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**DEPARTMENT OF THE ARMY**
**U.S. ARMY WHITE SANDS MISSILE RANGE**
**100 Headquarters Avenue**
**WHITE SANDS MISSILE RANGE, NEW MEXICO 88002-5000**

REPLY TO
ATTENTION OF

May 4, 2001

Environment and Safety Directorate

Ms. Cheryl Frischkorn
Hazardous Waste Bureau
New Mexico Environment Department
2044 A Galisteo
P.O. Box 26110
Santa Fe, New Mexico 87502

**Subject: Submittal of High Energy Laser System Test Facility (HELSTF) Groundwater Study and Conceptual Site Model**

Dear Ms. Frischkorn:

White Sands Missile Range is pleased to announce the completion of the data visualization/conceptual site model for the HELSTF facility. Two hard copies and one electronic copy of the final *High Energy Laser System Test Facility Groundwater Study and Conceptual Modeling* report dated March 2001 are enclosed for your information and review.

This study considered all solid waste management units at HELSTF as a single corrective action unit. A Corrective Measures Study is currently being completed.

We look forward to the opportunity to demonstrate the data visualization/conceptual site model when you visit in June 2001. Please contact Ms. Robin Paul of our staff at (505) 678-2224 if you have any questions.

Sincerely,

Thomas A. Ladd

Thomas A. Ladd
Director, Environment and Safety
Directorate

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This document details the groundwater study and conceptual modeling done at the HELSTF. The report contains visualization of complied subsurface environmental data and selected contaminants for all SWMUs at HELSTF. This study considered all SWMUs at HELSTF as one corrective action unit for the purpose of remediation.

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# HIGH ENERGY LASER SYSTEMS TEST FACILITY (HELSTF) GROUNDWATER STUDY AND CONCEPTUAL MODELING

**Submitted to:**

**U.S. Army**
**White Sands Missile Range**
**Environment and Safety Directorate**
**White Sands Missile Range, New Mexico 88002-5048**

**March 2001**

**Submitted by:**

**MEVATEC Corporation**
**Building 126**
**White Sands Missile Range, New Mexico 88002**

## EXECUTIVE SUMMARY

The High Energy Laser Systems Test Facility (HELSTF) covers approximately 15 acres, and has 21 Solid Waste Management Units (SWMU) currently defined. White Sands Missile Range has been performing SWMU-specific environmental investigations at HELSTF over the past 12 years. These studies have resulted in copious analytical and geophysical data that were spatially and temporally disjointed, and were not presented in the context of HELSTF as a single, interrelated site. The New Mexico Environment Department has requested that White Sands evaluate HELSTF as a single corrective action unit. A HELSTF Conceptual Site Model (CSM) was therefore developed to review and compile the best available subsurface environmental information and to visually present it.

Analytical and geophysical data sets selected for the CSM development satisfied stringent data quality criteria. Of the 48 investigative reports initially screened, only 22 were identified as having sufficient quality data for further evaluation. Following detailed evaluation of these reports, the database was populated with analytical data from five reports and geophysical data from thirteen reports. The selection and compilation of data allowed for conceptual modeling and visualization of the SWMUs as a single unit.

The CSM identifies three separate groundwater systems beneath HELSTF: an upper-perched water-bearing zone, a lower perched water-bearing zone, and the regional aquifer. Groundwater quality in the three systems is characterized as total dissolved solids averaging over the State's requirement for protected waters of 10,000 mg/L in each water-bearing zone.

Operations at HELSTF have resulted in release of contaminants that have impacted each water-bearing zone. Hexavalent chromium from laser cooling system corrosion inhibitors has been detected in all saturated zones. Dissolved phase hydrocarbons (indicated by benzene) due to the presence of the free-phase diesel pool acting as a continual source are limited to the lower perched water-bearing zone. Trichloroethylenes have been detected in the perched lower and regional groundwater. Concentrations of these contaminants have not significantly increased or decreased through time, although minor plume spreading has occurred in limited areas.

Source containment and further study at HELSTF is required in order to move site SWMUs towards the goal of closure or no further action. Source containment may consist of surface treatment, continued operation of a vacuum enhanced diesel recovery system that is currently in operation, and abandonment of two wells to prevent any migration pathways between the lower perched water-bearing zone and the regional aquifer. With respect to contaminant remediation at HELSTF, the SWMUs are well suited for the remedial approach of monitored natural attenuation. To support no further action or monitored natural attenuation, a more detailed risk assessment will be conducted to further evaluate potential exposures from soil contamination. A corrective measures study will further quantify potential risks and identify available technologies for remediation and/or removal activities.

