Site Conditions Summary Report for Hydrocarbon Risk Calculations and Site Status Determination

Technical Background Document and Recommendations

Prepared for

Alaska Statement of Cooperation Working Group

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Preface

This document was created under the Alaska Statement of Cooperation (SOC), which is an agreement between the Alaska Department of Environmental Conservation (ADEC), the U.S. Environmental Protection Agency (EPA), the Departments of the Army, Air Force, Navy, Military and Veterans Affairs (Army National Guard), Interior, and the Federal Aviation Administration (FAA) and U.S. Coast Guard. The objective of the agreement is to work cooperatively to identify and resolve issues affecting human health and the environment through promoting compliance with environmental laws, preventing pollution, creating partnerships to identify and cleanup contaminants and pollution, promoting training and coordinating with affected Tribes. A subcommittee or "working group" was formed under the SOC to evaluate the characterization and fate and transport of petroleum hydrocarbons spilled in the environment, and the risks posed by petroleum contamination. FAA contracted with Geosphere and CH2M Hill to research the issues and develop eight technical issue papers. The paper titles are listed below. Staff from ADEC, FAA, the Army and Army Corps of Engineers, and the Army National Guard reviewed and provided feedback on the draft papers. These papers provide sound scientific and technical information along with recommendations for use and/or future consideration.

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Statement of Cooperation Working Group Paper Titles

1. Three- and Four-Phase Partitioning of Petroleum Hydrocarbons and Human Health Risk Calculations, Technical Background Report Document and Recommendations
2. Hydrocarbon Characterization for Use in the Hydrocarbon Risk Calculator and Example Characterizations of Selected Alaskan Fuels, Technical Background Document and Recommendations
3. Dilution-Attenuation Factors at Fuel Hydrocarbon Spill Sites, Technical Background Document and Recommendations
4. Maximum Allowable Concentration, Residual Saturation, and Free-Product Mobility, Technical Background Document and Recommendations
5. Groundwater Sampling Techniques for Site Characterization and Hydrocarbon Risk Calculations, Technical Background Document and Recommendations
6. Migration to Indoor Air Calculations for Use in the Hydrocarbon Risk Calculator, Technical Background Document and Recommendations
7. Site Conditions Summary Report for Hydrocarbon Risk Calculations and Site Status Determination, Technical Background Document and Recommendations
8. Proposed Environmental Site Closeout Concepts, Criteria, and Definitions, Technical Background Document and Recommendations

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Acronyms and Abbreviations

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
DOT&PF	Alaska Department of Transportation and Public Facilities
ASPLS	Alaska State Professional Land Surveyors
BLM	Bureau of Land Management
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CORS	Continuously Operating Reference Stations
DGGS	Alaska Department of Geological and Geophysical Surveys
DNR	Department of Natural Resources
DRO	diesel-range organics
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FOC	fraction of organic carbon
g/cm	grams per centimeter
GPS	Global Positioning System
GRO	gasoline-range organics
lbs/ft	pounds per feet
mg/kg	milligrams per kilogram
NAPL	nonaqueous-phase liquid
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
OPUS	Online Positioning Users Service
PID	photoionization detector
PLS	Professional Land Surveyor
SOCWG	Alaska Statement of Cooperation Working Group
UCL	upper confidence level
USC&GS	United States Coast and Geodetic Survey

PAH	polycyclic aromatic hydrocarbon
ASTM	American Society for Testing and Materials
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey

SECTION 1

Introduction

The calculation of risk posed by a contaminated site and the determination of the "site status" requires an accurate characterization of the site conditions because *the site characterization is the foundation for the risk calculations and the determination of the site status*. As used here, determining the "site status" means placing the site in an open or closed category, as described in the Alaska Statement of Cooperation Working Group (SOCWG) technical background document on site closeout (Geosphere and CH2MHill, 2006). (The open and closed categories of the site status map are a proposed alternative to the existing Alaska Department of Environmental Conservation [ADEC] site closure and hazard ranking system and are not recognized by the ADEC at this time).

The purpose of this document is to describe the elements of a proposed "*Site Conditions Summary Report,*" and the presentation of those site characterization data that are considered essential for the accurate characterization of risk and determination of site status according to the proposed site status map. The *Site Conditions Summary Report,* is intended to develop and present the data needed as input to the hydrocarbon risk calculator and the site status map. The *Site Conditions Summary Report*, described herein, is a proposed report and is not currently required by the ADEC (but it overlaps significantly with existing ADEC reporting requirements as described below). When reading the following technical background report the reader should preface much of the discussion with the thought "if the proposed status map and Site Conditions Summary Reporting recommendations are accepted or implemented by the ADEC, then this is what would be required."

1.1 Purpose of the Site Conditions Summary Report

The ADEC currently requires two reports in the contaminated site regulations --- a "site characterization report" as described in 18 Alaska Administrative Code (AAC) 75.335, and a "final cleanup report" as described in 18 AAC 75.380. The site characterization report is conceptually prepared after the release of a contaminant (for this report assume a fuel hydrocarbon) has been discovered, and in general, is intended to assess the extent of soil and water contamination exceeding cleanup levels and collect data needed to remediate the site. The final cleanup report is conceptually prepared after remedial action has taken place, and in general, is intended to document that the site meets the cleanup criteria. A list of the information required in each report is provided in the regulations.

The *Site Conditions Summary Report*, as described herein, is proposed to fulfill the requirements of either or both of these required reports. All of the information requested by the ADEC in the regulations is valuable and/or necessary in the *Site Conditions Summary Report*, but the *Site Conditions Summary Report* requests some additional data and specifies formats for the presentation of the data to support use of the hydrocarbon risk calculator and site status map.

The "*Site Conditions Summary Report*" as described here is a single specific document prepared for the purpose of fully documenting the site conditions at a point in time, so that risk

calculations can be performed and the status of the site can be determined. To meet this purpose, the *Site Conditions Summary Report* must contain certain critical data and must clearly present those data so that the Alaska Department of Environmental Conservation (ADEC) can confidently, accurately, and efficiently determine the site status (that is, the closed or open site category). Note that it is common for contaminated sites to be studied over a period of years and for many reports to be prepared that address, in part, the type, extent, and concentration of contaminants, remedial design, remedial progress, and monitoring data, and that all of these reports may be considered site condition reports. However, these reports rarely meet the data collection and presentation standards needed for the cumulative risk calculations and site status determination. If multiple environmental reports exist for a site, then the *Site Conditions Summary Report* should use data from these other reports, but the *Site Conditions Summary Report* needs to summarize the data as presented herein. If the site being studied is a new site without previous documentation, then the *Site Conditions Summary Report* should collect and present data as described here. Note that under the proposed scenario, the data collection and presentation required for the cumulative risk calculations and site status determination are also the foundation for assessing remedial options and conducting the remedial design.

As stated above the *Site Conditions Summary Report* maybe submitted to fulfill the requirements of both the current site conditions report (18 AAC 75.335) and the final cleanup report (18 AAC 75.380) as follows:

- In concept, the *Site Conditions Summary Report* would be submitted following the initial field investigations, thereby meeting the requirements of the 18 AAC 75.335 site characterization report. The *Site Conditions Summary Report* would identify if site conditions posed an unacceptable risk and exposure routes and compounds that contribute most significantly to the cumulative risk.
- If the site poses an unacceptable risk then the exposure routes and compounds that contribute most significantly to the cumulative risk would be used to select a remedial and/or risk management approach for the site.
- If following the initial site investigation, the site presented acceptable risks then a closure category would be requested in the *Site Conditions Summary Report* and a site status determination would be made by the ADEC meeting the requirements of the 18 AAC 75.380 final cleanup report.
- If the site was originally found to pose a risk, and the responsible party conducted a remedial action and monitoring to demonstrate that the risk had been reduced to acceptable levels, then a new *Site Conditions Summary Report* documenting the site conditions following remediation would be prepared and submitted to the ADEC to meet the requirements of the 18 AAC 75.380 report. The ADEC would make another site status determination based on the new information and potentially the site would be closed.

1.2 Scope and Elements of the Site Conditions Summary Report

Determining the category of the closed or open site is proposed to follow a simple process that is integrated with existing ADEC regulations regarding the documentation of spill sites. To initiate the site status determination process, the responsible party or the responsible party's

consultant prepares an environmental *Site Conditions Summary Report* that describes the site history and, most importantly, documents the site conditions at the time the report is submitted to ADEC.

Examples of the data that should be contained in the *Site Conditions Summary Report* include, but are not limited to, the following:

- The extent of the nonaqueous-phase liquid (NAPL)-contaminated soil source area
- The extent and thickness of the NAPL on the water table (if present)
- The extent of the downgradient dissolved-phase plume
- The concentration of petroleum hydrocarbons within the NAPL-contaminated soil source area and dissolved-phase plume
- Hydraulic conductivity
- Seasonal changes in the groundwater flow direction, gradient, and elevation
- Soil texture, structure, and stratigraphy
- Human health risk calculations for each compound and exposure route, and cumulative risk calculations
- Documentation of the environmental/ecological risk posed by the contaminants
- A completed "site status map"
- Documentation of the land ownership and a lot and block description of the involved properties
- State Plain and Latitude and Longitude Survey Coordinates for the source area and property corners

Table 1 is a more complete list of the data proposed for the characterization of a site. Table 1 should be used in the *Site Conditions Summary Report* as a checklist to identify the sources of the data used in the calculations (that is, site-specific measurement or use of a default value). Much of the required data for the *Site Conditions Summary Report* may best be presented in tables and maps, as described in subsequent sections. The required human health risk calculations are performed by the hydrocarbon risk calculator, and the hydrocarbon risk calculator is the recommended tool for doing the risk calculations and presenting the results. However, other risk calculation/exposure models and presentation methods are acceptable as long as the calculations are clearly presented and well-documented in the professional technical literature. As proposed in the SOCWG technical background documents the *Site Conditions Summary Report* must also include a site status map with all appropriate boxes checked. The *Site Conditions Summary Report* and completed site status map will allow the responsible party to make a preliminary assessment of the status of the site before submitting the report to ADEC. If a site has been well-characterized, the status of the site should be readily determined by the responsible party, the responsible party's consultant, and ADEC.

1.3 Site Closeout Report Review

Under the alternative site closeout scenario proposed in the SOCWG documents, the ADEC would review the *Site Conditions Summary Report* and assess the quantity, quality, and completeness of the data presented in the *Site Conditions Summary Report* and then make a determination of the site status; that is, whether the site will be listed as "open" or "closed," and the category of open or closed site. Note that when ADEC is reviewing the *Site Conditions Summary Report*, if critical data are not available, are not presented clearly, or are not fully documented, then ADEC would make conservative assumptions about those data and possibly place the site in an appropriately higher risk category. Also note that under the alternative site closeout scenario proposed in the SOCWG documents, when new sites are discovered, by default they would enter the ADEC site tracking database as open category 1 sites until enough data have been collected, documented, and formally submitted to ADEC to justify a different site status.

Under the alternative site closeout scenario proposed in the SOCWG documents, the results of the ADEC review of the site conditions report would be documented in a letter report addressed to the responsible party. The letter report would present ADEC's assessment of the quality, quantity, completeness and clarity of the data presented in the *Site Conditions Summary Report* as they relate to determining the human health and environmental risk posed by the site. Shortcomings in the data set and assumptions that the responsible party made that affect the site status and are not supported by the presented data would be identified in ADEC's review letter. The ADEC review letter would also document ADEC's determination of the site status (the ADEC review letter does not need to summarize the site conditions data presented by the responsible party that ADEC agrees with). This ADEC determination of site status would remain in effect until the responsible party submits additional data to ADEC and requests another review of the data and site status determination.

1.4 Permanent Record of Site History, Conditions, and Status

Under the alternative site closeout scenario proposed in the SOCWG documents, all sites that have been in the ADEC-contaminated sites database would have a permanent record of the environmental conditions at the site and the results of the latest site status determination maintained in a database that may be searched by multiple parameters, including most importantly a legal description of the property (lot and block number) and the site's world coordinates (latitude and longitude). This permanent record could be an update to the existing ADEC-contaminated sites database, a new database maintained by an agency such as the State Division of Lands or a deed notice. As envisioned in the SOCWG technical background documents, it is likely that the best, risk-focused description of the environmental conditions at any particular site would be the *Site Conditions Summary Report* described herein. Therefore the database should ideally provide a link to the *Site Conditions Summary Report*.

The reason for maintaining a public record of the environmental conditions is that these reports will provide a valuable tool for a variety of purposes, such as facilitating property transfers; assessing the fair market value of the property; conducting due diligence audits; planning further development of the property (for example, avoiding placing a building on a corner of the property with potential indoor air migration risks); and conducting subsurface work at the

site (for example, anticipating and planning for the presence of contaminants along a new sewer line would help limit work stoppages when hydrocarbons were discovered and would allow monitoring of the excavation for protection of the workers). The long- term value and use of these reports require that the site conditions information in the reports be fully documented and that soil boring, monitoring wells, property corners, geologic features and infrastructure be mapping or survey grade geo-referenced data (i.e., sub meter accuracy and tied to State Plane Coordinates or latitude and longitude coordinates. The survey should be conducted by a professional Land Surveyor registered in Alaska. Global Positioning System (GPS) data with sub-meter accuracy are recommended.

SECTION 2

Conceptual Site Model

A conceptual site model forms a framework for collecting, interpreting, and presenting site conditions data and a conceptual site model is a required element of the site characterization work plan. Following are general descriptions of hydrocarbon spills in unfrozen and frozen soils.

2.1 Conceptual Model of a Fuel Hydrocarbon Spill in Unfrozen Soils

When a hydrocarbon release occurs on the surface of unfrozen soils, the fugitive hydrocarbon tends to spread laterally across the ground surface and then to infiltrate into the soils (Figure 1). The extent of lateral spreading across the ground surface is a function of quantity and rate of hydrocarbon release, and the permeability of the surface. Similarly, when a hydrocarbon release occurs from a below grade tank or pipeline, the fuel will initially tend to spread in response to a pressure gradient around the leak location and then infiltrate (Figure 2). The infiltrating fuel from the surface spill and subsurface release tends to flow primarily vertically under the influence of gravity, through larger air-filled soil pores, although capillary forces may cause some lateral spreading. If a relatively small volume of hydrocarbon is spilled, the hydrocarbon will likely be immobilized in the soil above the water table (as shown in Figures 1 and 2). If a sufficient quantity of fuel is spilled, the infiltrating fuel reaches the saturated capillary fringe, displaces some water from the saturated soil pores, and tends to migrate laterally as a mound of free product develops near the water table (Figure 3). As the water table rises and falls, the mobile free product in the vicinity of the water table encounters uncontaminated soil and tends to be smeared or trapped as immobile residual product (Figure 4). Because some years have higher and/or lower water tables than other years, and because many contaminated sites are several years to a few decades old, it is likely that product will be trapped or smeared both above and below the zone of water table fluctuation observed in only a few years of study (Figure 5). At some sites the releases from several tanks or piping leaks will coalesce into a complex contiguous source area (Figure 6). Gravity drainage and flow of the NAPL to a point of immobility occurs relatively quickly (weeks or months) at sites caused by a discrete spill event, but may occur over a period of years at sites with long-term fuel leaks. However, after the long-term leak has been stopped, any mobile NAPL will likely be immobilized in a period of weeks or months.

At all NAPL spill sites a portion of the free product or NAPL in the subsurface volatilizes into the air-filled soil pores, dissolves into the soil moisture, and is adsorbed by the soil solids (primarily the organic carbon) following the phase partitioning relationships. Infiltrating precipitation carries dissolved hydrocarbon toward the water table, where the infiltrating precipitation and dissolved hydrocarbon mixes with the groundwater, saturated-zone flow transports the dissolved hydrocarbon downgradient, and vapor-phase hydrocarbon tends to diffuse toward the ground surface and into the atmosphere. At some point downgradient of the spill location the groundwater will discharge to and mix with surface waters (that is, a lake,

stream, or the ocean). Biodegradation of fuel hydrocarbons will likely occur throughout the contaminated zone (whenever the soils are thawed).

Several general spatial and temporal concentration trends may be discerned in the vicinity of a hydrocarbon spill. In the area where the hydrocarbon was spilled (the source area), these fate and transport processes tend to reduce the concentration of a spilled chemical through time as mass is transported away from, and/or biodegraded in, the source area. Following a fuel spill, the dissolved-, vapor-, and adsorbed-phase hydrocarbon concentrations in the porous media surrounding the source area initially tend to increase to an equilibrium concentration (where the chemical enters an area at the same rates it leaves and/or is biodegraded). The concentrations then remain relatively stable for an extended time (which is dependent on the mass spilled). Finally, concentrations in the surrounding porous media decrease as the concentration in the source area decreases. At any given point in time following the spill, the chemical concentrations tend to decrease away from the NAPL-contaminated soil source area.

