2-dichloroethene and BTEX compounds in the drainage ditch sample SD06). Although methylene chloride was not detected in blanks specifically associated with the sediment samples, it was detected in many other blanks associated with the K&M samples. In addition, the presence of methylene chloride is not consistent with site-related VOCs. Therefore, the reported detections of methylene chloride are also considered to be artifacts of the sampling and analytical process. These VOCs were not retained for evaluation as compounds of concern.

The semivolatile organic compound (SVOC) analysis identified PAHs and phthalates. PAHs are anthropogenic compounds which are often detected in sediment and soils. In the comparison of Barker's Brook sediment samples with NOAA ER-L values (Table 4-13), PAH concentrations detected in the sediment were well below the NOAA ER-L values. Therefore, PAHs were eliminated from further consideration as compounds of concern.

The target phthalates detected (diethylphthalate, di-n-butylphthalate and di-n-octylphthalate) were grouped together owing to their similar physical/chemical properties and a general lack of compound specific toxicity data. Phthalates were selected as a compound of concern due to the frequency of detection and concentrations of phthalates detected. Di-n-butylphthalate was the most prevalent phthalate detected.

Tentatively Identified Compounds (TICs) were not included in the environmental assessment because of the lack of toxicity and chemical data.

The inorganic analytes detected in the sediment samples were compared to the NOAA ER-L guidelines. Only chromium exceeded the NOAA ER-L criterion and, therefore, chromium was selected as a compound of concern in the Barker's Brook sediments.

Compounds of Concern in the Marsh

No ecological toxicological criteria were available for soil. However, because the marsh is intermittently covered with water, NOAA guidelines were used to screen potential compounds of concern in this matrix.

Table 4-11 summarizes the results from analysis of soils sampled in the marsh area. Most of the volatile organic contaminants detected in marsh soils were common laboratory contaminants (methylene chloride and acetone) detected at low levels, and were, therefore, dismissed from further consideration. Carbon disulfide was also detected at low levels and, as discussed in Section 4.4, is assumed to be the product of biogenic emissions. Toluene and xylenes were each detected in three soil samples collected within the lagoon overflow area. Toluene was retained as a compound of concern since it was detected at concentrations significantly greater than its detection limit. In contrast, xylenes were quantified below their detection limit in each of the three samples and, based on the uncertainty associated with these data, xylenes were not retained as compounds of concern.

Phthalates were detected in nine of the 13 samples and were again grouped together for comparison. Total concentrations ranged up to 910 ppm of known phthalates and up to 4,898 ppm of TIC semivolatiles. Hence, phthalates were selected as compounds of concern. Phenol was detected once as an estimated value in 13 samples. Since Phenol was detected in less than 10% of the samples, it was eliminated from further consideration. PAHs were detected in two out of 13 samples at concentrations below the detection limit (i.e., estimated values). Based on the low concentrations and the uncertainty associated with quantitation, PAHs were not retained as a compound of concern.

Several of the inorganic analytes detected in the marsh soils exceeded background soil criteria. Of these inorganics, only chromium and lead were detected at concentrations which exceed the NOAA ER-L criteria and both, with the exception of one sample (SS17), were detected at concentrations below the NOAA ER-M. Both chromium and lead were retained as compounds of concern.

Compounds of Concern in Open Field Habitats

As was previously noted, no ecological toxicological criteria are available for soils. Therefore, criteria used in the human health risk assessment were also used in this evaluation of surface soil contaminants. The compounds of concern developed for the human health risk assessment were considered appropriate for this assessment since the toxicological studies that provide the basis for the human health toxicological criteria consider both human and animal exposure. Because safety factors are applied when extrapolating from animal to human exposure, use of the resulting human exposure criteria in an ecological assessment is considered to be conservative.The analytes selected as compounds of concern include PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene), phthalates (bis[2-ethylhexyl]phthalate and di-n-octyl phthalate), chromium, and beryllium.

Summary of Compounds of Concern

The following compounds of concern were selected for each habitat:

Barker's Brook (Stream):

- chromium
- phthalates

Marsh:

- beryllium
- chromium
- lead
- toluene
- phthalates

Open Field Soils:

- beryllium
- chromium
- polynuclear aromatic hydrocarbons (PAHs)
- phthalates

7.3.2 Receptors and Pathways

Receptors at the K&M Site include flora and fauna. Plants can absorb site contaminants through their roots and translocate these materials into the stems and leaves, or contaminants may be absorbed directly into the leaves. Animals feeding on plants may be exposed to contaminants via ingestion of plant material.

Aquatic organisms in the marsh and Barker's Brook may potentially be exposed to compounds of concern through direct contact and ingestion of contaminated sediment and food. Benthic macroinvertebrates and amphibians that inhabit contaminated sediments are chronically exposed via dermal contact. Additionally, many macroinvertebrate species consume sediments as they non-selectively ingest large quantities of sediment and detritus to extract food material. Demersal (bottom-dwelling) fish can also be exposed via contact and ingestion, as they are in constant contact with sediment to extract food materials. Pelagic fish, those that live in the water column, are potentially exposed through contact with contaminated water or through ingestion of contaminated organisms.

Small mammals, such as moles and voles, can burrow into potentially contaminated substrates. As a result, they have direct contact with contaminants. At the top of the food chain, carnivores such as raptors (e.g., American kestrel) feed on these small mammals.

The potential contaminant transport pathways at the K&M site are as follows:

Flora

1) Uptake of contaminants in soil;
2) Uptake of contaminants in surface water; and
3) Uptake of contaminants in sediments.

Fauna

1) Contact with contaminated soils;
2) Contact with contaminated surface water;
3) Ingestion of contaminated fauna or flora;
4) Ingestion of contaminated surface water;
5) Ingestion of contaminated soils;
6) Ingestion of contaminated sediments; and
7) Inhalation of contaminated particulates.

Since no compounds of concern were selected for Barkers Brook surface water, all surface water exposure pathways are considered to be incomplete.

7.3.3 Potential Impacts of Exposure

The potential impacts of contaminant exposure on local biota were assessed based upon: 1) whether exposure pathways were considered to be complete; 2) review of the available toxicological literature. Below is a general discussion of the potential effects of toluene, PAHs, phthalates, chromium, lead, and beryllium exposure.

Toluene

The critical effects observed from oral exposure to toluene are changes in liver and kidney weights in studies of rats and mice (IRIS, 1995). However, no signs of biologic significance were seen in doses less than or equal to 1250 mg/kg (ppm). Studies of inhalation of toluene in rats had a No Observed Adverse Effect Level (NOAEL) of 1250 ppm. The maximum concentration of toluene detected in marsh soils at the K&M Site was 6.2 mg/kg, well below the levels at which adverse effects have been observed. Since the maximum concentration of toluene detected on site is several orders of magnitude below levels at which effects have been observed, it is unlikely that toluene at the K&M Site will adversely affect the biological community.

PAHs

PAHs are ubiquitous in nature, primarily as a result of natural processes such as forest fires, microbial synthesis, and volcanic activities (Eisler, 1987) Industrial activities may result in localized areas of high PAH contamination. Unsubstituted lower molecular weight PAH compounds, containing two or three rings (e.g, pyrene, phenanthrene), exhibit acute toxicity and other adverse effects to some organisms, but are noncarcinogenic. The higher molecular weight PAHs, containing four to seven rings (e.g., benzo(a)pyrene, dibenzo(a,h)anthracene) are significantly less toxic, but demonstrably carcinogenic, mutagenic, or teratogenic to a wide variety of organisms.

Plants and vegetables can absorb PAHs from soils through their roots and translocate them to other plant parts (Eisler, 1987). However, PAH-induced phytotoxic effects were rare. The biomagnification potential of PAHs has not been measured Sediments heavily contaminated with PAHs have directly caused elevated PAH body burdens and increased frequency of liver neoplasia in fishes (Black, 1983). Limited PAH toxicity information is available on most terrestrial organisms, such as invertebrates, reptiles and birds, but studies on mammals have shown carcinogenic effects from external and oral exposure to

PAHs. Effects include tumors in epithelial cells, damage of reproductive organs, and altered blood serum chemistry. Effects vary widely depending on the PAH mixture, concentration, and exposure route.

Phthalates

Long-term exposure to phthalates in water can affect reproductive success in aquatic organisms such as water fleas, guppies and zebra fish at levels as low as 3 ug/l. Higher doses may cause reproduction problems in mice (Revelle and Revelle, 1984). Under short term exposure, phthalates do not appear to be highly toxic, even in large doses (Revelle and Revelle, 1984).

No studies are available that examine the impact of ingestion of or contact with phthalate-contaminated sediments and soils on aquatic or terrestrial organisms. Literature compiled by the Agency for Toxic Substances and Disease Registry (ATSDR) suggests that oral doses of less than 100 mg/kg/day of di-n-butyl phthalate and less than 10 mg/kg/day of bis(2-ethylhexyl)phthalate would not be expected to cause observable adverse effects in the study animals (generally small mammals) (ATSDR, 1989a; ATSDR, 1989b). No ATSDR information is reported for other phthalates.

Chromium

Eisler (1986) reports that under laboratory conditions, high concentrations of chromium can be mutagenic, carcinogenic and teratogenic to a wide variety of organisms. Aquatic plants and marine polychaete worms appear to be the most sensitive groups. There is great variability among species in the sensitivity to and accumulation of chromium. This is attributed partly to the route of exposure (or administration), partly to the concentration of chromium and its chemical species (trivalent or hexavalent), and partly to numerous biotic and physicochemical factors. Such factors include water temperature, pH, the presence of other contaminants or compounds, sex, age, and weight. High accumulations of chromium have been recorded among organisms from lower trophic levels, but there is little evidence of biomagnification through aquatic and terrestrial food chains (Eisler, 1986).Adverse effects of chromium (Cr) to sensitive freshwater species have been documented at 10.0 ug/l of Cr^{+6} and 30.0 ug/l of Cr^{+3} (Eisler, 1986).

A literature review by the National Oceanic and Atmospheric Administration (NOAA) suggests that the midpoint sediment concentration at which adverse biological effects were observed is 145 mg/kg (NOAA, 1990). Chromium levels in Barker's Brook sediments were below NOAA ER-M guidelines, but not below the NOAA ER-L.

Beryllium

The ecological impact of beryllium is not well understood at the present time. Only Ambient Water Quality Criteria guidelines (USEPA,1986d) provide information on the potential ecological toxicity of beryllium. The available data for beryllium indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations of 130 and 5.3 ug/L, respectively.

Lead

Lead may adversely affect survival, growth, reproduction, development, and metabolism of most species under controlled conditions, but its effects are substantially modified by physical, chemical and biological variables (Eisler, 1988). In general, organolead compounds are more toxic than inorganic lead compounds, food chain biomagnification of lead is negligible, and immature organisms are most susceptible to toxicity. Uptake of lead by terrestrial plants is limited by the low bioavailability of lead in soils; however, bioavailability may be enhanced by local soil conditions (e.g., low pH or low organic content).

Lead is toxic to all phyla of aquatic biota, but its toxic action is modified by species and physiological state. Wong et al. (1978) reported that only soluble waterborne lead is toxic to aquatic biota, and that free cationic forms are more toxic than complexed forms. Since lead was not detected (detection limit = 1 ppb) in the surface water of the K&M Site, and because only waterborne lead is toxic, no apparent toxicity effects on aquatic organisms are expected. Additionally, although lead is concentrated by biota from water, there is no convincing evidence that it is transferred through food chains (Wong et al., 1978; USEPA, 1979; Settle and Patterson, 1980). Lead concentrations were found to decrease markedly with increasing trophic levels in both detritus-based and grazing aquatic food chains (Wong et al., 1978). It has been shown that organisms, such as snails, which ingest lead-contaminated sediment, and those at higher trophic levels, such as fish which consume snails, rapidly release the lead; feces from both snails and fish return the lead to the ecosystem as particulates and detritus (Everand and Denny, 1984).