2.2 Conceptual Model of a Fuel Hydrocarbon Spill in Frozen Soils

When a hydrocarbon release occurs on frozen soils, similar infiltration and spreading processes are expected to occur, but the interactions of the liquid water and immiscible fuel are thought to be different because the frozen water in the soil pores is thought to behave similar to a mineral cement in the soil pores, and not as a wetting fluid. In addition, the extent of spreading of the spilled fuel across the frozen ground surface may be greater in the winter than in the summer (because precipitation occurring after freeze- up may tend to reduce the porosity and vertical conductivity of the surficial soils). The fuel that infiltrates still tends to flow primarily vertically under the influence of gravity, with some lateral spreading. If the seasonal frost penetrates to the water table (as would be expected on North Slope gravel pads and some floodplains and coastal/shoreline areas with very shallow groundwater), then at the saturated capillary fringe the spilled fuel would tend to migrate laterally across the frozen water table and capillary fringe as a mound of free product develops. However, the spilled fuel will not displace the frozen water at the capillary fringe. The spilled hydrocarbon may tend to spread farther across the frozen capillary fringe than it would across the water table because the oil travels through air-filled pores above the saturated zone and does not need to accumulate in thicknesses necessary to overcome the pore entry pressure of the saturated soil. The viscosity of the oil and the slope and roughness of the saturated capillary fringe will likely control or influence the extent of spreading.

When the ice melts in the following thaw season, the water and oil will again behave as immiscible fluids in a porous media. Mobile free product present in the saturated zone in the thaw season is thought to be immobilized during the winter because the majority of the oil volume is below the top of the saturated capillary fringe and the water cannot be displaced from the soil pores when it is frozen. During the winter a portion of the free product in the subsurface will still volatilize into the air-filled soil pores, although vapor pressures and vapor concentrations will be lower because of the lower temperatures. The lower vapor concentrations and reduced air-filled porosity near the ground surface will tend to reduce the rate of vapor-phase diffusion of hydrocarbons.

The dissolution of hydrocarbons into groundwater and advection of dissolved-phase hydrocarbons by the flowing groundwater is expected to essentially stop in the winter as the saturated zone freezes. Biodegradation of hydrocarbons throughout the frozen contaminated zone will also likely stop during the winter. Hydrocarbon mass is likely not lost from the soil environment (except by volatilization), so hydrocarbon concentrations in the contaminated soil source area and in the dissolved plume remain essentially unchanged from the end of one thaw season to the beginning of the next thaw season.

SECTION 3

Identification of NAPL-contaminated Soil Source Area

The following section describes the site characterization that is recommended for a *Site Conditions Summary Report*, for use in 4-phase cumulative risk calculations and to determine the site status as proposed in the SOCWG alternative scenario.

Many types of data (see Table 1) are needed to assess the risks presented by contaminants. These data are discussed in the following sections. Note that the order in which the data are discussed does not indicate the relative importance of the data.

One of the primary objectives of the *Site Conditions Summary Report* is to break the site down into zones where similar conditions exist and similar processes occur. The concentrations, concentration trends, and processes and risk can then be assessed in each different zone. In general, contaminated sites may be divided into zones or areas based on whether the hydrocarbon is present in three-phases or four-phases; whether the NAPL is discontinuous or continuous, but not mobile at the site scale or continuous and mobile at the site scale; and the extent and concentration of the dissolved-phase plume (and potentially the extent and concentration of the vapor-phase plume).

The site characterization and risk calculation approach described herein is geared toward characterizing the nature, extent, and risk posed by discrete contiguous source areas (and not toward the statistical characterization of a large area or industrial zone containing multiple sources, as might be done in a U.S. Environmental Protection Agency (EPA) risk assessment). This discrete contiguous source area approach is likely conservative compared to an area-wide risk assessment and the option to conduct an ADEC Method 4 risk assessment is always available to responsible parties.

3.1 NAPL Contaminated Soil Source Area

As described above, it is desirable to identify the "NAPL-contaminated soil source area," which is defined as the contiguous, three-dimensional volume of soil that contains NAPL. Within the NAPL-contaminated soil source zone, four-phases are present and fuel hydrocarbons will partition into soil moisture, groundwater, soil gases and soil organic carbon as described by the four-phase equations with Raoult's Law (see the technical background document on phase partitioning). The shape of the NAPL- contaminated soil source area is a complex function of the volume of hydrocarbon released; the rate of release; the soil texture, structure, stratigraphy and capillary forces; soil moisture content; and water table fluctuation history (see the technical background document on maximum allowable concentrations and free product mobility). The NAPL- contaminated soil source area may be identified by reviewing and compiling in tables the existing laboratory test results, soil log callouts of contaminated soils, and field screening data such as photoionization detector (PID) head space readings of soil samples. In addition, the location and depth (or elevation) of the data may be posted on maps and cross-sections of the site. The laboratory data may then be segregated based on whether or not they indicate the presence of NAPL. Recall that laboratory test results with diesel-range organics (DRO) test

results above about 50 milligrams per kilogram (mg/kg) and gasoline-range organics (GRO) test results above about 200 mg/kg are interpreted to indicate the presence of NAPL. Note that although DRO NAPL exists at concentrations above about 30 to 50 mg/kg it is likely acceptable to identify only the NAPL source area above the ADEC Table B2 screening level of 230 mg/kg. The sample locations that exceed or do not exceed these concentration criteria will define the NAPL source area (on both maps and cross-sections draw a polygon separating the NAPL-contaminated soils from the soils that do not contain NAPL). We can use what we know about the mechanics of migration of NAPL in the vadose zone and near the water table surface, and the fluctuation of the water table, to help identify the NAPL-contaminated soils. The distribution of hydrocarbon will likely be similar to one of those shown in Figures 1 through 6. Note that soil concentrations within the NAPL-contaminated soil source zone may vary significantly in concentration and that there can be some uncontaminated samples within the NAPL-contaminated soil source zone. These conditions are illustrated in Figure 7, which shows red-dyed hydrocarbon infiltrating through a tank filled with white sand. As shown in Figure 7, samples A through C are within the NAPL-contaminated soil source area, but sample A has a much higher concentration than sample B and sample C is uncontaminated. Because of this variability, it is generally not necessary to contour hydrocarbon concentrations within the NAPL source area.

A detailed understanding of the shape of the vadose zone contamination may be gained by drilling numerous test holes, collecting and screening batches of soil samples, and laboratory-testing many soil samples. A detailed understanding of the NAPL-contaminated soil source area may help in the design of a remedial system because the NAPL-contaminated soil source area is the primary remedial target. However, a very detailed understanding of the shape of the NAPL-contaminated soil source area may not greatly improve human health risk calculations (given that enough data are available to characterize the source concentration). Therefore the identification of the NAPL contaminated soil source area may emphasize delineating the smear zone source area while acknowledging that the distribution of NAPL in the vadose zone is commonly within the smear zone footprint area but potentially complex. A color coding system for NAPL source area maps that appears to work well involves highlighting contaminated vadose zone sample locations in yellow, highlighting contaminated smear zone and saturated zone sample locations in orange and highlighting smear zone samples that document the absence of NAPL in blue (the referenced colors are only suggestions). This color coding system allows a large amount of information to be conveyed quickly (without the complexity or cost of developing spider diagrams). Individual sample concentration information could be viewed on the data tables and the NAPL source area would contain yellow and orange highlighted sample locations while excluding the blue highlighted sample locations.

3.2 Free Product in Monitoring Wells

Recall from the technical background document on maximum allowable concentrations and free product mobility that discontinuous NAPL will not appear in monitoring wells, while continuous NAPL will appear in monitoring wells. This means that any areas where free product is observed in monitoring wells are positively inside the NAPL-contaminated soil source area and that it is likely there is a halo of discontinuous NAPL-contaminated soils surrounding the wells where free product was observed. If free product is present in site monitoring wells, it means that continuous NAPL is present and it will be necessary to measure the free product thickness during a period of sustained low groundwater to assess the

maximum or near maximum thickness of oil that may accumulate at the site. The area where free product is observed in monitoring wells should be identified on site maps. This may be done by drawing a polygon around the wells containing the NAPL. Some monitoring wells from inside this area of continuous NAPL may not show oil on the water table. In addition, the thickness of NAPL observed should be measured and compared to the Charbeneau thickness for the soil texture present at the water table. The measured oil thickness data should be reported by posting the thicknesses on the site maps and by presenting the oil thicknesses in a table identifying the monitoring well number, date of the measurement, the oil thickness and the piezometric surface elevation. If the measured NAPL thickness is greater than 50 percent of the Charbeneau thickness, then the mobility of the continuous oil should be assessed in greater detail (as described in the technical background document on maximum allowable concentrations and free product mobility). If the assessment of NAPL mobility indicates that oil mobile at the site scale is present, the portion of the site containing the mobile oil should be identified on the site maps.

3.3 Examples of Maps and Tables Identifying the Source Area

Examples of maps and cross-sections and tables used to identify and display/document the NAPL- contaminated soil source area are shown in Figures 8 through 11, and Tables 2 through 4. The example sites are discussed below:

- The Davis Property site at Strawberry Point on Hinchinbrook Island is representative of a relatively small and simple site. The site was impacted by diesel fuel leaking from an above grade pipeline joint. Figure 8 shows the borehole locations and highlights in gray the NAPL-contaminated soil source area. The table on the figure shows the PID, GRO, and DRO data from the site (Table 2 provides benzene, toluene, ethylbenzene and total xylenes [BTEX], DRO, and GRO data). Comparison of the data in the table with the sample locations and depth shows that the samples collected inside the gray highlighted area have DRO concentrations above 50 mg/kg and elevated PID head space values, while outside the gray highlighted areas the analyses show DRO concentrations less than about 10 mg/kg and generally lower PID readings. Note that the water table was at about the 6- to 7-foot depth during the site investigations and if NAPL was present in the zone of water table fluctuation then samples from this depth should have detected the hydrocarbon. Note that even though the samples were conducted over a period of several years, the data are very useful in identifying the NAPL-contaminated soil source area (which is the initial objective). Because there are numerous borings and laboratory analysis available to help identify the NAPL source area at the site, the map only highlights the NAPL source area instead of drawing a spider map or posting the DRO values on the map. The diesel fuel at the Davis Property is interpreted to have been derived from one pipe joint and to have been released in sufficient quantity for the NAPL to have percolated to the water table, spread across the water table surface, and smeared throughout the zone of seasonal water table fluctuation. The smear zone portion of the NAPL source area forms a disc of contaminated soil about 20 to 30 feet in diameter.
- The second example site is the Federal Aviation Administration (FAA) Shop and Generator Building site at Strawberry Point on Hinchinbrook Island. The site has housed an air navigation aid for about 60 years. Site soils were impacted by diesel fuel from fuel tank and pipe leaks and overfill /fuel handling incidents. The site was remediated by air sparging

and bioventing between 1996 and 2003. Figure 9 shows the borehole locations and highlights in gray the NAPL-contaminated soil source area. Table 3 provides the laboratory data from the site. The top portion of Table 3 (Table 3A) contains the results from samples collected outside the NAPL source areas and all of the analyses show DRO concentrations less than about 10 mg/kg. The bottom portion of Table 3 (Table 3B) contains the results from samples collected inside the NAPL source area and the analyses show DRO concentrations generally greater than 1000 mg/kg. Note that even though the samples were conducted over a period of several years and that some of the samples were collected during or following remediation, the data are very useful in identifying the NAPL-contaminated soil source area (which is the initial objective. In a subsequent step, the most recent post-remediation data will be used to statistically characterize the current source concentrations). Because there are numerous borings and laboratory analyses available to help identify the NAPL source area at the site, the map only highlights the NAPL source area instead of drawing a spider map or posting the DRO values on the map. The diesel fuel at Strawberry Point is interpreted to have been derived from numerous leaking tanks and pipes and to have been released in sufficient quantity for the NAPL to have percolated to the water table, spread across the water table surface, coalesced into a contiguous source, and smeared throughout the zone of seasonal water table fluctuation. The smear zone portion of the NAPL source area forms a disc of contaminated soil about 80 to 100 feet wide and 200 feet long. The long axis of the NAPL source area is almost perpendicular to the groundwater flow direction because the multiple spill and leak locations that created the source area are along a line that happens to be almost perpendicular to the groundwater flow direction. Soil boring descriptions of contaminated soil, PID screening, and the laboratory test results listed in Table 3 suggest that the majority of the NAPL source area and mass appears to be about 5 to 12 feet below grade in the zone of seasonal water table fluctuation. The laboratory test data also suggest that a relatively sharp or distinct boundary separates the NAPL-contaminated soil source area from the areas that were not impacted by NAPL. This distinct boundary should be expected, given the capillary forces that control the migration of NAPL (as described in the technical background memo on maximum allowable concentrations and free product migration).

- The third example is from the Gold Creek spill site. Figure 10 is a map that identifies the NAPL-contaminated soil source area. This area is labeled as the maximum extent of free product and all of the wells within this area showed free product on the water table in the first few months after the spill. The map also shows the portion of the site where free product was observed in monitoring wells and the portion of the site where the free product thickness was greater than 0.5 foot during an October 2002 monitoring event (the 0.5 foot thickness is an arbitrary thickness not related to mobility). The thicknesses of free product measured in selected monitoring wells on October 4, 2002, are posted on the map. Figure 11 is a cross-section approximately along the groundwater flow path that shows the NAPL-contaminated soil source area consisting of the path of infiltrating hydrocarbon in the vadose zone and the disc of contaminated soil in the zone of seasonal water table fluctuation.

3.4 Statistical Characterization of the NAPL-contaminated Soil Source Area Hydrocarbon Concentrations

The hydrocarbon concentrations used as input to the hydrocarbon risk calculator need to balance the desire to protect human health and the environment with the need to accurately represent site conditions. Consistent with the description in EPA risk-assessment guidance (EPA, 1996a and 1999) and as explicitly stated in an ADEC technical memorandum (ADEC, 2001), "the arithmetic average concentration measured in a representative group of samples collected from the exposure area is generally considered the most appropriate and representative value for use as the concentration term in environmental risk assessment." EPA and ADEC also point out that 1) the arithmetic average concentration of a relatively small group of samples is only an estimate of the true mean, and 2) to protect human health, the 95 percent upper confidence level (UCL) of the mean should be used to conservatively represent the mean concentration. Therefore, to assess human health risk, the soil concentrations used as input to human health risk calculations should typically be the 95 percent UCLs of a valid data set that has been collected from within the exposure area. In a valid data set, the sample locations should be randomly selected (or the results of a biased sampling plan should be appropriately stratified or grouped) and the sample population should be large enough to characterize the site. As an alternative, the highest DRO; GRO; BTEX; and polycyclic aromatic hydrocarbon (PAH) concentrations measured at a site may be used in place of the 95 percent UCL of the mean (if the highest DRO, GRO, BTEX and PAH concentrations do not represent significant risk. Given that the highest measured values do not represent significant risk, it may be easier to use the highest measured values than to spend time and money calculating the 95 percent UCLs for DRO, GRO, and each BTEX and PAH compound.) If the highest measured values present significant risk, the 95 percent UCL values should be calculated. Note that in general, as the number of samples in a sample set increases, the 95 percent UCL value will tend to approach the mean or average concentration of the sample set. Hence, if the 95 percent UCL values indicate that an unacceptable risk exists, but the average or mean concentration of the sample set presents an acceptable risk, the responsible party may want to consider collecting additional samples to better characterize the site and potentially reduce the 95 percent UCL value. If re-sampling is conducted the new samples would ideally be collected at random locations inside the NAPL contaminated soil source area. The intent of the re-sampling event would be to increase the size of the data set used to statistically characterize the NAPL source area concentrations. Note that based on the re-sampling results the source area size and shape could be redefined. Also note that most existing contaminated site data sets likely are biased high data sets, because it is common to field screen samples (visual, olfactory, and PID screening) and to analyze the most heavily contaminated samples. The use of a biased high data set makes the risk calculations conservative.

Exposure Area. In this document, the exposure area is interpreted to be the NAPL-contaminated soil source area. Hence, all samples from within the NAPL- contaminated soil source area that are representative of the site conditions at the time that a site status determination is conducted should be used to calculate the source area input concentrations. In the Strawberry Point shop and generator building example (see Figure 9 and Table 3), the soil samples collected prior to and during remediation and the samples from outside the NAPL-contaminated soil source area were culled from the full data set to derive a data set representative of 2003—the time that the risk calculations were performed (Table 4). Calculating

the risk associated with the NAPL-contaminated soil source area is conservative (compared with calculating the risk associated with a larger exposure area, as might be done in a Method 4 risk assessment).

95 Percent UCL Calculation Methods. Several methods and tools are available for calculating the 95 percent UCL values for input to the risk calculations. Possibly the most readily accepted approach would be to use the EPA developed statistics calculator named ProUCL. The ProUCL software is available free from the EPA web site (www.epa.gov). The EPA ProUCL calculator assesses the data distribution and automatically selects the most appropriate method of calculating the 95 percent UCL.