The primary threat of lead poisoning to wildlife (particularly waterfowl and other bird groups) is the ingestion of shotgun pellets or other such lead objects. In general, forms of lead other than shot, or routes of administration other than direct ingestion, are unlikely to cause clinical signs of lead poisoning in birds (Eisler, 1988). It is therefore unlikely that lead concentrations at the K&M Site are toxic to birds. There are no data for toxic and sublethal effects of lead on mammalian wildlife in the available literature. Oral doses of lead to species of domestic and laboratory animals, however, have caused acute and chronic effects (Eisler, 1988).

7.4 Ecological Significance of Findings

The only observed contaminant-related stress to the ecosystem was the vegetation in the portion of the marsh immediately adjacent to the lagoon. The flora in the remainder of the study area appeared healthy and exhibited a species composition indicative of similar habitats elsewhere. (Volume III - Appendix G). No obvious physical abnormalities were observed in the fauna of the study area, including the stressed area of the marsh, which contained numerous frogs. The birds, mammals and herpetofauna of the study area contained species typical of each habitat type.

The assemblage of macroinvertebrate taxa in Barker's Brook adjacent to, upstream of, and downstream of the K&M facility were typical for a small stream. There were no clear patterns of benthic macroinvertebrate tolerance or intolerance detected in sampling locations upstream of, adjacent to, and downstream of the K&M facility (see Volume III Appendix G). Three relatively intolerant taxa were collected at each of the three sampling locations. Since sensitive, intolerant macroinvertebrate taxa were collected from all three areas of Barker's Brook, there is no evidence of adverse contaminant-related impacts to the aquatic ecosystem.

Review of the available literature provided little toxicity data for compounds of concern in sediment and soil matrices. However, it is unlikely that contaminants are equally toxic in these environments. Generally, contaminants are more readily bioavailable in an aqueous matrix than in a solid (soil or sediment) matrix.

The concentrations of phthalates, chromium, and toluene detected at the K&M Site are unlikely to cause any adverse effects in the local flora or fauna. Toxicity data for beryllium were sparse. Concentrations detected on site were only slightly above background levels, therefore, it is not known whether beryllium concentrations are the result of previous site activities. The potential impacts of PAHs are difficult to evaluate, as individual PAHs have variable toxicities and the PAH contribution from activities at the K&M Site is unknown. Based upon the field investigation results, there is no evidence, with the exception of the isolated area of stressed vegetation in the portion of the marsh directly adjacent to the lagoon, of any adverse effects due to exposure to contaminants at the levels detected at the K&M site. However, because toxicological data are limited, individual organisms living in highly contaminated areas for extended periods may be at higher risk than individuals living in uncontaminated areas.

8.0 SUMMARY AND CONCLUSIONS

A remedial investigation (RI) of the K&M Site, Jobstown, New Jersey was performed for the USEPA, Region II by TAMS Consultants, Inc. The purposes of the investigation were threefold: 1) to determine the physical characteristics of the site and sources of contamination, 2) to evaluate the nature and extent of contamination, and 3) to characterize the potential human health risk and environmental impact posed by the site. This chapter presents a summary of the findings of the RI, and overall conclusions are presented with regard to remedial action objectives.

8.1 Summary

Historically, K&M transported bulk liquids consisting primarily of organic substances including plasticizers, resins, vegetable oils, soaps, petroleum oils, and alcohols. From 1960 through at least 1981, wastewater generated from the washing of tanker interiors was discharged to an on-site lagoon. The 0.7-acre, irregularly shaped, unlined lagoon was about three to 10 feet deep prior to being drained in the summer of 1991 by USEPA. Since that time the lagoon has refilled due to precipitation.

A small marsh immediately adjacent to the eastern property boundary gives rise to an intermittent stream. This stream flows south-southeast into a branch of Barker's Brook which is located approximately 575 feet south of the K&M property. Springfield Township does not operate a public water supply system; potable water is obtained by private on-site wells. Below the site and directly below the Navesink Formation (a sandy clay layer, approximately 10 to 25 feet thick in the site vicinity) is the Wenonah - Mt. Laurel Aquifer, which supports 80 percent of the potable supply wells in the area. The nearest well drawing water from this aquifer is located approximately 500 feet from the K&M lagoon.

Starting in 1978, a series of site inspections was initiated by State and County regulatory agencies. Regulatory directives, including an early order to dispose of lagoon and process wastewaters properly, were largely ignored by K&M. On June 1, 1984, the dike surrounding the lagoon broke and a portion of the lagoon contents was released to the adjacent marsh and downstream areas. A Hazard Ranking System (HRS) score of 28.51 was developed for the K&M Site in 1986, based on the groundwater route evaluation. The K&M facility was subsequently placed on the National Priorities List (NPL). Remedial investigation field work was initiated at the K&M Site in September 1991 and was completed in March 1992.

The following RI field activities were conducted at the site: land survey; cultural resources survey; geophysical survey; soil gas survey; investigation of lagoon sediments, berm soils and subsurface soils; drilling of exploratory borings and collection of soil samples in fill materials in the Navesink Formation and in the Wenonah - Mt. Laurel Aquifer; sampling of surface soils in the marsh, in the intermittent stream leading from the marsh to Barker's Brook and in the drainage ditch extending along the southwestern boundary of the site into

Barker's Brook; sampling of surface water and sediments in Barker's Brook; installation and sampling of groundwater monitoring wells in both the Navesink Formation and Wenonah - Mt. Laurel Aquifer; human population and land use survey; and an ecological investigation.