An initial estimate of the 95 percent UCL may be calculated using Excel spreadsheet functions to calculate the average concentration and standard deviation for each hydrocarbon compound, and the confidence limit function to calculate a 95 percent UCL assuming a normal distribution.

Note that the H statistic is likely not a good tool for calculating the 95 percent UCL because hydrocarbon concentration data sets are likely to fail the four tests for applying the H statistic. That is, the sample populations are commonly less than 30; the population coefficient of variation is commonly greater than 1; the sample set contains extreme or outlier values; and the sample set may not have a log normal distribution, but rather may be drawn from two distinct populations.

Use of Non-detect Values in Statistical Summaries. Laboratory analyses of samples from within the exposure area may not detect or report concentrations for some of the hydrocarbon compounds used as input to the four-phase calculator. These samples may be included in the calculation of the 95 percent UCL in several ways, as follows:

- If the analysis result is listed as non-detect and a value below the method reporting limit but above the method detection limit is provided, this value may be used as the sample concentration. These values are commonly described as qualified or "J" flagged data and are usually available from the laboratory (but may have to be requested).

- If the analysis result is below the method detection limit, then the sample concentration used in the statistics may be the method detection limit, one half the method detection limit, or potentially zero. The EPA recommends using a value of one half the method detection limit in its risk assessment guidance document (EPA, 1996a). If a value of one half the method detection limit is used in the calculation of the 95 percent UCL and the cumulative risk is close to the acceptable risk criteria, then it may be desirable to assess the change in risk if the method detection limit value is used instead of one half the method detection limit. Similarly, if an analyte is not detected but the method detection limit is high enough that a value of one half the detection limit indicates that risk criteria maybe exceeded, then the impact of using a zero concentration in the statistics to the cumulative risk calculation may be assessed. Note that it is common, especially in older data sets, for compounds like benzene to have not been detected, but to have relatively high detection limits, such that when a value of half the detection is used as input to the calculation of a 95 percent UCL, the 95 percent UCL value causes a significant portion of the risk posed by the site. Under some circumstances the 95 percent UCL may be compared with the detection limits to answer the question "if the compound was present at the calculated 95 percent UCL would it have been

detected by the testing" and if the compound would have been detected then it may be appropriate to handle the non-detect values differently than described here.

Tables 2 through 4 show example data sets used in the calculation of 95 percent UCL values for the Strawberry Point Davis Property and Shop & Generator Building site displayed in Figures 8 and 9. Table 2 presents data from the Davis Property site and contains four parts as follows: Table 2A lists all of the 2003 laboratory test results; Table 2B lists the samples from the source area used in the 95 percent UCL calculation and the mean, standard deviation, standard deviation of the mean and 95 percent UCL values for the data set; Table 2C lists the groundwater laboratory test results; and Table 2D lists the groundwater aromatic and aliphatic concentrations. Table 4 presents data from the Shop & Generator Building site and contains three parts as follows: Table 4A lists all of the 2003 laboratory test results; Table 4B lists the samples from the source area used in the 95 percent UCL calculation and the mean, standard deviation, standard deviation of the mean and 95 percent UCL values for the data set; Table 4C lists additional laboratory test result data used in the calculation of the 95 percent UCL for benzene. Note that DRO data from 2000 were included in the statistical evaluation even though remediation occurred after 2000. The inclusion of the 2000 data yields a larger data set, which allows a better characterization of the source area (the 95 percent UCL is closer to the mean) given that relatively little remediation occurred after 2000.

SECTION 4

Dissolved-phase Plume Characterization

The dissolved-phase plume is the three-dimensional volume of groundwater containing dissolved-phase hydrocarbons. At most fuel hydrocarbon spill sites the dissolved phase is caused by partitioning of the hydrocarbon from the NAPL into the dissolved or aqueous phase. This dissolution process tends to establish a local equilibrium and as dissolved hydrocarbon is transported (advected) downgradient of the source area by the flowing groundwater and/or biodegrades in the source area, more hydrocarbon dissolves into the groundwater from the NAPL. Because of biodegradation and hydrodynamic dispersion, the dissolved concentration will decrease downgradient of the NAPL source area. At most spill sites the majority of the hydrocarbon mass will be in the NAPL phase, not in the dissolved phase (or adsorbed or vapor phases).

4.1 Dissolved Phase Plume Mapping

The dissolved-phase plume area may be subdivided into areas based on whether a three- or four-phase distribution is present, and based on the hydrocarbon concentrations in the plume. This may result in distinct mapped areas as described below.

If the NAPL source area extends into the saturated zone (that is, the NAPL extends below the water table) as it does at most Alaskan spill sites, then in the saturated portion of the NAPL-contaminated soil source area a four-phase distribution will exist and the dissolved equilibrium concentration (that is, the concentration in the groundwater) should follow Raoult's Law. The dissolved plume which coincides with the NAPL contaminated smear zone soil source area may be described as the source area plume and will be delineated by the identification of the NAPL source area in the sear zone.

A three-phase distribution will exist downgradient of the saturated portion of the NAPL-contaminated soil source area, and likely in the saturated zone below the NAPL source area if the NAPL source is entirely above the water table. The dissolved-phase plume downgradient of the source area may be described as the "downgradient dissolved-phase plume." If a portion of the downgradient dissolved-phase plume exceeds the 18 ACC 75 Table C groundwater concentration criteria, then that portion of the plume should be delineated on the maps. In addition, tables of the groundwater laboratory test results should be provided in the site conditions report. The dissolved-phase plume area exceeding the Table C criteria will require an institutional control prohibiting the consumption of groundwater while the plume persists, and/or remediation to protect human health.

In addition, the portion of the downgradient dissolved-phase plume exceeding the Alaska Ambient Water Quality Criteria should be identified on the site maps to assess if dissolved phase plume above ambient water quality criteria extends to a surface water body. If the dissolved plume above ambient water quality criteria extends to a surface water body then the impact of the plume on the water quality in the surface water body must be determined. If the dissolved plume does not extend to a surface water body or is below the ambient water quality

criteria at the edge of the water body then the plume may be considered to not adversely impact the surface water body and to be incompliance with environmental criteria.

4.2 Characterization of the Dissolved-phase Plume Hydrocarbon Concentration Trend

As described above, in the conceptual model of a fuel hydrocarbon release the dissolved-phase plume will tend to expand further downgradient and increase in concentration for a period of a few years following the hydrocarbon release and then stabilize in area and concentration for an extended time (years to decades) as the NAPL source is depleted. To make good site management decisions and accurately assess risk, the responsible party and ADEC need to know if the dissolved-phase plume is expanding, stable, or contracting. At fuel hydrocarbon spill sites that are decades old and still have a significant mass of NAPL in the source zone, the dissolved-phase plume may be assumed to be stable. At recent spill sites, the stability of the dissolved-phase plume may be assessed by conducting a Mann-Kendall trend analysis of concentrations in the plume. The Mann-Kendall trend analysis describes the likelihood that the plume is expanding, stable, or contracting. EPA documents and several textbooks describe the Mann-Kendall trend analysis (EPA, 2000; Bedient et. al., 1999). In addition or as an alternative, groundwater fate and transport modeling using a simple screening tool such as BioScreen (Newell et. al., 1996) or Modflow and MT3D may be used to assess the time required for the dissolved-phase plume from a new spill to reach its maximum extent. The fate and transport modeling data may be very useful in developing long-term monitoring programs for recent spill sites.

4.3 Characterization of the Dissolved-phase Plume Hydrocarbon Concentrations

Consistent with ADEC policy, the maximum measured dissolved-phase concentration (not the average dissolved concentration) are suggested for use in calculations of groundwater ingestion risk. Note that the DRO concentrations measured in groundwater in the NAPL- contaminated soil source area may commonly be above the solubility limit for diesel fuels, indicating that the groundwater samples contained NAPL. The value of data from water samples containing NAPL is limited for many reasons, such as (1) the NAPL does not migrate with the groundwater; hence, the data cannot be used to assess the source term in transport models, (2) the sampling method and technique, groundwater elevation, and well development effort often impacts the NAPL concentration in the water sample; hence the concentration data may be invalid for groundwater concentration trend analysis and 3) the high concentrations caused by NAPL incorporation in groundwater samples may result in overestimates of human health risk. The overestimate of human health risk occurs because maximum concentrations from shallow, poorly developed monitoring wells are commonly used to characterize the groundwater that could be consumed by persons at the contaminated sites, whereas drinking water wells at hydrocarbon spill sites generally do not tap the shallow water sampled by monitoring wells and drinking water wells are typically developed extensively compared to monitoring wells (drinking water well development tends to reduce or eliminate sediment production and NAPL entrainment). In addition, long- term consumption of water containing NAPL is not likely

because the water would smell like fuel, taste like fuel, and have a sheen that would alert the user to the presence of the contamination. In contrast, dissolved phase contamination above risk-based levels may not exhibit a smell or taste and would not have a sheen to alert the consumer to the presence of the contaminant; hence, long-term consumption of the tainted water could persist undetected. For the above reasons, sampling techniques that limit NAPL and sediment inclusion in groundwater samples are advised. These methods include low- flow sampling and possibly use of diffusion bag samplers.

SECTION 5

Hydrogeologic Data

The hydraulic conductivity and groundwater gradient are valuable site data that should be documented at every site where the hydrocarbon has reached the water table. Several methods are available to measure or estimate the hydraulic conductivity, such as conducting pump tests or slug tests, permeameter testing of soil samples, and estimating the conductivity based on sieve analyses. Slug tests and small-scale pump tests using 2-inch monitoring wells and data loggers can be accomplished in about 2 to 4 hours and offer valuable data relative to the time invested. The slug test and/or small- scale pump test data can be readily reduced and documented using any of several commercially available pump test software programs, spreadsheets or hand calculations. The software typically graphs the pump test drawdown data, calculates the conductivity, and prints a simple report that can be included in the site conditions report as an appendix.

At the lowest level of effort, the groundwater gradient and flow direction may be determined by measuring the depth to groundwater in a minimum of three monitoring wells, using swing ties and a level survey to establish the location and collar elevations on the monitoring wells, then using a graphical technique (Fedder, 1986) to calculate the flow direction and gradient. If the site is large (1000 to 10,000+ square feet), then more than three wells will likely be necessary to document the gradient and characterize the extent of the dissolved-phase plume. In general, as many wells as possible should be used to document the gradient and flow direction (e.g., if a site has 5 or 8 monitoring wells gage and use all of them to assess the flow direction and gradient, not just 3 monitoring wells). When more than three wells are used to assess the gradient, a surface contouring program such as Surfer® (Golden Software) may used to document the groundwater contours and gradient. When using contouring programs such as Surfer®, always highlight the well locations from which the contoured data were derived, and use blanking files to limit the splay of contours outside the area of data (the contouring algorithms commonly cause the contours to misleadingly splay apart outside the area of the monitoring wells). When calculating the gradient it is desirable to show the location or locations that were used in the calculation. Provided the soils are isotropic, the groundwater flow direction will be perpendicular to the groundwater contours. The groundwater velocity may be calculated as the hydraulic conductivity multiplied by the gradient.

The aquifer's saturated thickness is used in calculations of the dilution-attenuation factor and is valuable data when assessing potential impacts to drinking water supplies. However, data regarding the thickness of the aquifer are in general not required for the risk calculations. The thickness of the aquifer may be documented by drilling deep test holes near the release site, or by using data from other boring/geologic studies of the area. The U.S. Geological Survey (USGS) and Alaska Department of Geological and Geophysical Surveys (DGGS) have published hydrogeologic data and the Alaska Department of Transportation and Public Facilities (ADOT&PF) and/or municipalities often have libraries of test hole and well logs related to road and utility construction projects.

An example of a groundwater contour map is shown in Figure 12. This map from the Gold Creek project shows the NAPL-contaminated soil source area, the groundwater contours at 0.5-foot intervals, the wells from which water elevation data were derived (identified by black dots at the well locations), and the groundwater flow direction and gradient at two locations are shown.

The water table should be expected to rise and fall seasonally and this change in water table elevation should be documented at sites with groundwater contamination above 18AAC75 Table C levels, because the seasonal variation affects, for example, the calculation of the dilution-attenuation factor, the characterization of the smear zone thickness, modeling of the dissolved-phase plume extent, and assessment of the plume stability (the Mann-Kendall concentration trend analysis may have to be adjusted for seasonal concentration changes related to water table elevation and precipitation changes). The characterization of the water table fluctuation may be as simple as presenting water table elevation data from the existing monitoring events in a report table (list the monitoring well number, the observation data, and the water table elevation). Note that the groundwater elevation data that are collected should be representative of both periods of low water (typically late winter conditions) and high water (typically late spring/breakup or autumn). If the site is large and/or complex, then data logger records are an excellent way to document the water table fluctuation.

SECTION 6

Soil Input Parameters for the Hydrocarbon Risk Calculator

The soil properties present at contaminated sites greatly influence the fate and transport, risk, and remedial options associated with the site; therefore, the site characterization effort needs to document many soil parameters. The soil properties used in calculations with the hydrocarbon risk calculator are listed Table 1 and highlighted in yellow in the top section of the hydrocarbon risk calculator spreadsheet. These values should ideally be based on the site-specific measurements or should match the ADEC default soil properties (but do not use the ADEC default values if they are obviously not appropriate). Soil characterization needs and methods are discussed in the following sections. When the American Society for testing and Materials (ASTM) standard methods exist to measure a soil parameter, the ASTM method should be used.

Soil Stratigraphy and Soil Texture/Grain Size Distribution. Soil stratigraphy (as described here) involves describing the layers of soils present at the site and, as much as possible, attributing those layers to a depositional process or environment. Examples of soil stratigraphy that may be encountered at Alaskan sites include fine- grained, silty, over-bank fluvial deposits, overlying coarse-grained stream bed sediments; or aeolian loess overlying glaciofluvial outwash; or interbedded fine and coarse sands deposited in a fluvial environment overlying marine clays. Knowledge of the soil stratigraphy forms a framework for understanding the site and surrounding area soils (for example, the lateral continuity of aquifers and vapor migration pathways).

Soil textures or the grain size distribution should be documented because the soil textures greatly influence the capillary properties, soil moisture content, and hydraulic conductivity. The soil textures of each major stratigraphic layer at the site should be described and, to the extent practical, soil from each layer should be sampled and analyzed by sieve and/or hydrometer. If sieve and hydrometer measurements are not made, then the fraction of the soil mass in the gravel, sand, silt and clay-sized particle ranges should be estimated. The soils should be assigned to a USCS group. If the soils are described in more detail than simply identifying their USCS group, then the ASTM descriptions listed in standard D-432 should be used (arbitrary or consultant-specific classification/description systems are not helpful). Note that if layered soils are discovered at the site, then the soil stratigraphy and texture descriptions should identify the presence of the layering, the thickness of the layers, and the sharpness of the contacts between the layers. Samples from each layer should be analyzed by sieve and/or hydrometer. Interlayered soils, such as an interlayered sand and silt soil, should not be mixed, analyzed for grain size distribution, and then described as silty sand or sandy silt.

Soil Bulk Density, Porosity, and Moisture Content. The soil bulk density, soil moisture content, total porosity, air-filled porosity and water-filled porosity values are used in the phase partitioning calculations and the migration to indoor and migration to outdoor air risk calculations. Soil bulk density is a measure of the weight of the soil particles per unit volume of the porous media (grams per centimeter [g/cm]^3 or pounds per feet [lbs/ft]^3). The soil bulk

density is usually measured by driving a cylindrical sampler (for example, a brass liner) into the soil and extracting a relatively undisturbed, known volume of soil and measuring the wet and dry weights of the known volume of soil. The gravimetric moisture content of the soil is calculated from the wet and dry soil weights, and the total porosity is calculated based on either a measured or estimated specific gravity of the soil solids. The water-filled porosity may be readily calculated from the soil moisture data and the air-filled porosity may be calculated from the total porosity and water-filled porosity data.

Fraction of Organic Carbon. The fraction of organic carbon (foc) is used in the phase partitioning calculations performed by the four-phase cumulative risk calculator, and in modeling dissolved-phase migration (where the presence of organic carbon in the aquifer causes the dissolved-phase plume to be retarded relative to the groundwater velocity). The ADEC default foc value of 0.001-gram organic carbon per gram of soil is commonly described as the point above which adsorption into the organic carbon dominates the adsorption process (at foc values below about 0.001, adsorption into clay minerals may be as significant as adsorption into the naturally occurring organic carbon). The ADEC default foc may be used in calculations or the soil foc values may be measured in (four or more) soil samples collected from near or below the water table depth, outside the NAPL-contaminated soil source area. Note that the dissolved- and vapor-phase equilibrium concentrations calculated by the hydrocarbon risk calculator are less sensitive to the foc value than those values calculated by the three-phase model.

SECTION 7

Survey Location of Data Presented in the Site Conditions Summary Report

This technical background document describes a *Site Conditions Summary Report* that is proposed as an alternative to the existing ADEC-contaminated site reporting requirements and references an SOCWG technical background report that proposes environmental site closeout criteria that are an alternative to the existing ADEC criteria. Under the reporting and site closeout scenario described in this SOCWG documents the *Site Conditions Summary Report* would become the primary documentation for the extent and concentration of contaminants and risk for the site. Hence, the data collected at contaminated sites and presented in the *Site Conditions Summary Report* must be precisely and confidently located.

Site conditions and geographic location information contained in the *Site Conditions Summary Report* such as soil borings, monitoring wells, test pits, property corners, easements, infrastructure (buildings, roads, parking lots, utilities), and geologic or terrain features (changes in slope, stream and lake shorelines, vegetation breaks) will have significant value long after the report has been submitted and a determination of the site status has been made. Accurate information is necessary to be able to identify the locations of environmental site data after infrastructure and site conditions have changed (for example after buildings have been removed and/or vegetation has grown over a site). Therefore, the SOCWG recommends site survey standards as described herein. The overall objective of these survey recommendations is to help document the site conditions and to support the environmental decisions being made about the site. On a site specific basis less detailed and/or less accurate survey may be acceptable provided the existing data supports the decision being made.

Surveying must be performed in accordance with the Alaska State Professional Land Surveyors (ASPLS) Standards of Practice as appropriate for the services being provided. Surveying shall be conducted by, or under the direct supervision of a Professional Land Surveyor (PLS) holding a current registration in the State of Alaska.

Site conditions and geographic location information contained in the *Site Conditions Summary Report,* such as soil borings, monitoring wells, property corners, infrastructure, and geologic or terrain features relavent to the project should be fully documented and geo-referenced to the Alaska State Plane Coordinate System of 1983 (NAD83, in US Survey feet). Metadata (details on the survey methods and accuracy) should be provided for all geographic information.

The primary project survey control should originate from the National Geodetic Survey (NGS) Continuously Operating Reference Stations (CORS) referenced to NAD83 (CORS Epoch) system. The NGS Online Positioning Users Service (OPUS) utility should be used to establish the primary control coordinates for at least two project control points. The global GPS control survey should consist of at least two independent 4-hour GPS static observations at each of the two control points (yielding a total of 8 hours of observation at each point and a total of 16 hours of observation at the two control points. The GPS observations at the two control points must be simultaneous observations). Subsequent GPS and conventional surveys for locating soil

borings, monitoring wells, property corners, geologic features and infrastructure shall be tied directly to the primary project control. If existing survey data are translated to State Plane coordinates then the translation parameters must be provided. Elevations should be referenced to the North American Vertical Datum of 1988 (NAVD88) established at each control point using OPUS. The elevations at each monitoring well must be tied directly to the primary control using differential leveling techniques and reported the nearest 0.01 feet.

Boundary surveys shall be performed to Third Order, Class I standards, as specified by the ASPLS Standards of Practice, with an allowable error of closure of 1:10,000 or better.

Prior to commencement of the survey, the surveyor must review title reports, title documents and mapping which is relevant to the project. Additionally, the surveyor must research additional relevant documentation from other sources. These documents may include but are not limited to the following:

Bureau of Land Management (BLM) and Department of Natural Resources (DNR) land status plats, BLM township survey plats, Mineral and U.S. Survey plats and field notes, any records of survey, subdivisions, and relevant engineering control surveys, United States Coast and Geodetic Survey (USC&GS)/NGS control diagrams-descriptions, ADOT&PF right-of-way records and other easement or boundary documents of record, ADOT&PF engineering as-builts, DNR surveys, and aerial photos.

One legible portable document format (PDF) copy of the research materials should be submitted on a CD for all of the above referenced reports, plats, notes and other source materials.

All research for property corner ties (generally includes local platting authority subdivision plats and right-of-way plats, BLM U.S. Surveys, state land survey plats, waiver documents, deeds, record of surveys and monument records) should be done prior to commencement of searching and tying property controlling corners.

Preliminary engineering information must be analyzed to determine where additional property boundary ties are needed, and title reports relevant to the project site should be examined. When preparing base maps, the surveyor must thoroughly review and document existing right-of-way rights and analyze preliminary engineering information to determine where additional survey ties are needed. Survey conflicts with existing right of way and boundary locations should be identified. If Boundary Survey conflicts are resolved then a written summary of the rationale for the solution must be provided.

A survey base map shall be prepared for the entire project limits and shall include the following information:

A. Project Control

B. Soil borings, monitoring wells, geologic features and infrastructure

C. Existing property boundaries, including all Public Land Survey System survey lines

D. All subdivisions, including name, plat number, and lot and block designations or aliquot parts description

E. Existing rights-of-ways and easements

F. Horizontal and vertical control statement

G. Projection/Coordinates Table, scale, units, source

In addition to the survey described above the *Site Conditions Summary Report* should include the results of a title search conducted by a professional title search company. The title search results should be submitted as an appendix to the *Site Conditions Summary Report*.

In general hand-held GPS data and swing ties from building corners, by themselves, are not sufficient for the *Site Conditions Summary Report* because, for example, buildings and similar structures are not permanent features and after the buildings are removed it may be impossible to recreate the contaminant locations, and hand-held GPS data have errors of tens of feet and are subject to operator error (for example, the hand-held GPS user does not know the datum for the measurement, the accuracy of the measurement, and/or how to report the measurement).

An example of the recommended data is presented in Figure 9, from the Strawberry Point project. Figure 9 shows that a section line passes through the NAPL-contaminated soil source area, there is a 33-foot easement on either side of the section line, and the sections have differing land status (that is, section 15 is part of the Chugach National Forest and selected by both the State of Alaska and Eyak and Chugach Native Corporations, while section 16 is subject to an interim conveyance to Eyak and Chugach Native Corporations).

SECTION 8

Summary and Recommendations

This document describes a proposed "*Site Conditions Summary Report,*" and the collection and presentation of site characterization data that are considered essential for the accurate characterization of risk and determination of site status according to the proposed site status map. The *Site Conditions Summary Report* is a proposed report that overlaps significantly with existing ADEC reporting requirements. Not all of the elements of the *Site Conditions Summary Report* are currently required by the ADEC, but the *Site Conditions Summary Report* requires essentially all of the information listed in the site characterization report and final cleanup reports descritbed in the regulations (18AAC 75.335 and 18 AAC 75.380). The primary purposes of the *Site Conditions Summary Report* are to help ensure that data needed for risk calculations are collected, that the field data are presented on maps and in tables in a consistent and meaningful way, that the human health risk calculations and ecological risk characterizations are complete and fully supported; and to evaluate the open or closed site status category. (The open and closed categories of the site status map diagram are a proposed alternative to the existing ADEC site closure and hazard ranking system and are not recognized by the ADEC at this time).

Key parts of the *Site Conditions Summary Report* that are not explicitly identified in the existing reporting requirements include the following:

- The division of the site into the NAPL source area, downgradient dissolved phase plume and unaffected areas
- The statistical characterization of the NAPL contaminated soil source area
- The use of survey grade (sub meter) world coordinates (Alaska State Plane Coordinate System of 1983) to identify monitoring well locations, boring locations, the NAPL-contaminated soil source area, site infrastructure and property boundaries
- The identification of land ownership through a title search
- The use of the hydrocarbon risk calculator to assess the human health risk posed by the site, and to identify the compounds and exposure routes which contribute most significantly to risk
- The use of the site status map to place the site in site status category which facilitates risk communication and risk management.

The SOCWG recommends that the ADEC consider adding to the existing 18 AAC 75 reporting requirements to meet the proposed requirements of the *Site Conditions Summary Report* and that the ADEC require the collection and presentation of the data as described herein when closing sites using 18 AAC 75 Method 3 or Method 4 approaches.

In addition, the SOCWG recommends that the ADEC upgrade the existing the contaminated site database to contain some of the critical data discussed in this report including but not

limited to Alaska State Plane coordinates for the NAPL source area and provide a link to the *Site Conditions Summary Report*.

SECTION 9

References

Alaska Department of Environmental Conservation. 1999a. "Oil Spill and Hazardous Substances Pollution Control Regulations." *Alaska Administrative Code*. Title 18, Chapter 75. January 22, 1999.

Bedient, Phillip B., Hanadi Rafai, and Charles Newell. 1999. *Ground Water Contamination, Transport and Remediation*. Prentice Hall. Upper Saddle River, N. J.

Charbeneau, Randall, R. Johns, L. Lake, and M. McAdams. 1999. *Free-Product Recovery of Petroleum Hydrocarbon Liquids*. API Publication No. 4682.

Geosphere and CH2M HILL. 2006. *Maximum Allowable Concentration, Residual Saturation, and Free-Product Mobility Technical Background Document.* Report prepared for the Statement of Cooperation Working Group.

Geosphere and CH2M HILL. 2006. *Proposed Environmental Site Closeout Concepts, Criteria and Definitions Technical Background Document.* Report prepared for the Statement of Cooperation Working Group.

Newell, C.J., R. K. McLeod, and J. R. Gonzales. 1997. BIOSCREEN Natural Attenuation Decision Support System. Version 1.4 Revisions.

Tables

TABLE 1
Data to be Included in the Site Conditions Summary Report

Land Status	Data Description	Notes	Default Value	Source of Data	4-phase calculator input
	Land Use Scenario & Zoning Classification	Residential or Industrial		ADEC Default	Yes
	Land Ownership Boundaries & Title search results for subject site				No
	Documentation of the presence or absence of Off Site Migration				
	Land Ownership Boundaries & and title search results for adjacent properties if off-site migration is occurring				
	Potential Groundwater Use	Potable or Non-potable Water		ADEC Default	Yes
	Current Groundwater Use Scenario	not currently used or current use			
	Professional Survey Coordinates for wells, property corners, source area limits, etc.				
	Source and Age of spill	leaking UST, surface spill event			
Soils Characterization					
	Stratigraphy Description				
	Grain Size Analyses				
	USCS Classification & ASTM soil descriptions				
	Soil Bulk Density		94 lbs/ft^3	ADEC Default	Yes
	Specific Gravity		2.65	ADEC Default	Yes
	Soil Moisture Content		20%	ADEC Default	Yes
	Total Porosity		0.44	ADEC Default	Yes
	Water Filled Porosity		0.21	ADEC Default	Yes
	Air Filled Porosity				Yes
	Soil Organic Carbon Content		0.001	ADEC Default	Yes
Hydrogeology (by stratigraphic unit)					
	Hydraulic Conductivity		0.002 cm/sec	ADEC Default	Yes
	Hydraulic Gradient		0.0018	ADEC Default	Yes
	Aquifer Saturated Thickness		100	ADEC Default	Yes
	Precipitation Rate		20 inches/year	ADEC Default	Yes
	Seasonal Water Table Fluctuation				Yes
	Heterogeneity & Anisotropy				
	Calculation of Dilution Attenuation Factor				Yes
Source Characterization					
	3D NAPL Contaminated Volume Identified				
	Source Length	perpendicular to groundwater flow	105 ft.		Yes
	Source Width	parallel to groundwater flow			
	Source Saturated Thickness	measured at high water level	0 ft.		Yes
	NAPL characterization (EPH data from source area or use fresh fuel assumption)				Yes
	Dissolved Phase Plume above Table C Values Identified				
	Dissolved Phase Plume above AWQC Identified--documentation that surface water is or is not impacted				
	Mann-Kendal Trend Analysis for Dissolved phase plume				
	Source Area Groundwater and Soil Concentrations 95% UCL	**95% UCL Soil Concentration (mg/kg)**		**Maximum Water Concentration (mg/L)**	
	Benzene				Yes
	Toluene				Yes
	Ethylbenzene				Yes
	Xylene				Yes
	GRO				Yes
	DRO				Yes
	DRO aromatics				Yes
	DRO aliphatics				Yes
	RRO				Yes
	Naphthalene				Yes
	Acenaphthene				Yes
	Fluorene				Yes
	Anthracene				Yes
	Fluoranthene				Yes
	Pyrene				Yes
	Benzo (a) Anthracene				Yes
	Chrysene				Yes
	Benzo (b) fluoranthene				Yes
	Benzo (k) fluoranthene				Yes
	Benzo (a) pyrene				Yes
	Indeno (1,2,3-cd) pyrene				Yes
	Dibenz (a,h) anthracene				Yes
Free Product Data					
	Identify if free product is present in monitoring wells				
	Document free product thickness during periods of stable & low groundwater				
	Compare to Charbeneau thickness for given soil type				
	Document detailed assessment of free product mobility as necessary				
	Document Soil Moisture Retention Properties as Necessary				
Intrinsic Remediation Parameters					
	Dissolved Oxygen Data				
	Nitrate Data				
	Ferrous Iron Data				
	Manganese Data				
	Sulfate Data				
	Methane Data				
	Determination of primary electron acceptor & rate function				
Remediation History					
	Excavation, Bioventing, Air Sparging history as appropriate				
Risk Characterization					
	4-phase calculator output				Yes
Institutional Controls in Place					
	Document all Institutional Controls that are in Place				
Long Term Monitoring Plan in Place					
	Document all Monitoring Plans that are in Place				
Site Status					
	Complete the Site Status Map form and request the appropriate Status				

TABLE 2A

2003 BTEX, GRO & DRO Data, Davis Property, FAA Strawberry Point Station

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	Benzene			Toluene			Ethylbenzene			Xylenes			Gasoline Range Organics			Diesel Range Organics			DRO Aromatics			DRO Aliphatics			RRO
			Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Stat Value mg/kg
TH 161-7	Davis Property	11/03/2003	0.0160		0.0160	0.0610		0.0610	0.0160		0.0160	0.100		0.1000	0.59	ND	0.5900	1.7	ND	1.7							
TH 155 6.5	Davis Property	10/31/2003	0.0039	ND	0.0039	0.0190		0.0190	0.0045	ND	0.0045	0.039		0.0390	6.40		6.4000	1,100.0		1100.0	8.1		8.1	129.7		129.7	5
TH 154 6.0	Davis Property	10/31/2003	0.0022	ND	0.0022	0.0100		0.0100	0.0032	ND	0.0032	0.018		0.0180	0.24	ND	0.2400	13.0		13.0							
TH 153 6.0	Davis Property	10/31/2003	0.0024	ND	0.0024	0.0094	ND	0.0094	0.0024	ND	0.0024	0.013	ND	0.0130	0.91	ND	0.9100	28.0		28.0							
TH 152 6.0	Davis Property	10/31/2003	0.0028	ND	0.0028	0.0120		0.0120	0.0027	ND	0.0027	0.013	ND	0.0130	0.37	ND	0.3700	4.2	ND	4.2							
TH 151 6.5	Davis Property	10/31/2003	0.0740		0.0740	0.2500		0.2500	0.0350	ND	0.0350	0.290		0.2900	52.00		52.0000	5,000.0		5000.0	209.1		209.1	2,234.0		2,234.0	16.8
MW 115-7	Davis Property	11/03/2003	0.0019	ND	0.0019	0.0071	ND	0.0071	0.0019	ND	0.0019	0.013	ND	0.0130	0.17	ND	0.1700	1.9	ND	1.9							
MW 114 6	Davis Property	10/31/2003	0.0057	ND	0.0057	0.0310		0.0310	0.0064	ND	0.0064	0.038		0.0380	0.99	ND	0.9900	690.0		690.0							
MW 114 4.5	Davis Property	10/31/2003	0.0028	ND	0.0028	0.0130		0.0130	0.0031	ND	0.0031	0.017	ND	0.0170	0.40	ND	0.4000	250.0		250.0	38.8		38.8	552.7		552.7	14.1
MW 109 6	Davis Property	10/31/2003	0.0140		0.0140	0.0660		0.0660	0.0094	ND	0.0094	0.079		0.0790	12.00		12.0000	1,900.0		1900.0	61.5		61.5	686.5		686.5	37.7
MW 109 4.5	Davis Property	10/31/2003	0.0029	ND	0.0029	0.0160		0.0160	0.0046	ND	0.0046	0.059		0.0590	12.00		12.0000	2,100.0		2100.0	197.1		197.1	2,427.0		2,427.0	76.5