The direction of groundwater flow within the Navesink Formation and within the Wenonah - Mt. Laurel Aquifer was determined to be generally south-southwest. An order-of-magnitude difference in average hydraulic conductivity was observed between the two formations. While differences in groundwater elevation indicate that the Navesink provides recharge to the Wenonah-Mt. Laurel Aquifer in the vicinity of the site, the rate of recharge is relatively slow compared to the rate of lateral flow in the Wenonah-Mt. Laurel.

8.1.1 Nature and Extent of Contamination

Samples submitted for chemical analysis were analyzed by USEPA Contract Laboratory Program (CLP) protocols for Target Compound List (TCL) volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), as well as Target Analyte List (TAL) inorganics. In addition, most soil samples were also analyzed for total petroleum hydrocarbons (TPHC) and total organic carbon (TOC), and some were analyzed for the hazardous characteristic of toxicity using the Toxicity Characteristic Leaching Procedure (TCLP). Surface water and groundwater samples were also analyzed for various conventional and wet chemistry analytes (e.g., nitrate, biochemical oxygen demand). Volatile organic compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX compounds), and chlorinated aliphatics; SVOCs, including phthalates and polynuclear aromatic hydrocarbons (PAHs); as well as several metals are the principal contaminants detected. Results were generally consistent with previous data for the site.

BTEX compounds and chlorinated VOCs, SVOCs, including phthalates, as well as TPHC, were detected in the lagoon sediment samples. Various PAHs were also found. The concentration of trichloroethene detected in the TCLP extract at one location would cause the material to be classified as hazardous waste (EPA hazardous waste number D040). Based on sediment thickness measurements made by TAMS in March 1992 and by Environics, Inc. (consultant to K&M) in August 1986, the lagoon sediment volume was estimated to be within the range of 600 to 1,200 cubic yards.

Relatively low levels of BTEX compounds, compared to concentrations detected in lagoon sediments, were found in lagoon berm soils. Semivolatile organic compounds identified are limited to phthalates, and the levels detected are comparable to concentrations found in the lagoon sediments at most locations. Concentrations of inorganics detected are consistently within the background criteria and no TCLP constituents were found in excess of the regulatory limits for RCRA toxicity.

In general, phthalates concentrations in subsurface samples from a lagoon profile boring were found to decrease with depth, with the concentrations in the

10 to 12 foot interval about one order of magnitude less than in the 2 to 4 foot interval. A similar pattern is apparent for BTEX, other VOCs, and TPHC. The concentration of chromium in both the shallow and the deep sample exceed the background criterion for chromium. In addition, concentrations of antimony, selenium, and vanadium in detected in sample SB02 exceed background criteria.

Various organic compounds, including BTEX and other VOCs, phthalates, PAHs and other SVOCs, TPHC, as well as several inorganic contaminants, were detected in surface and subsurface soil samples collected from the unpaved operations lot and other targeted areas within the K&M property.

VOCs and SVOCs were also detected in soil samples collected in the marsh. In addition, a TPHC concentration of 4,610 ppm was detected in sample SD08 located adjacent to the lagoon and within the lagoon overflow area. Several metals, including beryllium, cadmium, chromium, copper, selenium, vanadium, and zinc were detected at elevated levels in samples collected within the overflow area. In addition, chromium, copper, selenium, vanadium, and zinc were detected at elevated levels in samples collected beyond the lagoon overflow area.

No target VOCs were detected in surface water samples collected from stagnant puddles in the intermittent stream and drainage ditch. However, SVOCs including phenol and phthalates (bis(2-ethylhexyl)phthalate, di-n-octyl phthalate and butylbenzylphthalate) were detected in the intermittent stream and drainage ditch samples. In general, the highest inorganic concentrations were detected in unfiltered drainage ditch sample SW06. While filtered samples SW04A (intermittent stream) and SW05A (drainage ditch sample nearest to Barker's Brook) show similar concentrations of inorganic analytes, filtered sample SW06A tends to have slightly, but noticeably, higher inorganic concentrations. Thus, the drainage ditch, which was intentionally used for site stormwater discharge, exhibits higher concentrations of inorganics than the intermittent stream, which only received occasional discharge due to lagoon overflow events.

In the soil sample collected at the corresponding location in the intermittent stream bed, the BTEX VOC toluene was detected. In addition the target SVOCs butylbenzylphthalate and di-n-octylphthalate, which were also detected in at least five of the marsh area surface soil samples, were detected. TPHC was detected at a concentration of 21,000 ppm (2.1 percent).

BTEX compounds and low levels of chlorinated VOCs were detected in the drainage ditch bed soil sample collected on the K&M property directly adjacent to the lagoon. No target VOCs were detected in the downstream drainage ditch surface soil sample. SVOCs butylbenzylphthalate and di-n-octyl phthalate were detected in both drainage ditch bed soil samples. In addition, TPHC was also detected in both samples and, similar to the SVOC distribution, concentrations detected in SD06 were generally greater than those detected in the downstream SD05 sample. Several metals, including antimony (SD05 only), cadmium, chromium, copper, mercury (SD05 only), selenium, vanadium, and zinc were detected above the background criteria in both samples.

Barker's Brook surface water samples showed no detections of VOCs or SVOCs; detections of inorganics and conventional analytes are below New Jersey Surface Water Quality Criteria (NJSWQC). Several VOCs including acetone, 2-butanone, and methylene chloride were detected in the Barker's Brook sediment samples. However, the prevalence of these common laboratory contaminants in lab, trip, and rinsate blanks suggests that these VOCs are artifacts of laboratory contamination. Low levels of PAHs and phthalates were detected in all three sediment samples. In addition, TPHC concentrations were found to increase in the downstream direction, ranging from 83 ppm in sample SD03 to 5,360 ppm in SD01. However, it is not certain whether the TPHC detection is entirely related to the site or partly to the nearby roadway. Inorganic analytes in the sediment samples were detected below the NOAA ER-M criteria used to evaluate sediments in aquatic environments.