TABLE 2B

Soil Source Area Characterization, Davis Property Site, Strawberry Point

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	Benzene			Toluene			Ethylbenzene			Xylenes			Gasoline Range Organics			Diesel Range Organics			DRO Aromatics			DRO Aliphatics			RRO
			Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Stat Value mg/kg
TH 155 6.5	Davis Property	10/31/2003	0.0039	ND	0.0039	0.0190		0.0190	0.0045	ND	0.0045	0.039		0.0390	6.40		6.4000	1,100.0		1100.0	8.1		8.1	129.7		129.7	5
TH 151 6.5	Davis Property	10/31/2003	0.0740		0.0740	0.2500		0.2500	0.0350	ND	0.0350	0.290		0.2900	52.00		52.0000	5,000.0		5000.0	209.1		209.1	2,234.0		2,234.0	16.8
MW 114 6	Davis Property	10/31/2003	0.0057	ND	0.0057	0.0310		0.0310	0.0064	ND	0.0064	0.038		0.0380	0.99	ND	0.9900	690.0		690.0							
MW 114 4.5	Davis Property	10/31/2003	0.0028	ND	0.0028	0.0130		0.0130	0.0031	ND	0.0031	0.017	ND	0.0170	0.40	ND	0.4000	250.0		250.0	38.8		38.8	552.7		552.7	14.1
MW 109 6	Davis Property	10/31/2003	0.0140		0.0140	0.0660		0.0660	0.0094	ND	0.0094	0.079		0.0790	12.00		12.0000	1,900.0		1900.0	61.5		61.5	686.5		686.5	37.7
MW 109 4.5	Davis Property	10/31/2003	0.0029	ND	0.0029	0.0160		0.0160	0.0046	ND	0.0046	0.059		0.0590	12.00		12.0000	2,100.0		2100.0	197.1		197.1	2,427.0		2,427.0	76.5
HBK01-2P-02	Davis Property	8/28/2001	0.0183	ND	0.0092	0.0734	ND	0.0367	0.0734	ND	0.0367	0.0734	ND	0.0367	3.67	ND	1.8350	2,520		2520.0							
SB 42 2.5' (HLA)	Davis Property	7/5/1992																14,524.0		14524.0							
Test results below the method reporting limit were provided in the electronic data deliverables--therefore these data were reported along with their "ND" qualifier. Test results below the method detection limit were listed as "0" in the electronic deliverables. When "0" values were listed	average		0.0161			0.0617			0.0142			0.0798			12.2			3,510.5			103			1,206		30
	std. dev.		0.0259			0.0850			0.0149			0.0947			18.2			4,682.4			93.5			1,049.1		28.6
	count		7			7			7			7			7			8.0			5			5		5
	std. dev. of mean		0.0098			0.0321			0.0056			0.0358			6.9			1,655.5			41.8			469.2		12.8
	95%UCL		0.0356			0.1259			0.0255			0.1514			26.0			6,821.5			186.5			2,144.4		55.6
	maximum		0.0740			0.2500			0.0367			0.2900			52.0			14,524.0			209.1			2,427.0		76.5

TABLE 2C

2003 BTEX, GRO & DRO Groundwater Concentrations, Davis Property Site, Strawberry Point

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	Benzene			Toluene			Ethylbenzene			Xylenes			Gasoline Range Organics			Diesel Range Organics			DRO Aromatics			DRO Aliphatics			RRO
			Lab Result ug/L	Lab qualifier	Stat Value ug/L	Lab Result ug/L	Lab qualifier	Stat Value ug/L	Lab Result ug/L	Lab qualifier	Stat Value ug/L	Lab Result ug/L	Lab qualifier	Stat Value ug/L	Lab Result ug/L	Lab qualifier	Stat Value ug/L	Lab Result mg/L	Lab qualifier	Stat Value mg/L	Lab Result ug/L	Lab qualifier	Stat Value ug/L	Lab Result ug/L	Lab qualifier	Stat Value ug/L	Stat Value ug/L
MW 109	Davis Property	11/06/2003	0.1000	ND	0.1000	0.4800	ND	0.4800	0.1200	ND	0.1200	1.000	ND	1.0000	14.00	ND	14.0000	2.700		2.700	71.0		71.0	190.6		190.6	50
MW 115	Davis Property	11/06/2003	0.0900	ND	0.0900	0.3500	ND	0.3500	0.1600	ND	0.1600	0.790	ND	0.7900	6.40	ND	6.4000	0.028	ND	0.028							
Test results below the method reporting limit were provided in the electronic data deliverables--therefore these data were reported along with their "ND" qualifier. Test results below the method detection limit were listed as "0" in the electronic deliverables. When "0" values were listed	average		0.0950			0.4150			0.1400			0.8950			10.2			1.4			71			191		50
	std. dev.		0.0071			0.0919			0.0283			0.1485			5.4			1.9			NA			NA		NA
	count		2			2			2			2			2			2.0			1			1		1
	std. dev. of mean		0.0050			0.0650			0.0200			0.1050			3.8			1.3			NA			NA		NA
	95%UCL		0.1050			0.5450			0.1800			1.1050			17.8			4.0			NA			NA		NA
	maximum		0.1000			0.4800			0.1600			1.0000			14.0			2.7			71.0			190.6		50.0

Test Hole Number & Depth (ft. bgs)	Date Collected:	C8-C10 Aromatics			C8-C10 Aliphatics			C10-C12 Aromatics			C10-C12 Aliphatics			C12-C16 Aromatics			C12-C16 Aliphatics			C16-C21 Aromatics			C16-C21 Aliphatics			C21-C34 Aromatics		
		Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L	Lab Result ug/L	Method Detection Limit ug/L	Stat Value ug/L
MW109	11/6/2003	ND	50	25	ND	50	25	ND	50	25	ND	50	25	ND	50	25	113	50	113	71	50	71	77.6	50	77.6	ND	50	25

TABLE 3A

TPH and DRO Soil Concentrations Outside the Generator and Shop Building NAPL Contaminated Soil Source Area, FAA

Primary Location Description	Revised or Alternate Location Description	Inside or Outside Source Area	Sampling Date	Sample Depth (ft)	TPH (mg/kg)	DRO (mg/kg)	Average of TPH & DRO (mg/kg)
SB7		Outside	July-92	9	7.5	70	
SB9		Outside	July-92	10	0.94		
SB10		Outside	July-92	7	8.7		
SB10		Outside	July-92	10	3		
SB17		Outside	July-92	3	3.7		
SB17		Outside	July-92	5	8.9		
SB17		Outside	July-92	8	3.5		
SB18		Outside	July-92	9.5	39		
SB21		Outside	July-92	6.5	1.9		
SB21		Outside	July-92	9	38		
SB23		Outside	July-92	1	4.8		
SB23		Outside	July-92	2.5	ND (<10)		
SB26		Outside	July-92	1	1.7		
SB26		Outside	July-92	2.5	ND (<10)		
SB34		Outside	July-92	7	4.4		
SB35		Outside	July-92	8	2.7		
SB38		Outside	July-92	8	11		
SB59		Outside	July-92	3	24		
SB59		Outside	July-92	8	20		
SB61		Outside	July-92	6	11		
MW1		Outside	July-92	3	6.8	ND (<10)	
MW1		Outside	July-92	10	4.7	ND (<10)	
MW2		Outside	July-92	3	3.3		
MW2		Outside	July-92	10	4.2		
MW3		Outside	July-92	3	8.4	ND (<10)	
MW3		Outside	July-92	10	7.3	ND (<10)	
SB7		Outside	July-92	5	ND (<10)		
SB9		Outside	July-92	7		ND (<10)	
SB10		Outside	July-92	5		ND (<10)	
SB10		Outside	July-92	10		ND (<10)	
SB15		Outside	July-92	7		ND (<10)	
SB16		Outside	July-92	8		ND (<10)	
SB16		Outside	July-92	9.5		ND (<10)	
SB17		Outside	July-92	3		ND (<10)	
SB17		Outside	July-92	5		ND (<10)	
SB17		Outside	July-92	8		ND (<10)	
SB18		Outside	July-92	9.5		ND (<10)	
SB18		Outside	July-92	10.5		ND (<10)	
SB18		Outside	July-92	20		ND (<10)	
SB21		Outside	July-92	9		ND (<10)	
SB22		Outside	July-92	2.5		ND (<10)	
SB22		Outside	July-92	5		ND (<10)	
SB22		Outside	July-92	7		ND (<10)	
SB34		Outside	July-92	4		ND (<10)	
SB34		Outside	July-92	5.5		ND (<10)	
SB34		Outside	July-92	10.5		ND (<10)	
SB39		Outside	July-92	11		ND (<10)	
SB59		Outside	July-92	6		ND (<10)	
SB59		Outside	July-92	11		ND (<10)	
SB60		Outside	July-92	8		ND (<10)	
SB60		Outside	July-92	11		ND (<10)	
SB61		Outside	July-92	8		ND (<10)	
SB61		Outside	July-92	11		ND (<10)	

TABLE 3B

TPH and DRO Soil Concentrations Inside the Generator and Shop Building NAPL Contaminated Soil Source Area, FAA

Primary Location Description	Revised or Alternate Location Description	Inside or Outside Source Area	Sampling Date	Sample Depth (ft)	TPH (mg/kg)	DRO (mg/kg)	Average of TPH & DRO (mg/kg)
MW-4		Inside	7/1/1992	5	15,835	14,000	14,918
MW-4		Inside	7/2/1992	10		1,300	1,300
MW-5		Inside	7/3/1992	5	15,422	14,000	14,711
MW-5		Inside	7/4/1992	8.5	14,929	16,000	15,465
MW-6		Inside	7/5/1992	5		11,000	11,000
MW-6		Inside	7/6/1992	9		4,100	4,100
SB-8		Inside	7/7/1992	5		19,000	19,000
SB-13		Inside	7/2/1992	6	30,398		30,398
MW-19		Inside	7/2/1992	8 [2]		7,950	7,950
MW-33		Inside	7/4/1992	5	13,594		13,594
MW-33		Inside	7/4/1992	8.5	33,332	11,000	22,166
MW-33		Inside	7/4/1992	11		4,300	4,300
SB-36		Inside	7/4/1992	6		2,500	2,500
SB-36		Inside	7/4/1992	8	15,077		15,077
SB-36		Inside	7/4/1992	11 [2]		9,700	9,700
SB-37		Inside	7/4/1992	8	5,671	5,000	5,336
SB-37		Inside	7/4/1992	11		10,000	10,000
SB-41		Inside	7/4/1992	6	30,987		30,987
SB-42		Inside	7/5/1992	2.5	14,524		14,524
SB-55		Inside	7/6/1992	5	22,500		22,500
SB-55		Inside	7/6/1992	11	13,756		13,756
SB-56		Inside	7/6/1992	8	8,342		8,342
SB-57		Inside	7/9/1992	6	22,886		22,886
SB-57		Inside	7/9/1992	11		15,000	15,000
SB-58		Inside	7/7/1992	6	8,308		8,308
SB-58		Inside	7/7/1992	8	25,399		25,399
SB-58		Inside	7/7/1992	11		20,000	20,000
SB-62 (MW)		Inside	7/9/1992	8		3,000	3,000
SB-63		Inside	7/10/1992	8		20,000	20,000
TH-9	SW-9	Inside	6/3/1994	6		17,500	17,500
TH-11	SW-12	Inside	6/4/1994	5.5		23,700	23,700
TH-16	SW-16	Inside	6/2/1994	10.5 [2]		11,250	11,250
TH-24		Inside	5/31/1994	6		2,600	2,600
TH-29	SW-27	Inside	5/31/1994	6		7,300	7,300
TH-33	MW-1	Inside	6/1/1994	10		2,000	2,000
TH-36	SW-18	Inside	6/3/1994	6		1,500	1,500
MW-4		Inside	11/14/1998	6.5		4000	4,000
MW-5		Inside	11/14/1998	6.5		12000	12,000
MW-5		Inside	11/14/1998	8.5		8700	8,700
MW-6		Inside	11/14/1998	5.5		4500	4,500
MW-6		Inside	11/14/1998	9		7100	7,100
SB-8		Inside	11/14/1998	5.5		14000	14,000
SB-13		Inside	11/14/1998	6		12000	12,000
MW-19		Inside	11/14/1998	8		5400	5,400
MW-33		Inside	11/14/1998	5.5		220	220
MW-33		Inside	11/14/1998	8.5		7300	7,300
SB-36		Inside	11/14/1998	8		240	240
SB-36		Inside	11/14/1998	10		170	170
SB-37		Inside	11/14/1998	8		40	40
SB-37		Inside	11/14/1998	10		38	38
SB-41		Inside	11/14/1998	6 [2]		8950	8,950
SB-55		Inside	11/14/1998	5.5		3500	3,500
SB-55		Inside	11/14/1998	10		9400	9,400
SB-57		Inside	11/14/1998	6		11000	11,000
SB-57		Inside	11/14/1998	10		19000	19,000
SB-58		Inside	11/14/1998	6		2800	2,800
SB-58		Inside	11/14/1998	8		6400	6,400
SB-58		Inside	11/14/1998	10		9100	9,100
SB-63		Inside	11/14/1998	8		10000	10,000
TH-9	SW-9	Inside	11/14/1998	6.5 [2]		650	650
TH-11	SW-12	Inside	11/14/1998	6 [2]		14000	14,000
TH-16	SW-16	Inside	11/14/1998	10		12000	12,000
TH-29	SW-27	Inside	11/14/1998	6.5		120	120
SSW1	Southwest	Inside	11/14/1998	6		2200	2,200

TABLE 3B

TPH and DRO Soil Concentrations Inside the Generator and Shop Building NAPL Contaminated Soil Source Area, FAA

Primary Location Description	Revised or Alternate Location Description	Inside or Outside Source Area	Sampling Date	Sample Depth (ft)	TPH (mg/kg)	DRO (mg/kg)	Average of TPH & DRO (mg/kg)
SSW2	Southeast	Inside	11/14/1998	7.5		320	320
SSW3	Center	Inside	11/14/1998	7.5		2800	2,800
SSW4	North	Inside	11/14/1998	9		720	720
	SW2 NE	Inside	11/14/1998	9.5		4900	4,900
	SW31 NW	Inside	11/14/1998	9.5		13000	13,000
MW-5		Inside	6/2/2000	6.5		2200	2,200
SB-8		Inside	6/2/2000	6		9200	9,200
SB-13		Inside	6/2/2000	6.5		390	390
SB-57		Inside	6/2/2000	8		17000	17,000
SB-57		Inside	6/2/2000	10		10000	10,000
TH-11	SW-12	Inside	6/2/2000	6		3800	3,800
TH-16	SW-16	Inside	6/2/2000	10		9000	9,000
	SW31 NW	Inside	6/2/2000	9.5		10000	10,000
MW-4		Inside	10/28/2003	MW 4 6.5		7,400.0	7,400
MW-5		Inside	10/28/2003	MW 5 8.5		2,800.0	2,800
SB-13		Inside	10/28/2003	SB 13 7		42.0	42
MW-33		Inside	10/28/2003	MW 33 8		840.0	840
SB-55		Inside	10/28/2003	MW 106 10		5,400.0	5,400
SB-56		Inside	10/28/2003	TH 101 9.5		1,800.0	1,800
SB-57		Inside	10/28/2003	TH 102 11		12,000.0	12,000
SB-58		Inside	10/28/2003	TH 103 9		5,800.0	5,800

Notes: 1) average of triplicate samples

2) average of duplicate samples

Table 4A 2003 BTEX, GRO & DRO Data, Shop & Generator Building Site, FAA Strawberry Point Station

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	Benzene			Toluene			Ethylbenzene			Xylenes			Gasoline Range Organics			Diesel Range Organics			DRO Aromatics			DRO Aliphatics			RRO
			Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Stat Value mg/kg
TH 103 9	Shop & Gen Bldg	10/28/2003	0.0047	ND	0.0047	0.0180	ND	0.0180	0.0065	ND	0.0065	0.023	ND	0.0230	22.00		22.0000	5,800.0		5800.0	822.0		822.0	5,934.0		5,934.0	218
TH 102 11	Shop & Gen Bldg	10/28/2003	0.0054	ND	0.0054	0.0240	ND	0.0240	0.0340		0.0340	0.770		0.7700	70.00		70.0000	12,000.0		12000.0	1,201.8		1,201.8	9,432.0		9,432.0	676
TH 101 9.5	Shop & Gen Bldg	10/28/2003	0.0019	ND	0.0019	0.0075		0.0075	0.0014	ND	0.0014	0.020		0.0200	3.10		3.1000	1,800.0		1800.0	154.5		154.5	1,583.0		1,583.0	26.4
SB 13 7	Shop & Gen Bldg	10/28/2003	0.0030	ND	0.0030	0.0094	ND	0.0094	0.0027	ND	0.0027	0.026		0.0260	0.48	ND	0.4800	42.0		42.0	8.3		8.3	67.4		67.4	148
MW 5 8.5	Shop & Gen Bldg	10/28/2003	1.4000		1.4000	2.7000		2.7000	0.1800		0.1800	1.000		1.0000	32.00		32.0000	2,800.0		2800.0	452.8		452.8	5,619.0		5,619.0	268.3
MW 4 6.5	Shop & Gen Bldg	10/28/2003	0.0100		0.0100	0.0730		0.0730	0.0150		0.0150	0.076		0.0760	0.52	ND	0.5200	7,400.0		7400.0	585.2		585.2	838.7		838.7	104.7
MW 33 8	Shop & Gen Bldg	10/28/2003	0.0200	ND	0.0200	0.0640		0.0640	0.0090	ND	0.0090	0.066		0.0660	6.60		6.6000	840.0		840.0	63.4		63.4	7,113.0		7,113.0	258.94
MW 106 10	Shop & Gen Bldg	10/28/2003	0.0110	ND	0.0110	0.0600		0.0600	0.0360		0.0360	0.270		0.2700	78.00		78.0000	5,400.0		5400.0	623.0		623.0	3,994.0		3,994.0	23.4
MW 104 11.5	Shop & Gen Bldg downgradient	10/27/2003																1.6	ND	1.6							
MW 103 11.5	Shop & Gen Bldg downgradient	10/27/2003																1.7	ND	1.7							
MW 102 11.5	Shop & Gen Bldg downgradient	10/27/2003																1.3	ND	1.3							
MW 101 11.5	Shop & Gen Bldg downgradient	10/28/2003																1.3	ND	1.3							