Chlorinated VOCs, which are typically associated with solvents, were detected in samples from Navesink Formation (shallow) wells MW102S (southwest and downgradient of the lagoon) and MW105S (west and immediately downgradient of the lagoon). The concentrations of tetrachloroethene and 1,1-dichloroethene detected in MW102S are both within the Federal MCLs. The concentrations of vinyl chloride, 1,2-dichloroethene and trichloroethene detected in MW105S exceed the NJ groundwater quality criteria for Class II-A waters as well as the state and Federal MCLs. The BTEX compounds benzene and xylenes were also detected in MW105S but at concentrations equal to or below the applicable criteria. No volatile organic compounds were detected in any of the other shallow groundwater samples collected from the site.

Trace levels of phthalates (SVOCs) were detected in wells MW104S (along the northwest marsh boundary) and MW106S (adjacent to the former washwater collection pit). Non-target SVOCs were detected in all the shallow well samples, except that from MW101S. The concentration of isophorone detected in MW105S exceeds the NJ Groundwater Quality Criterion. Petroleum hydrocarbons (TPHC) were not detected in any of the samples.

Metals were typically present at higher concentrations in the unfiltered aliquot of a sample than in the filtered aliquot. Also, metals were often detected in the unfiltered fraction of a sample, but not in the filtered aliquot. Manganese exceeds the NJ Groundwater Quality criterion in eight of nine unfiltered samples (MW104S being the only exception) and in six of the filtered (dissolved metals) samples. Arsenic and chromium exceed the applicable criteria in unfiltered samples from MW-3 and MW101S, but either were not detected or were detected below the applicable criteria in the corresponding filtered samples. Lead exceeds the NJ Groundwater Quality Criterion in the unfiltered samples from MW101S, MW103S, and MW106S, but was either not detected or was detected below the criterion in the corresponding filtered samples. The only other inorganic analyte which exceeds the applicable criterion is nickel, in both the filtered and unfiltered samples from MW106S.

Monitoring wells MW101D, MW102D, MW103D were installed to monitor groundwater quality in the Wenonah-Mt. Laurel Aquifer. These wells are part of three two-well clusters that include corresponding Navesink Formation wells. With the exception of methylene chloride, a common laboratory contaminant detected in MW102D, no target or non-target VOCs or target SVOCs were detected in samples from the deeper monitoring wells. Non-target SVOCs were detected in the samples from MW102D and MW103D at relatively low levels. Petroleum hydrocarbons were not detected in any of the deep well samples.

As expected, detected inorganic analyte concentrations for the filtered sample aliquots are typically lower than the concentrations found in the unfiltered samples. Similarly to the shallow groundwater samples, manganese exceeds the NJ Groundwater Quality criterion in both the filtered and unfiltered samples from all three wells. The chromium concentration found in the unfiltered sample from MW101D exceeds the state and Federal MCLs; however, chromium was not detected in the filtered sample. No other inorganic analyte concentrations detected in the filtered and unfiltered samples from the deep wells exceed the applicable criteria.

8.1.2 Contaminant Fate and Transport

Observed contamination consists mainly of phthalates, aromatic hydrocarbons, chlorinated VOCs, and petroleum hydrocarbons in lagoon sediments, and phthalates and petroleum hydrocarbons in the surface soils and ditch and stream sediments. Elevated concentrations of metals (chromium, lead, and others) occur periodically. Manganese occurs in elevated concentrations in most aqueous (surface water and shallow and deep groundwater) samples.

Several of the environmental media studied have the potential for off-site migration, primarily lagoon sediment and surface soil, via physical transport and leaching of contaminants. Subsurface soils do not have the potential for off-site transport unless exposed by excavation. Although several contaminants of concern were detected in subsurface soil samples, the mode of transport of these contaminants would be through leaching and subsequent groundwater transport.

Sediments in Barker's Brook as well as bed soils in the drainage ditch and intermittent stream are subject to waterborne transport. Drainage ditch and intermittent stream bed soils are subject to waterborne transport only after periods of significant rainfall, since these water bodies are normally dry.

Surface water flow consists of discharges from the drainage ditch and intermittent stream and surface runoff from precipitation. Surface water quality appears impacted only in the immediate vicinity of the site, namely, at discharge locations between the K&M property and Barker's Brook. Dilution or natural renovation occurs downstream of the site, i.e., at Barker's Brook, so that no discernible effects attributable to the site were observed in surface water samples from Barker's Brook. However, contaminated surface water does represent a potential route of migration from the site.

The data for aromatic hydrocarbons (BTEX compounds), along with the data for chlorinated VOCs as well as SVOCs (other than phthalates or PAHs) suggest that organic contaminants have migrated from the lagoon into the shallow groundwater in the Navesink Formation, and then migrated with the groundwater toward the south or southwest. The groundwater samples collected from the deeper monitoring wells as part of this investigation do not show any apparent contamination attributable to the site. The elevated concentrations of manganese appear to be a local anomaly, as opposed to resulting from site contamination. It should be noted that groundwater from the Wenonah - Mt. Laurel Aquifer is used as a drinking water source in the vicinity of the site.

The mobility of organic contaminants in the environment, other than by physical processes, such as erosion and deposition, is controlled primarily by four chemical characteristics: vapor pressure; Henry's Law Constant; aqueous solubility; and the organic carbon-water partition coefficient (Koc).

While widespread at the site, VOCs are present primarily at low concentrations. The principal mechanism for the natural removal of VOCs is through volatilization, as indicated by high vapor pressures and Henry's Law Constants. Based on the moderate aqueous solubility and low to moderate Koc values, the BTEX compounds are fairly mobile in soil. The environmental half-life of the BTEX compounds is fairly short in soil and surface water, but may be substantially longer in groundwater, where biodegradation is not significant. The chlorinated VOCs would exhibit a similar fate and transport pattern to the BTEX compounds. The environmental half-life of the chlorinated VOCs is longer, however, indicating less rapid natural attenuation of these substances in all media; therefore, the chlorinated VOCs are expected to be fairly persistent, especially in groundwater.

The SVOCs, particularly the PAHs, are persistent in the environment due to their chemical nature. PAHs were detected sporadically, i.e., in one sediment sample collected from the lagoon (the highest detection), various surface soil samples, and all three samples from Barker's Brook. PAHs generally have a very low solubility. The Koc values of PAHs are generally high indicating that PAHs readily adsorb to organic carbon in soils. This accounts for their virtual absence from the groundwater and surface water samples.

The occurrence of phthalate esters is widespread across the site, including presumed background sample locations. They generally exhibit low solubility and high Koc, and so would not be expected to be mobile in soil. The data from Barker's Brook and discharge location sediment samples suggest that some migration of phthalates has occurred. Control of phthalate migration would require control of sediment and soil migration, as well as discharges from the lagoon.

Based on the site history and age, the petroleum hydrocarbons remaining on site would be expected to be the less volatile, higher molecular weight constituents. The absence of detectable concentrations of TPHC in groundwater samples is consistent with both the expected and observed behavior of these compounds. The observed attenuation of TPHC concentration in soils with depth, along with the expected moderate to high Koc values and low aqueous solubilities of these compounds, would indicate that migration of these compounds into groundwater is not likely to be significant.

The presence of numerous inorganic analytes was reported. Many metals have an affinity for soils (particularly clay particles and organic matter in soils) which reduce their mobility. However, under low pH conditions, most metals can be rendered mobile. The inorganic analytes which appeared elevated above soil background evaluation criteria in one or more samples are: beryllium, cadmium, chromium, copper, selenium, vanadium and zinc. Migration of inorganics in soils, even from the lagoon sediments, is not expected to be of concern.

Chromium, arsenic, and lead detections exceed the applicable criteria in a few unfiltered groundwater samples, but were detected at less than the applicable limits in the filtered samples. While there is a potential for contaminant migration to and subsequent degradation of Barker's Brook, there is no evidence to date of inorganic contamination of Barker's Brook, either from surface water or sediment sample data.

In summary, three major contaminant transport pathways have been identified at the site, based on the data generated during the RI. These are:

1. Vertical migration of mobile organics from the lagoon sediments through the underlying soil and into the shallow groundwater in the Navesink Formation, and subsequent migration of contaminated water. Chlorinated aliphatics and BTEX compounds have been detected in shallow groundwater samples from monitoring wells near the lagoon. However, there is no evidence to date of further horizontal or vertical migration of these contaminants to the deeper aquifer or to off-site wells.

2. Transport of contaminants from the lagoon (by sediment or water) to the marsh immediately adjacent to the lagoon through overflow or breaching of the lagoon berm. Phthalates, especially di-n-octylphthalate, were detected in high concentrations in marsh sediment samples collected adjacent to the lagoon. Although phthalates were also detected in several other samples from the marsh, the concentrations decreased significantly with distance from the lagoon.

3. Overland transport of contaminants via surface flow (stormwater runoff contaminated by contact with site soils and contaminated soils entrained in the runoff) to the drainage ditch and intermittent stream, followed by potential or actual transport of contaminated sediments to Barker's Brook. High concentrations of phthalates, petroleum hydrocarbons, unidentified

semivolatile organics, and to a lesser extent, BTEX compounds and chlorinated aliphatics, were detected in the drainage ditch adjacent to the unpaved operations lot. Many of these contaminants were also detected farther downstream in the ditch and in Barker's Brook sediments, although at lower concentrations. Phthalates, unidentified semivolatile organics, and petroleum hydrocarbons were also detected at high concentrations in the intermittent stream connecting the marsh and Barker's Brook, although the concentrations are not as high as those in the ditch samples.

8.1.3 Summary of Human Health Risk Assessment

The human health assessment for the K&M Site examined current and future exposure scenarios to determine if concentrations of contaminants present in various media pose unacceptable carcinogenic or noncarcinogenic risks to potentially exposed populations. A total of 24 compounds of concern were examined in six distinct media. Exposures to site surface soils, site subsurface soils, lagoon sediments, ditch and marsh soils, Navesink Marl groundwater, and Wenonah-Mt. Laurel groundwater were examined.

The quantitative risk assessment for current residents calculated risks above the target level of 1×10^{-6} (one in a million) excess cancer cases for both the high-end risk and central tendency scenarios. All pathways that individually exceeded the target level resulted from use of the Navesink Marl groundwater. For the high-end risk scenario inhalation of volatiles while showering, inhalation of volatiles due to whole house exposure, and ingestion of groundwater all individually exceeded the target level of one excess cancer case in a million. The only pathway to exceed the target level for the central tendency scenario was ingestion of Navesink Marl groundwater. Risks from noncarcinogenic compounds fell below target levels.

If the K&M Site is developed for residential housing in the future without remediation of any kind, residents may be exposed to additional health risks. Future-use scenarios showed risks above carcinogenic and noncarcinogenic target levels. Under the high-end risk scenario, site soils fugitive dust inhalation, site soils ingestion, and all Navesink Marl groundwater pathways had excess cancer risks greater than 1×10^{-6}. When central tendency assumptions were applied, only the ingestion of Navesink Marl groundwater exceeded the target level. Noncarcinogenic risks from inhalation of volatile organics from the lagoon and ingestion of lagoon sediments (children only) were above target levels under the high-end scenario. The only pathway to have potential noncarcinogenic risks under the central tendency scenario was ingestion of lagoon sediments by children.

Trespassers were not determined to be exposed to unacceptable carcinogenic and noncarcinogenic risks by entering the K&M Site. However, as trespassers are considered likely to be local residents, they are currently at risk from use of the Navesink Marl groundwater.