Table 4B Soil Source Area Characterization, Shop & Generator Building Site, Strawberry Point

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	Benzene			Toluene			Ethylbenzene			Xylenes			Gasoline Range Organics			Diesel Range Organics			DRO Aromatics			DRO Aliphatics			RRO
			Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	Lab Result mg/kg	Lab qualifier	Stat Value mg/kg	
TH 103 9	Shop & Gen Bldg	10/28/2003	0.0047	ND	0.0047	0.0180	ND	0.0180	0.0065	ND	0.0065	0.023	ND	0.0230	22.00		22.0000	5,800.0		5800.0	822.0		822.0	5,934.0		5,934.0	218
TH 102 11	Shop & Gen Bldg	10/28/2003	0.0054	ND	0.0054	0.0240	ND	0.0240	0.0340		0.0340	0.770		0.7700	70.00		70.0000	12,000.0		12000.0	1,201.8		1,201.8	9,432.0		9,432.0	676
TH 101 9.5	Shop & Gen Bldg	10/28/2003	0.0019	ND	0.0019	0.0075		0.0075	0.0014	ND	0.0014	0.020		0.0200	3.10		3.1000	1,800.0		1800.0	154.5		154.5	1,583.0		1,583.0	26.4
SB 13 7	Shop & Gen Bldg	10/28/2003	0.0030	ND	0.0030	0.0094	ND	0.0094	0.0027	ND	0.0027	0.026		0.0260	0.48	ND	0.4800	42.0		42.0	8.3		8.3	67.4		67.4	148
MW 5 8.5	Shop & Gen Bldg	10/28/2003	1.4000		1.4000	2.7000		2.7000	0.1800		0.1800	1.000		1.0000	32.00		32.0000	2,800.0		2800.0	452.8		452.8	5,619.0		5,619.0	268.3
MW 4 6.5	Shop & Gen Bldg	10/28/2003	0.0100		0.0100	0.0730		0.0730	0.0150		0.0150	0.076		0.0760	0.52	ND	0.5200	7,400.0		7400.0	585.2		585.2	838.7		838.7	104.7
MW 33 8	Shop & Gen Bldg	10/28/2003	0.0200	ND	0.0200	0.0640		0.0640	0.0090	ND	0.0090	0.066		0.0660	6.60		6.6000	840.0		840.0	63.4		63.4	7,113.0		7,113.0	258.94
MW 106 10	Shop & Gen Bldg	10/28/2003	0.0110	ND	0.0110	0.0600		0.0600	0.0360		0.0360	0.270		0.2700	78.00		78.0000	5,400.0		5400.0	623.0		623.0	3,994.0		3,994.0	23.4
MW-5 6.5	Shop & Gen Bldg	6/2/2000																2,200.0		2200.0	26.0		26.0	760.0		760.0	
SB-8 6	Shop & Gen Bldg	6/2/2000																9,200.0		9200.0	170.0		170.0	2,500.0		2,500.0	
SB-13 6.5	Shop & Gen Bldg	6/2/2000																390.0		390.0	26.0		26.0	140.0		140.0	
SB-57 8	Shop & Gen Bldg	6/2/2000																17,000.0		17000.0	1,300.0		1,300.0	18,000.0		18,000.0	
SB-57 10	Shop & Gen Bldg	6/2/2000																1,000.0		1000.0	1,000.0		1,000.0	7,600.0		7,600.0	
TH-11/ SW-12 6	Shop & Gen Bldg	6/2/2000																3,800.0		3800.0	300.0		300.0	2,700.0		2,700.0	
TH-16/ SW-16 10	Shop & Gen Bldg	6/2/2000																9,000.0		9000.0	480.0		480.0	4,300.0		4,300.0	
SW31 NW 9.5	Shop & Gen Bldg	6/2/2000																10,000.0		10000.0	560.0		560.0	7,900.0		7,900.0	
Test results below the method reporting limit were provided in the electronic data deliverables--therefore these data were reported along with their "ND" qualifier. Test results below the method detection limit were listed as "0" in the electronic deliverables. When "0" values were listed in the electronic deliverable a		average	0.1820			0.3695			0.0356			0.2814			26.6			5,542.0			486			4,905			215
		std. dev.	0.4922			0.9420			0.0599			0.3862			31.4			4,878.5			421.2			4,599.6			209.2
		count	8			8			8			8			8			16.0			16			16			8
		std. dev. of mean	0.1740			0.3331			0.0212			0.1365			11.1			1,219.6			105.3			1,149.9			73.9
		95%UCL	0.5300			1.0356			0.0779			0.5545			48.8			7,981.3			696.4			7,204.9			363.4
		maximum	1.4000			2.7000			0.1800			1.0000			78.0			17,000.0			1,300.0			18,000.0			676.0

Table 4C Soil Source Area Benzene Characterization, Shop & Generator Building Site, Strawberry Point

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	Benzene		
			Lab Result mg/kg	Lab qualifier	Stat Value mg/kg
TH 103 9	Shop & Gen Bldg	10/28/2003	0.0047	ND	0.0047
TH 102 11	Shop & Gen Bldg	10/28/2003	0.0054	ND	0.0054
TH 101 9.5	Shop & Gen Bldg	10/28/2003	0.0019	ND	0.0019
SB 13 7	Shop & Gen Bldg	10/28/2003	0.0030	ND	0.0030
MW 5 8.5	Shop & Gen Bldg	10/28/2003	1.4000		1.4000
MW 4 6.5	Shop & Gen Bldg	10/28/2003	0.0100		0.0100
MW 33 8	Shop & Gen Bldg	10/28/2003	0.0200	ND	0.0200
MW 106 10	Shop & Gen Bldg	10/28/2003	0.0110	ND	0.0110
SB-13 6.5	Shop & Gen Bldg	6/2/2000	0.1300	ND	0.0650
SB-57 8	Shop & Gen Bldg	6/2/2000	0.1200	ND	0.0600
TH-11/ SW-12 6	Shop & Gen Bldg	6/2/2000	0.1400	ND	0.0700
TH-16/ SW-16 10	Shop & Gen Bldg	6/2/2000	0.1000	ND	0.0500
SW31 NW 9.5	Shop & Gen Bldg	6/2/2000	0.1100	ND	0.0550
MW5 8.5'	Shop & Gen Bldg	11/14/1998	0.1100	ND	0.0550
SB8 5.5'	Shop & Gen Bldg	11/14/1998	0.1100	ND	0.0550
SB 57 10'	Shop & Gen Bldg	11/14/1998	0.0960	ND	0.0480
SW 9A 6.5'	Shop & Gen Bldg	11/14/1998	0.1100	ND	0.0550
SW 12A 16'	Shop & Gen Bldg	11/14/1998	0.1000	ND	0.0500
SW 16 10'	Shop & Gen Bldg	11/14/1998	0.0910	ND	0.0455
SW 31 9.5'	Shop & Gen Bldg	11/14/1998	0.0940	ND	0.0470
MW-33 8.5'	Shop & Gen Bldg	11/14/1998	0.0980	ND	0.0490
Test results below the method reporting limit were provided in the electronic data deliverables--therefore these data were reported along with their "ND" qualifier. Test results below the method detection limit were listed as "0" in the electronic deliverables. When "0" values were listed in the electronic deliverable a		average			0.1029
		std. dev.			0.2981
		count			21
		std. dev. of mean			0.0650
		95%UCL			0.2330
		maximum			1.4000

Table 4D Summary of 95% UCL Values from "ProUCL" Program

UCL Method	Benzene	Benzene B (without 1.4 mg/kg value)	Toluene	Ethylbenzene	Xylenes	Gasoline Range Organics	Diesel Range Organics
Student"s T	0.214117	0.046537	0.998199	0.074914	0.539391	47.58061	**7680.072**
Approx Gamma	0.195735	0.057565	1.861401	0.123371	**0.898029**	96.10766	9531.044
Adjusted Gamma	0.206249	0.059681	2.971191	**0.177896**	1.250878	**138.9553**	10162.47
H Lognormal UCL	0.402463	0.172429	43.94947	3.483832	11.70135	56789.19	41335.71
99% Chebyshev (MVUE)	0.492631	0.2556	**1.37489**	0.257201	1.950612	408.2403	45513.06
Standard Bootstrap	0.206974	0.045832	0.882142	0.067063	0.490809	43.59882	7469.531
Hall's Bootstrap	0.893528	0.045317	8.749428	0.191546	1.612772	64.78736	8055.49
Percentile Bootstrap	0.231062	0.045635	1.031175	0.073619	0.498688	44.525	7564.375
BCA Bootstrap	0.299433	0.045185	1.361025	0.095638	0.552188	46.9125	7763.75
99% Chebyshev	**0.749801**	**0.09245**	3.684991	0.247381	1.642523	137.104	17677.16