Site workers were calculated to be exposed to carcinogenic and noncarcinogenic risks above target levels for the high-end risk scenario, and for carcinogenic risks under the central tendency scenario. Pathways that individually exceeded carcinogenic risks under the high-end scenario were ingestion of Navesink Marl groundwater, site soils fugitive dust inhalation, and site soils ingestion. Inhalation of volatiles from the lagoon exceeded noncarcinogenic risk levels under the high-end risk scenario. Under the central tendency scenario only carcinogenic risks from the ingestion of Navesink Marl groundwater exceeded the target risk level.

If the K&M Site is developed for residential use, the construction workers building the units will be exposed to carcinogenic risks slightly above the target level for both the high-end risk and central tendency scenario from ingestion of Navesink Marl groundwater.

The majority of the risk to residents (current and future), site workers, and future construction workers is due to use of the Navesink Marl groundwater. The Navesink Marl groundwater usage pathways are not substantiated at the present time. Hydrological tests indicate that it would be difficult to obtain a sufficient yield from the Navesink Marl Formation, and therefore it is unlikely that receptors would use this formation exclusively. Approximately 70% of the risk from groundwater ingestion was due to vinyl chloride, and all the risk from Navesink Marl inhalation pathways was attributed to benzene. Each of these compounds was detected in only one of nine samples, indicating that contamination in the Navesink Marl Formation is not widespread. Therefore, exposure point concentrations used in this assessment are considered to be conservative. Conversely, toxicity values were not available for several compounds in this assessment (i.e., 1,1,1-trichloroethane, trichloroethene, several PAHs, TIC benzene derivatives and TIC phthalates), which may underestimate potential risks.

Lagoon sediments exceeded target risk levels via volatile ingestion and inhalation pathways. Risks were mainly derived from toluene for the inhalation pathway and from di-n-octylphthalate, butylbenzylphthalate, and 1,2-dichloroethane for the ingestion pathway. Risk calculations assumed that the lagoon would be left "as is" and individuals would have open access to it. The air model for volatilization of compounds from the lagoon assumed no depletion from the lagoon sampling time to the time receptors are on-site, which may overestimate the risk from volatile inhalation.

Site soils exceeded the target risk level for site soil ingestion and site soil fugitive dust inhalation. Beryllium and benzo(a)pyrene contributed the majority of the risk. Target risk levels were not exceeded using central tendency exposure assumptions.

8.1.4 Summary and Conclusions of the Environmental Assessment

The primary objective of the environmental assessment was to estimate the potential ecological impacts associated with the release of contaminants from the K&M facility.

Two wetland areas were identified and mapped as part of the ecological investigation. One wetland (marsh area) of about 2.3 acres is located northeast of the K&M property; a second, approximately 2.5 acres in size, is located southeast of the K&M property, adjacent to Barker's Brook. No Federal or State protected vegetative or animal species were found during the ecological investigation.

The only area where there was obvious contaminant-related stress to the ecosystem was in the portion of the marsh directly adjacent to the lagoon and subject to lagoon overflow. The flora in the remainder of the study area appeared healthy and exhibited a species composition indicative of similar habitats elsewhere. No obvious physical abnormalities were observed in the fauna of the study area either, including the stressed area of the marsh, which contained numerous frogs. The birds, mammals and herpetofauna of the study area contained species typical of each habitat type. Additionally, the assemblage of macroinvertebrate taxa in Barker's Brook adjacent to, upstream of, and downstream of the K&M facility were typical for small streams.

There were no clear patterns of benthic macroinvertebrate tolerance or intolerance among sampling locations upstream of, adjacent to, or downstream of the K&M facility. Three relatively intolerant taxa were collected at each of the three sampling locations. Since sensitive, intolerant macroinvertebrate taxa were collected from all three areas of Barker's Brook, it appears that the aquatic ecosystem is not experiencing adverse contaminant-related impacts.

Based on evaluation of receptors, pathways and chemical toxicity for the environmental assessment, contaminants of concern at the site for various media in identified habitats were defined as beryllium, chromium, PAHs, and phthalates. Review of the available literature and the site-specific data indicate that it is unlikely that phthalate concentrations at the K&M Site are acutely toxic to aquatic and terrestrial resources. The effects of long-term exposure to small doses of phthalates in water is unclear, although it is has been speculated that it can cause reproductive problems in some organisms. However, phthalates in water do not appear to be highly toxic during short-term exposures, even at high doses.

Beryllium and chromium were not detected in surface water samples. These contaminants may adsorb to sediments and therefore have low bioavailability potential. Since these metals were not detected in surface water samples, no adverse effects from contact with surface water are expected.

Chromium concentrations detected in the Barker's Brook sediments are below concentrations reported to produce adverse effects in sensitive freshwater species. Additionally, there is little evidence of biomagnification through food chains.

Although the potential for adverse effects exist, there is no evidence, with the exception of the isolated area of stressed vegetation in the portion of the marsh directly adjacent to the lagoon, of any adverse effects due to exposure to contaminants at the levels detected at the K&M site. Based upon: 1) the baseline information gathered during the field investigation, 2) review of available data and literature, and 3) a comparison of the levels of site contamination to available toxicity data, there are no apparent contaminant-related impacts on the surrounding aquatic and terrestrial habitats.

8.2 Conclusions

Results of the RI indicate that contaminants from the lagoon and site activities have been released to surrounding areas by lagoon overflow, surface water runoff and subsurface leaching. While site-related contaminants were found in site soils, marsh sediments, intermittent stream and drainage ditch sediments and surface water, Barker's Brook sediments, and shallow groundwater adjacent to the lagoon, there is no evidence of on-going contamination of Barker's Brook surface water or of groundwater in the Wenonah-Mt. Laurel Aquifer, which is used for potable water supply in the site vicinity. The primary contaminants are phthalates, BTEX compounds and TPHC; isolated occurrences of other contaminants such as metals and chlorinated VOCs were also detected.