ProUCL reccommendation in bold

Figures

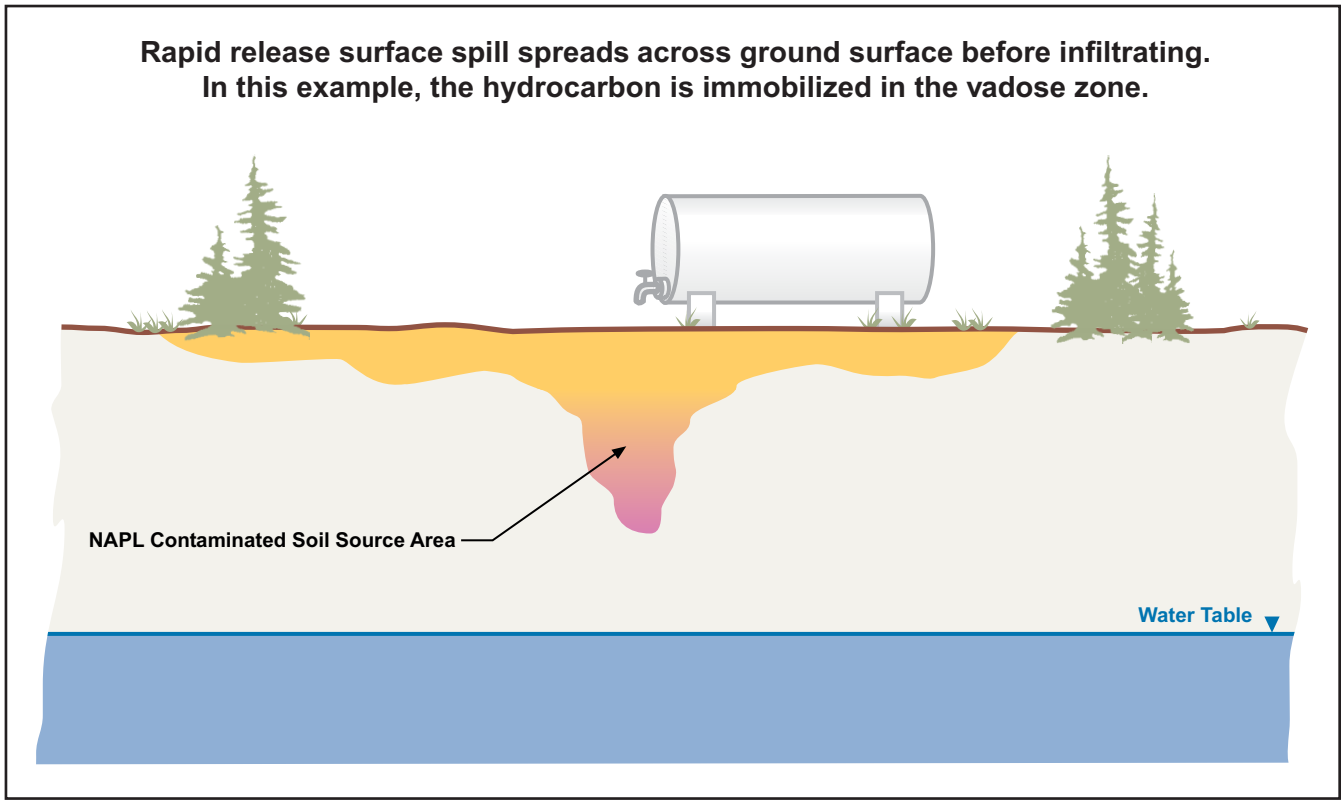

Figure 1. **Vadose Zone NAPL Source Area from Surface Spill**

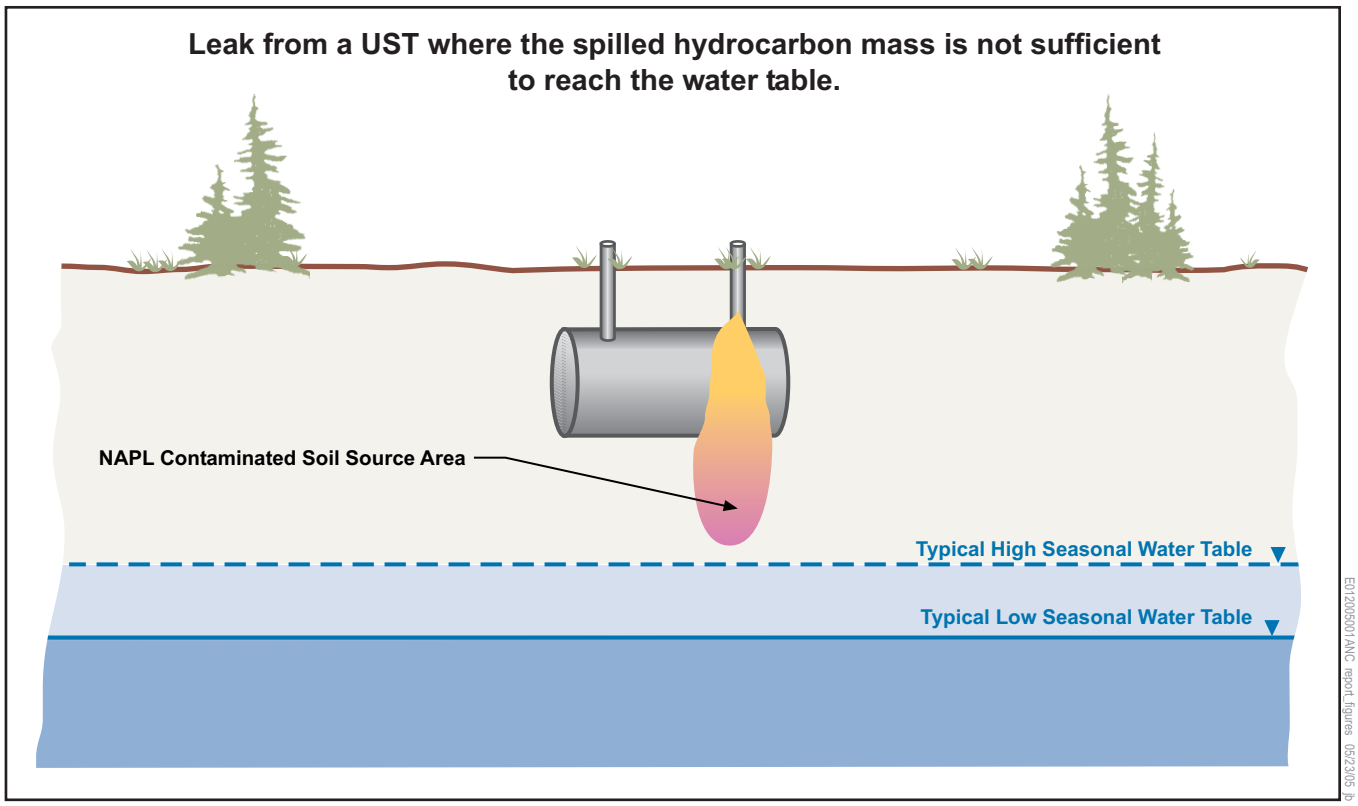

Figure 2. **Vadose Zone NAPL Source Area from Subsurface Release**

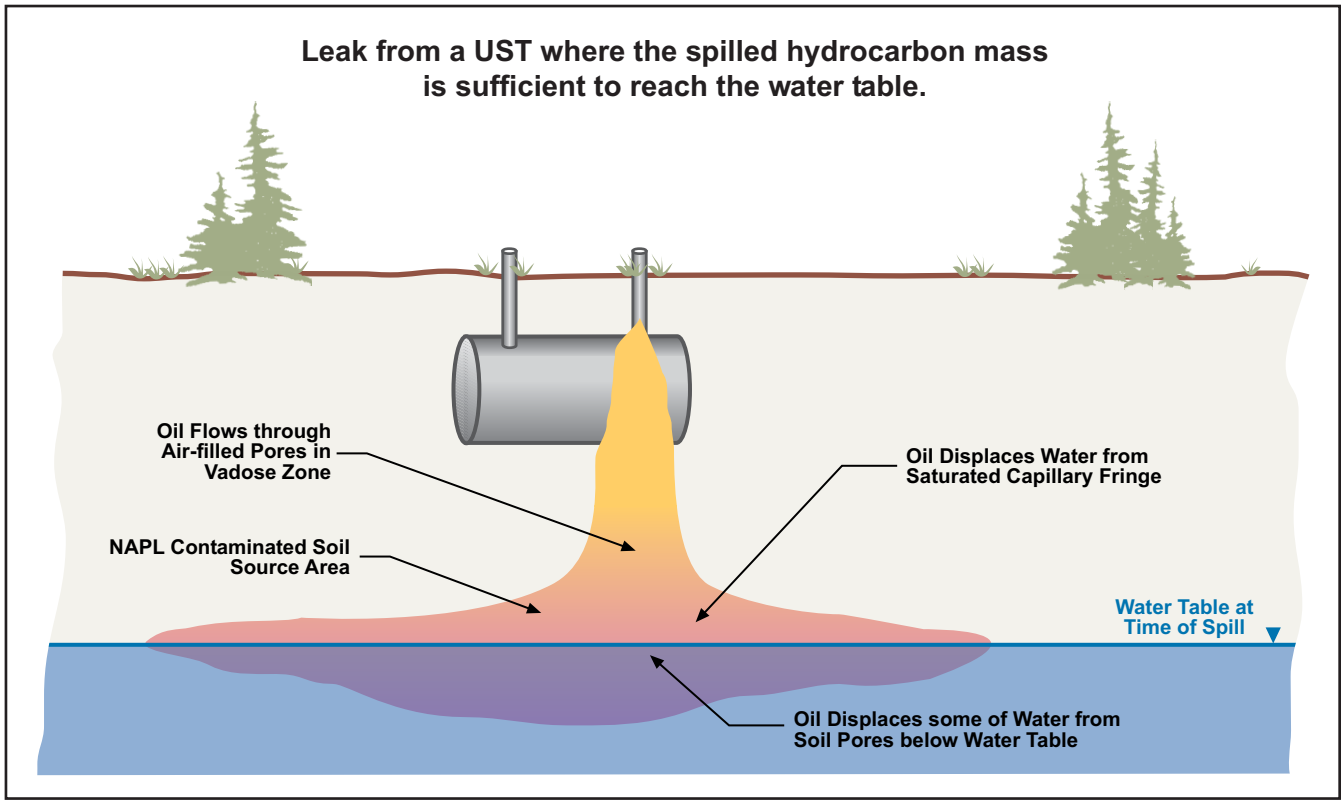

Figure 3. **Saturated Zone NAPL Source Area from Subsurface Release**

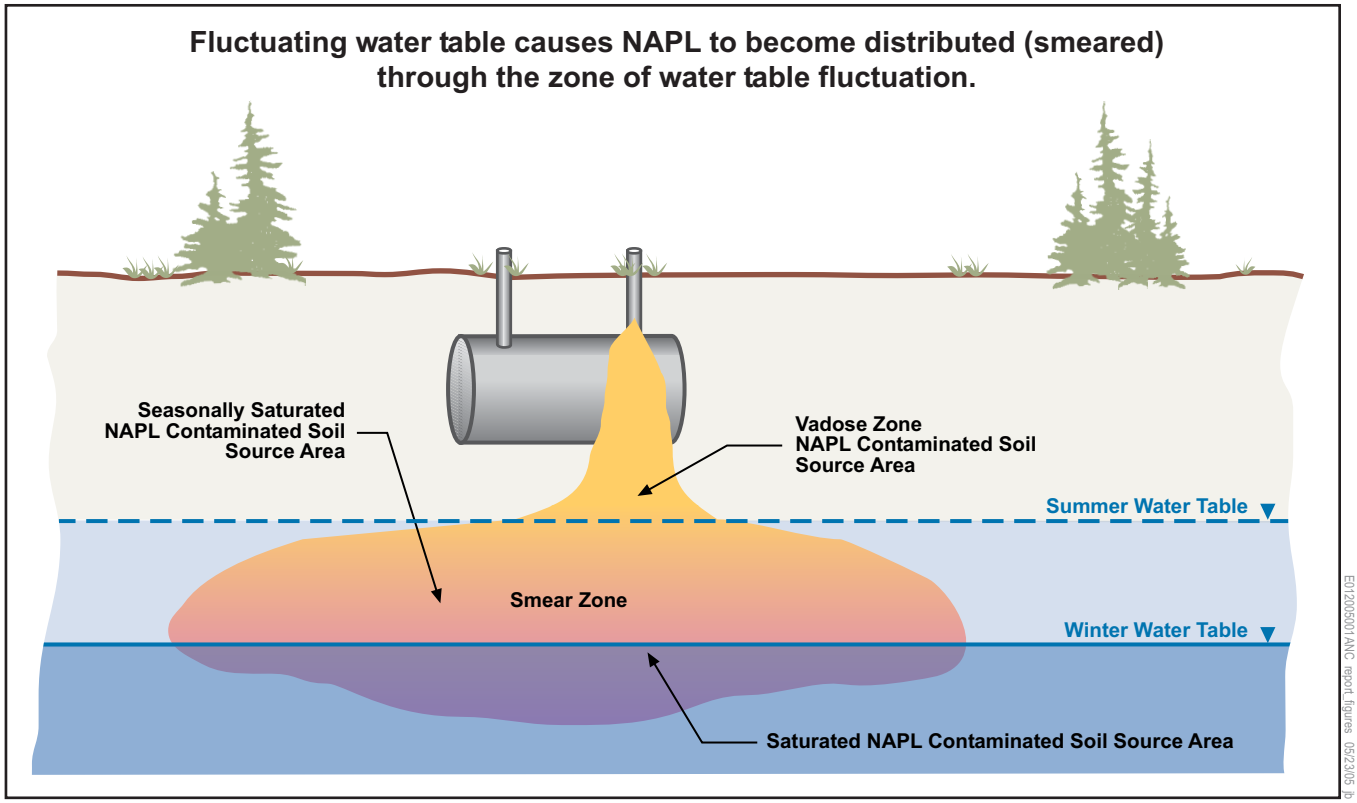

Figure 4. **Saturated Zone NAPL Source Area Subject to Seasonal Groundwater Fluctuation**

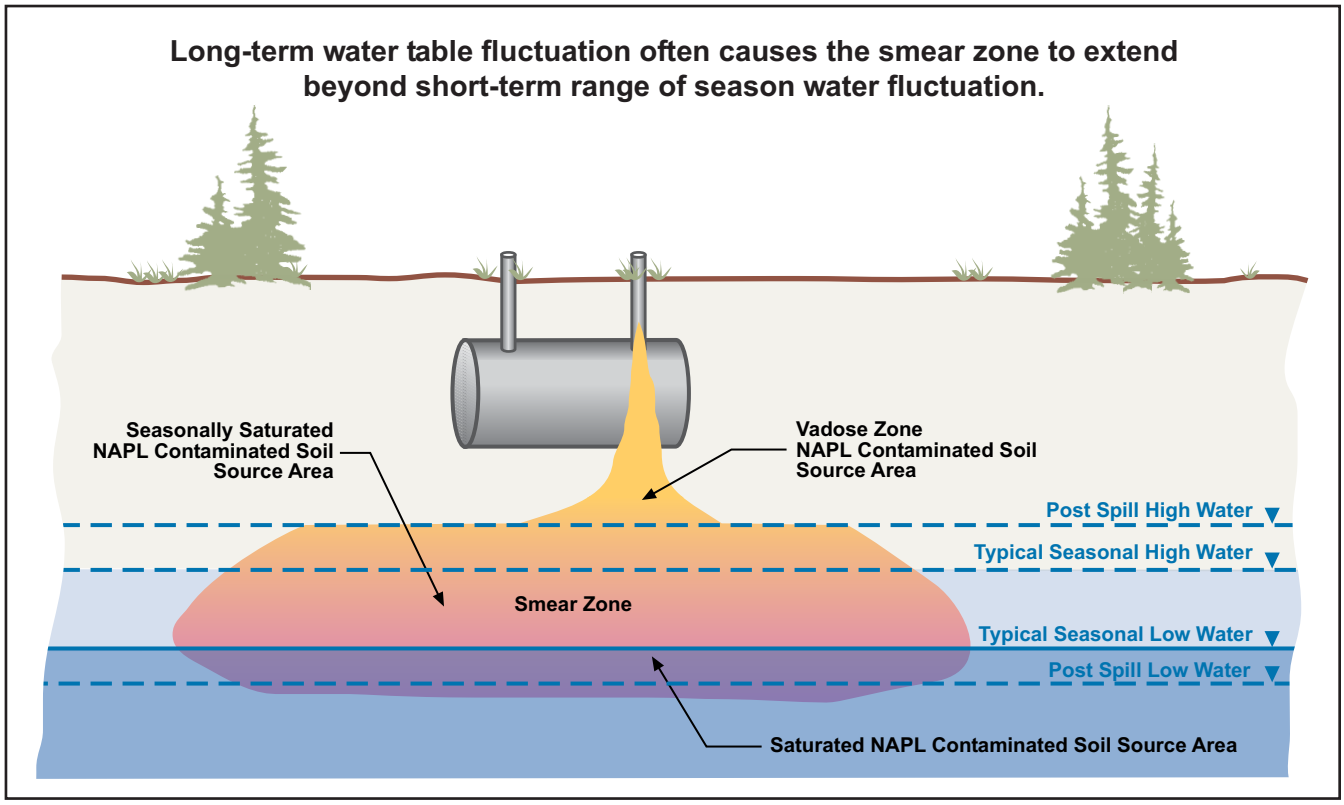

Figure 5. **Saturated Zone NAPL Source Area Subject to Long-Term Groundwater Fluctuation**

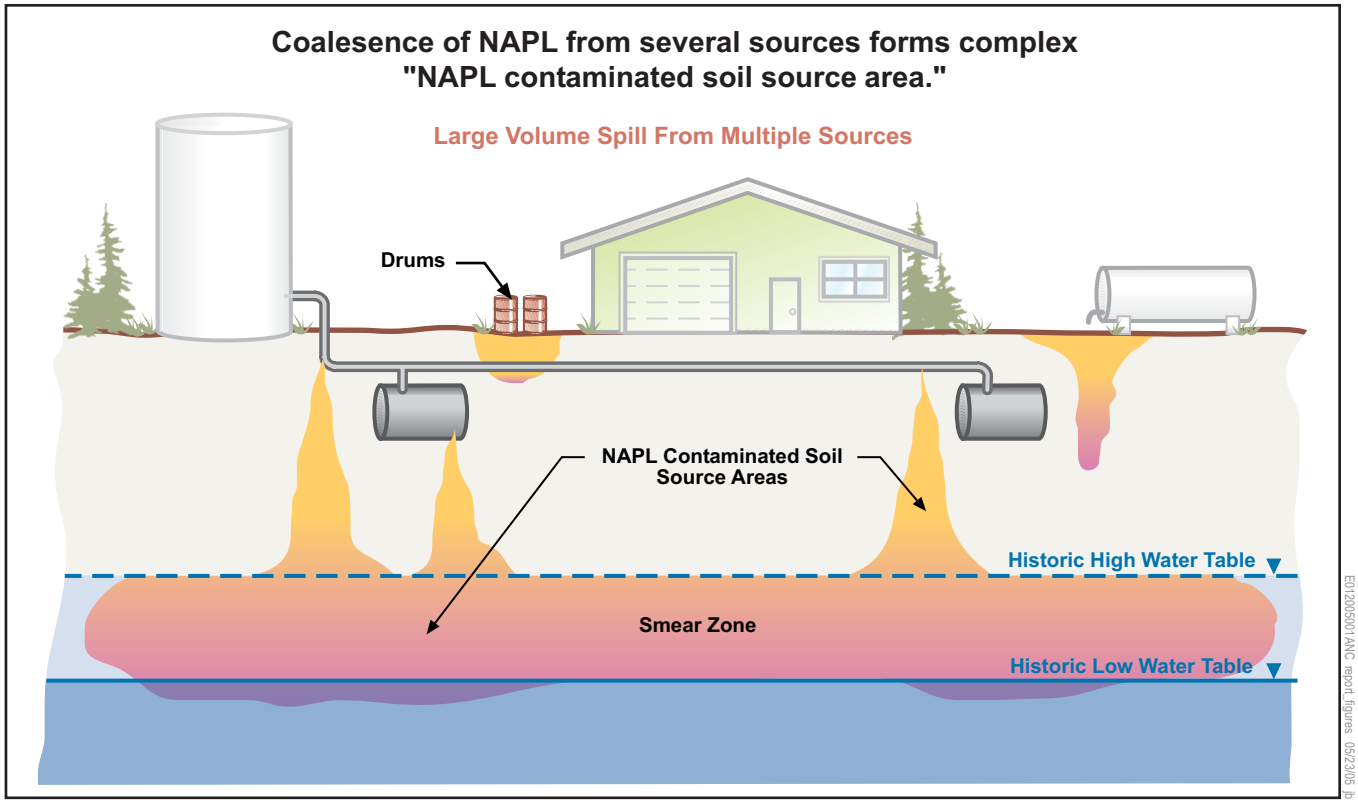

Figure 6. **Complex NAPL Source Area Resulting From Multiple Releases**

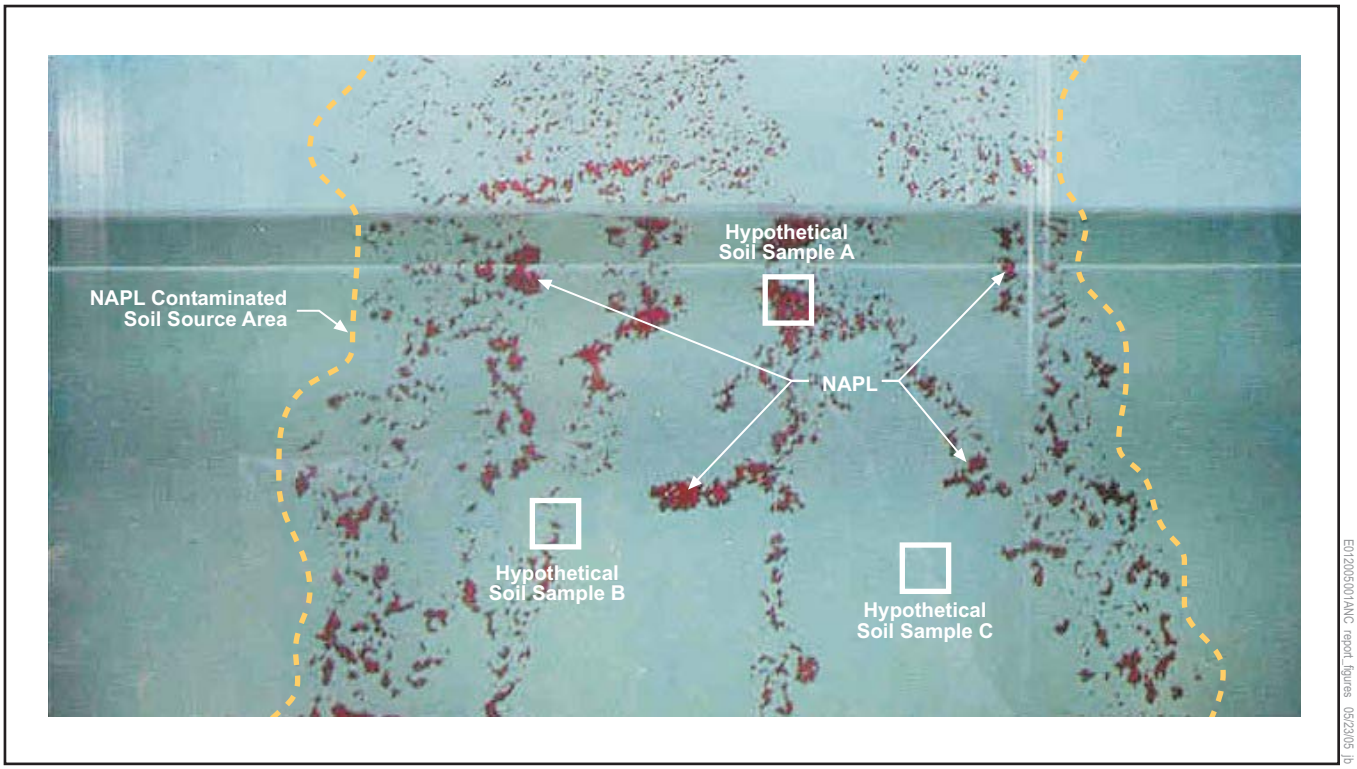

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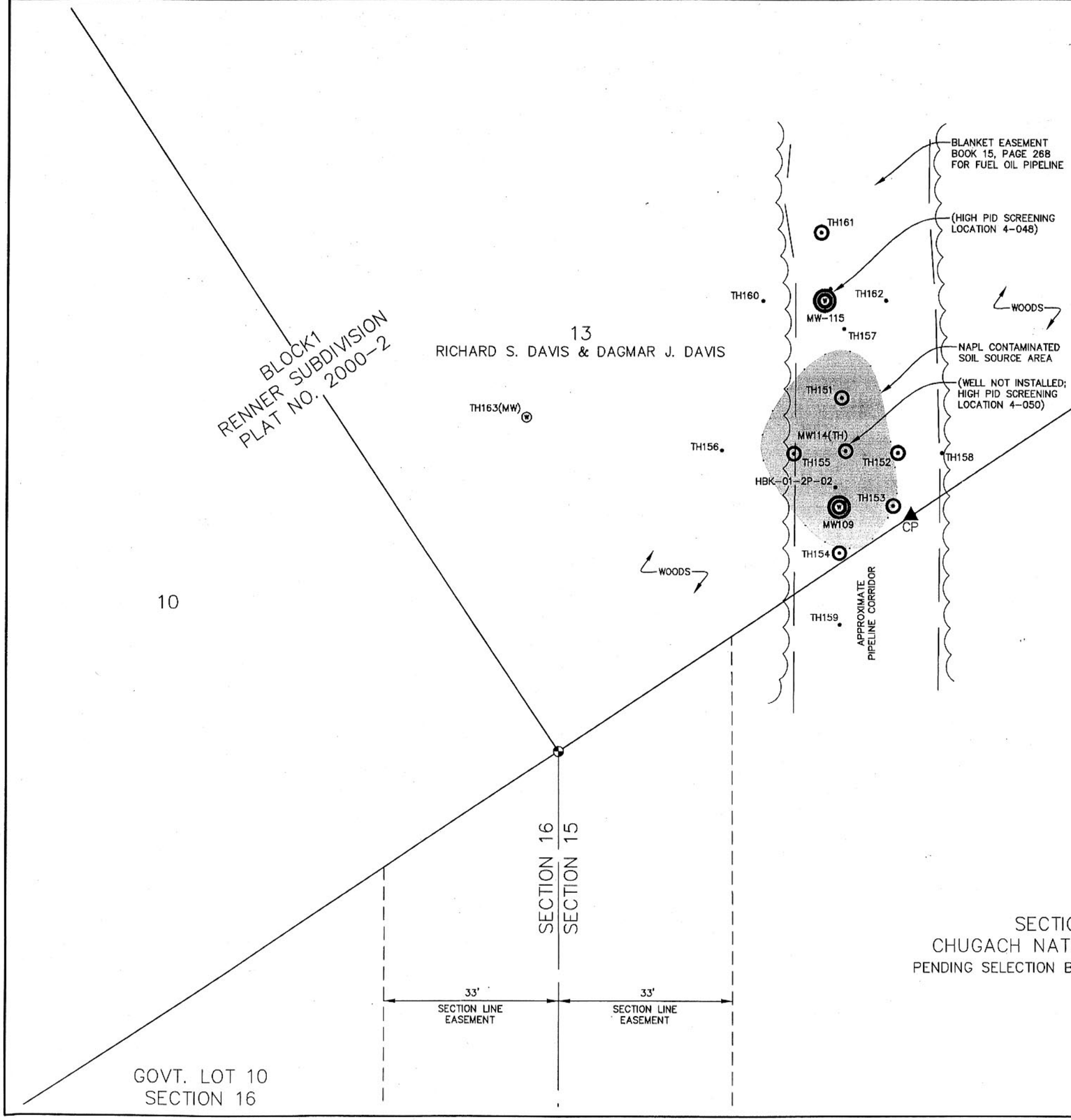
Figure 7. **Sand Tank Example of NAPL Contaminated Soil Source Area**



GRAPHIC SCALE

20 0 10 20

(IN FEET)

1 inch = 20 ft.

Renner Subdivision Lot 13 Soil Screening Data and Soil DRO & GRO Results

Test Hole Number & Depth (ft. bgs)	Location	Date Collected:	PID Reading	GRO		DRO	
			ppm	Lab Result mg/kg	Lab qualifier	Lab Result mg/kg	Lab qualifier
HBK01-2P-02	Renner	8/28/2001				2,520	
High PID screening location 4-048	Renner	pre 2003	63				
High PID screening location 4-050	Renner	pre 2003	281				
MW109 4.5	Renner	10/31/2003		12.00		2,100.0	
MW109 5	Renner	10/31/2003	190				
MW109 6	Renner	10/31/2003	54.7	12.00		1,900.0	
MW114 4.5 (TH)	Renner	10/31/2003		0.40	ND	250.0	
MW114 5 (TH)	Renner	10/31/2003	24.1				
MW114 6 (TH)	Renner	10/31/2003	43.5	0.99	ND	690.0	
TH151 5	Renner	10/31/2003	132/315				
TH151 6.5	Renner	10/31/2003		52.00		5,000.0	
TH151 7	Renner	10/31/2003	151				
TH152 5	Renner	10/31/2003	8.6				
TH152 6	Renner	10/31/2003		0.37	ND	4.2	ND
TH152 7	Renner	10/31/2003	4.6				
TH153 5	Renner	10/31/2003	68.9/108				
TH153 6	Renner	10/31/2003		0.91	ND	28.0	
TH153 7	Renner	10/31/2003	23.4				
TH154 5	Renner	10/31/2003	10.3/12.7				
TH154 6	Renner	10/31/2003		0.24	ND	13.0	
TH154 6.5	Renner	10/31/2003	11.3				
TH155 5	Renner	10/31/2003	200/296				
TH155 6.5	Renner	10/31/2003	79.2	6.40		1,100.0	
TH156 6.5	Renner	11/4/2003	0				
TH157 6.5	Renner	11/4/2003	0				
TH158 6.5	Renner	11/4/2003	0				
TH159 6.5	Renner	11/4/2003	0				
TH160 7	Renner	11/4/2003	0				
TH161 7	Renner	11/4/2003	0	0.59	ND	1.7	ND
TH162 7	Renner	11/4/2003	0				
MW115 7	Renner	11/4/2003	0	0.17	ND	1.9	ND
TH163 (MW)	Renner	11/4/2003	0				

Numerous other PID readings from the area (collected during pipeline decommisioning) had low or 0 ppm readings.

SECTION 15
CHUGACH NATIONAL FOREST
PENDING SELECTION BY STATE OF ALASKA

LOCATED WITHIN T17S, R5W, C.R.M.
CORDOVA RECORDING DISTRICT

FAA SITE STRAWBERRY POINT HINCHINBROOK ISLAND, ALASKA

Figure 8 Davis Property Monitoring Well and Sampling Locations & NAPL Source Area

GRAPHIC SCALE

40 0 20 40

(IN FEET)

1 inch = 40 ft.

GOVT. LOT 10
SECTION 16
THE EYAK CORPORATION IC 1772
CHUGACH ALASKA CORPORATION IC 1773

SECTION 15
CHUGACH NATIONAL FOREST
PENDING SELECTION BY STATE OF ALASKA,
THE EYAK CORPORATION, AND CHUGACH ALASKA
CORPORATION PER BLM MASTER TITLE PLAT

WOODS
POL STORAGE BUILDING
SEPTIC
FUEL TANKS
NAPL CONTAMINATED SOIL SOURCE AREA
REMEDIATION CONNEX
DUMP SITE
MW-207
MW-1
MW-4
MW-62
MW-5
MW-6
MW-2
MW-3
MW-19
MW-66
MW-33
MW-101
MW-103
MW-104
MW-105
MW-106
MW102
GRASS
DIRT ROAD
W/3
PUMP HOUSE
SECTION 16
SECTION 15
33' SECTION LINE EASEMENT
33' SECTION LINE EASEMENT

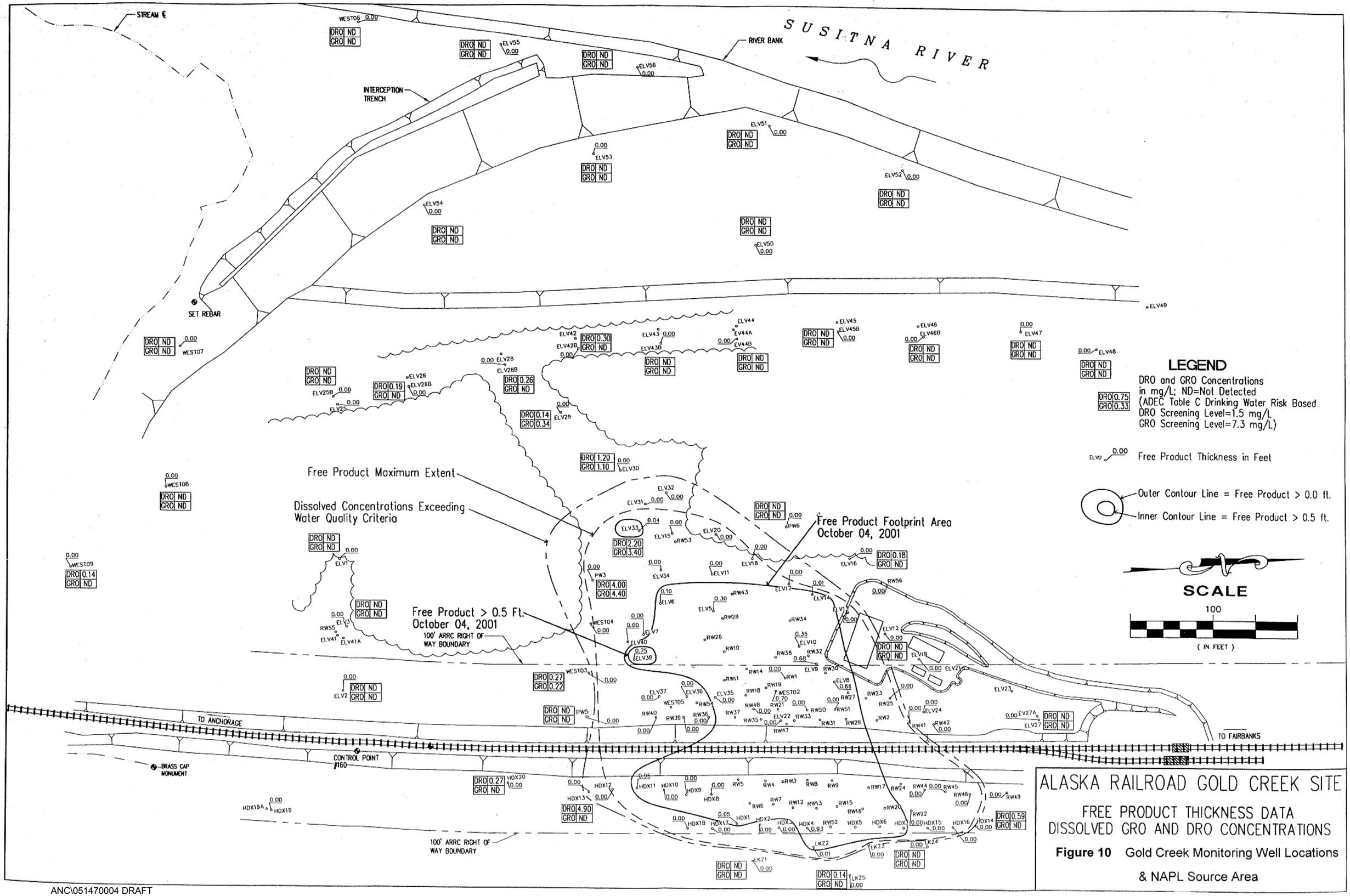
LEGEND

- Existing Groundwater Monitoring Well
- SB, TH Previous Soil Boring or Test Hole
- SW Previous Air Sparging Well
- HBK, BES Soil Grab Sample Location
- 3 inch diam. PVC Septic Vent
- 42 inch diam. Vert. CMP Fuel Valve Box
- 60 inch diam. Vert CMP above Septic Tank
- Aluminum Cap Monument
- Survey Control Monument
- E Underground Electric
- RF Underground RF Cable
- F Underground Fuel Line
- W Underground Water
- C Underground Communication Line
- Bollard Guard Post
- Soil Sampling Location (2003)
- Water Sampling Location (2003)

LOCATED WITHIN T17S, R5W, C.R.M.
CORDOVA RECORDING DISTRICT

FAA SITE STRAWBERRY POINT
HINCHINBROOK ISLAND, ALASKA

Figure 9 Shop & Generator Building Monitoring Well and Sampling Locations & NAPL Source Area



ALASKA RAILROAD GOLD CREEK SITE

FREE PRODUCT THICKNESS DATA DISSOLVED GRO AND DRO CONCENTRATIONS

Figure 10 Gold Creek Monitoring Well Locations & NAPL Source Area

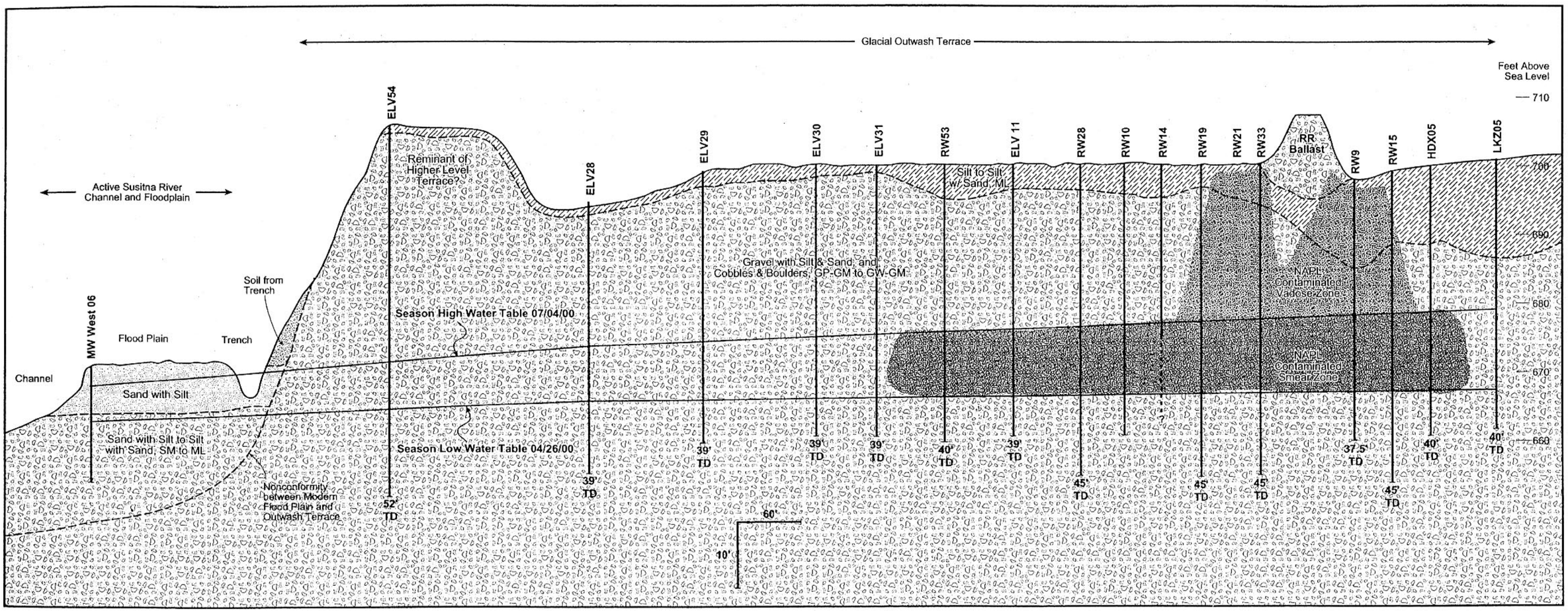


Figure 11 Gold Creek Cross-Section Showing the NAPL Source Area and Seasonal Groundwater Fluctuation

Figure 12 Groundwater Contours 6-23-01, ARRC Gold Creek Site