One sampling location in the lagoon sediment revealed the presence of trichloroethene in excess of RCRA toxicity limits by TCLP (thus, a hazardous waste). Risk-based action criteria may be derived. They will be exceeded for toluene (inhalation pathway) and for di-n-octylphthalate, butylbenzlphthalate, and 1,2- dichloroethane (ingestion pathway) in lagoon sediments, for benzo(a)pyrene and beryllium (ingestion) and chromium (inhalation) in site soils, and for vinyl chloride, isophorone, and beryllium (ingestion) and benzene (inhalation) in the Navesink Marl Formation groundwater. It is important to note that the Navesink Marl groundwater usage pathways are not substantiated at the present time and hydrological tests indicate that it would be difficult to obtain a sufficient yield from this formation to support future use a sole source of potable water. For beryllium and benzo(a)pyrene in site soils, phthalates and 1,2-dichloroethane in lagoon sediments, the risk-based action criteria exceedances would only occur under future-use scenarios. For beryllium, vinyl chloride, isophorone, and benzene in the Navesink Formation groundwater, toluene in the lagoon sediments, and chromium in the site surface soils, the risk-based action criteria exceedances could occur under present-use scenarios.

8.2.1 Data Limitations and Recommendations for Future Work

There were 10,666 analytical data points generated in support of this investigation (not including QA/QC samples). Of these, 136 were rejected through data validation process due to significant quality control problems. This yields an overall rejection rate of 1.3%, or 98.7% data usability. In no case were data for an entire fraction (volatile organics, semivolatile organics, or inorganics) rejected for an individual sample.

The K&M Site was investigated extensively, using a number of surface and subsurface techniques, and including the chemical sampling of various media. The sampling program was targeted toward source areas, such as the lagoon, facility lot and former washwater collection pit, and likely areas of contaminant migration, such as the marsh, intermittent stream, drainage ditch and Barker's Brook. It is believed that these areas have been sufficiently characterized for conduct of the Feasibility Study. However, detailed delineation of areas of contamination may be required during Remedial Design, depending on the final remedial action objectives developed for the project.

As noted above, the lagoon was drained in the summer of 1991, but since that time has been refilled by precipitation. Sampling of aqueous lagoon contents was not included in the Remedial Investigation program. Remediation of the site may require draining of the lagoon again in order to treat or remove sediments and effect closure. This may be accomplished as an additional interim removal measure (IRM) by USEPA or incorporated into the Feasibility Study and Remedial Design. In either case sampling of the aqueous contents will be required for characterization.

The Remedial Investigation program included only one round of groundwater sampling, and did not include modeling to evaluate possible migration of contaminants to the Wenonah-Mt. Laurel Aquifer. If contaminants found in the Navesink Formation do eventually migrate to the Wenonah-Mt. Laurel Aquifer, the drinking water supply of local residents may be impacted. While there is no evidence that such an occurrence is imminent, periodic monitoring of the deeper wells is recommended until the ROD is executed.

8.2.2 Recommended Remedial Action Objectives

Typical remedial action objectives were originally presented in the Final RI/FS Work Plan for the K&M Site (May 1991). These included:

- Groundwater: Clean up groundwater contamination such that available ARARs and/or risk-based levels are attained at the end of the remedy.
- Soils: Prevent exposures to contaminated soil that exceed risk-based levels developed in the risk assessment.
- Surface Water/Sediment: Prevent exposure to contaminated surface water and sediment such that recreational uses can be restored.

For groundwater, there is no evidence at present that site-related contaminants have entered the Wenonah-Mt. Laurel Aquifer and, therefore, no remediation of this medium is necessary. Samples collected of shallow Navesink Formation groundwater show exceedances of NJ groundwater standards and state and Federal MCLs. While low hydraulic conductivity largely precludes the use of the Navesink Formation as a potable water source, there are currently no restrictions to placement of a well in the Navesink Formation in the immediate vicinity of the K&M Site. Thus, there is potential for a complete exposure pathway to exist for the Navesink groundwater. Therefore, the remedial action objective for groundwater may be stated as:

- Protect groundwater in the Wenonah-Mt. Laurel Aquifer from potential future degradation exceeding Federal and State drinking water standards by site-related contaminants.
- Prevent use of the Navesink Formation as a groundwater source in the immediate vicinity of the K&M Site.

VOCs and SVOCs were detected in soils from the facility lot and exposed soils in the marsh, intermittent stream and drainage ditch The data indicate unacceptable carcinogenic risks under current-use (site worker) scenarios. The remedial action objective for soil and exposed sediment would remain as indicated in the RI/FS Work Plan:

- Prevent exposures to contaminated soil and exposed sediment that exceed risk-based levels developed in the risk assessment.

Lagoon sediments were found to be hazardous in one location and to exhibit unacceptable risks under conservative interpretations of a current-use scenario involving inhalation by site workers of volatile organics and a future-use scenario involving ingestion by young children. The remedial action objective for this source material is similar to that for soils, as follows:

- Prevent exposures to lagoon sediments that exceed risk-based levels developed in the risk assessment and remediation of hazardous (toxic) sediments.

Samples of stagnant surface water from the intermittent stream and drainage ditch were found to contain phthalates. The remedial action objective for this potential source material may be stated as follows:

- Prevent discharge to Barker's Brook of surface water runoff from site sources and contaminated areas, including the lagoon, site soils and contaminated marsh, intermittent stream and drainage ditch sediments which may impair recreational use or the ability of the stream to support aquatic life; or which may cause exceedance of NJSWQC limits.

No levels of contaminants were found in Barker's Brook surface water or sediments which exceed any applicable proposed or existing standard or risk-based remediation level. Therefore, no remediation of this medium is required. However, the remedial action objective may be stated as follows:

- Prevent short term and long term degradation of Barker's Brook surface water and sediment by site discharges which may impair recreational use or the ability of the stream to support aquatic life; or which may cause exceedance of NJSWQC limits.

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