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APPENDIX C Initial Visualization Meeting Presentation

# LIST OF ACRONYMS

| | |
|---|---|
| AA | Administrative Authority |
| CAMU | Corrective Action Management Unit |
| $Cr^{+6}$ | Hexavalent Chromium |
| CSM | Conceptual Site Model |
| CMS | Corrective Measures Study |
| DQO | Data Quality Objectives |
| DRO | Diesel Range Organic's |
| EPA | Environmental Protection Agency |
| GIS | Geographical Information System |
| GPS | Global Positioning System |
| GRO | Gasoline Range Organic's |
| HELSTF | High Energy Laser Systems Test Facility |
| HMW | HELSTF Monitoring Well |
| HRMB | Hazardous and Radioactive Materials Bureau |
| LNAPL | Light Non-Aqueous Phase Liquid |
| MCL | Maximum Contaminant Level |
| NFA | No Further Action |
| NGVD | National Geodetic Vertical Datum |
| NMA | Monitored Natural Attenuation |
| NMED | New Mexico Environmental Department |
| NMSP | New Mexico State Plan |
| QA/QC | Quality Assurance/Quality Control |
| RCRA | Resource Conservation and Recovery Act |
| RFA | RCRA Facility Assessment |
| RFI | RCRA Facility Investigation |
| SVOC | Semi-Volatile Organic Carbon |
| SWMU | Solid Waste Management Units |
| TCE | Trichloroethylene |
| TDS | Total Dissolved Solids |
| THEL | Theatre High Energy Laser |
| TPH | Total Petroleum Hydrocarbons |
| UTM | Universal Transverse Mercator |
| VEDRS | Vapor Enhanced Diesel Recovery System |
| VCA | Voluntary Corrective Action |
| VOC | Volatile Organic Carbon |
| WSMR | White Sands Missile Range |

# HIGH ENERGY LASER SYSTEMS TEST FACILITY GROUNDWATER STUDY AND CONCEPTUAL MODELING

## 1.0 INTRODUCTION

White Sands Missile Range (WSMR) has been performing environmental investigations at the High Energy Laser Systems Test Facility (HELSTF) over the past 12 years. HELSTF is located 35.4 kilometers (22 miles) northeast of the White Sands Headquarters in Otero County New Mexico, approximately 120.7 kilometers (75 miles) due north of El Paso. The facility is situated approximately 3.2 kilometers (2 miles) northwest of Highway 70 (Figure 1-1). HELSTF covers approximately 6.07 hectares (15 acres), and has 21 Solid Waste Management Units (SWMU) currently defined (Figure 1-2). Several of these SWMUs have been proposed for a Class III Permit Modification to remove them from the RCRA Part B Permit Corrective Action ModuleVIII. These SWMUs are often adjacent or overlapping, and exert influence over the same subsurface environments. Groundwater contaminant plumes at HELSTF are co-mingled, and sometimes found in more than one of the saturated zones present beneath HELSTF.

The Resource Conservation and Recovery Act (RCRA) include regulatory requirements and appropriate investigative actions to evaluate the presence, quantity, and spatial extent of environmental contamination. At the conclusion of the Phase II RCRA Facility Investigation (RFI) (Sverdrup 1994), several recommendations were made for subsequent actions to be taken at individual HELSTF SWMUs. The New Mexico Environment Department (NMED) serves as the Administrative Authority (AA) that enforces RCRA regulations. The NMED Hazardous Waste Bureau (HWB) identified several areas of uncertainty, or conflicting recommendations, in the Phase II RFI. The HWB subsequently requested that White Sands evaluate investigative data for all SWMUs as a single corrective action unit.

Environmental investigation reports for HELSTF include results of surface and subsurface investigative efforts as performed by several distinct entities. These reports are hard copy, and little or no electronic data exists for the site. From the previous reports, no apparent correlation existed between the contaminant plumes observed and the distinct SWMUs, and no conceptual modeling of the entire site had been performed. Therefore, the overall objective of the HELSTF Groundwater Study and Conceptual Site Model (CSM) was to collect the most relevant and reliable investigation data for all of the SWMUs at HELSTF and incorporate the data into an information management and visualization system to facilitate risk screening and closure of the SWMUs.

This report presents the results of conceptual modeling efforts at HELSTF. The following components were completed in developing the HELSTF Groundwater Study and CSM, and are described in this report:

- Data evaluation/selection of data sets appropriate for conceptual modeling;
- Development and population of the data management system (database);
- Development of the geographic information system (GIS) component;
- Production of two- and three-dimensional visualizations of the site to comprise the CSM; and
- Performance of preliminary risk screening.

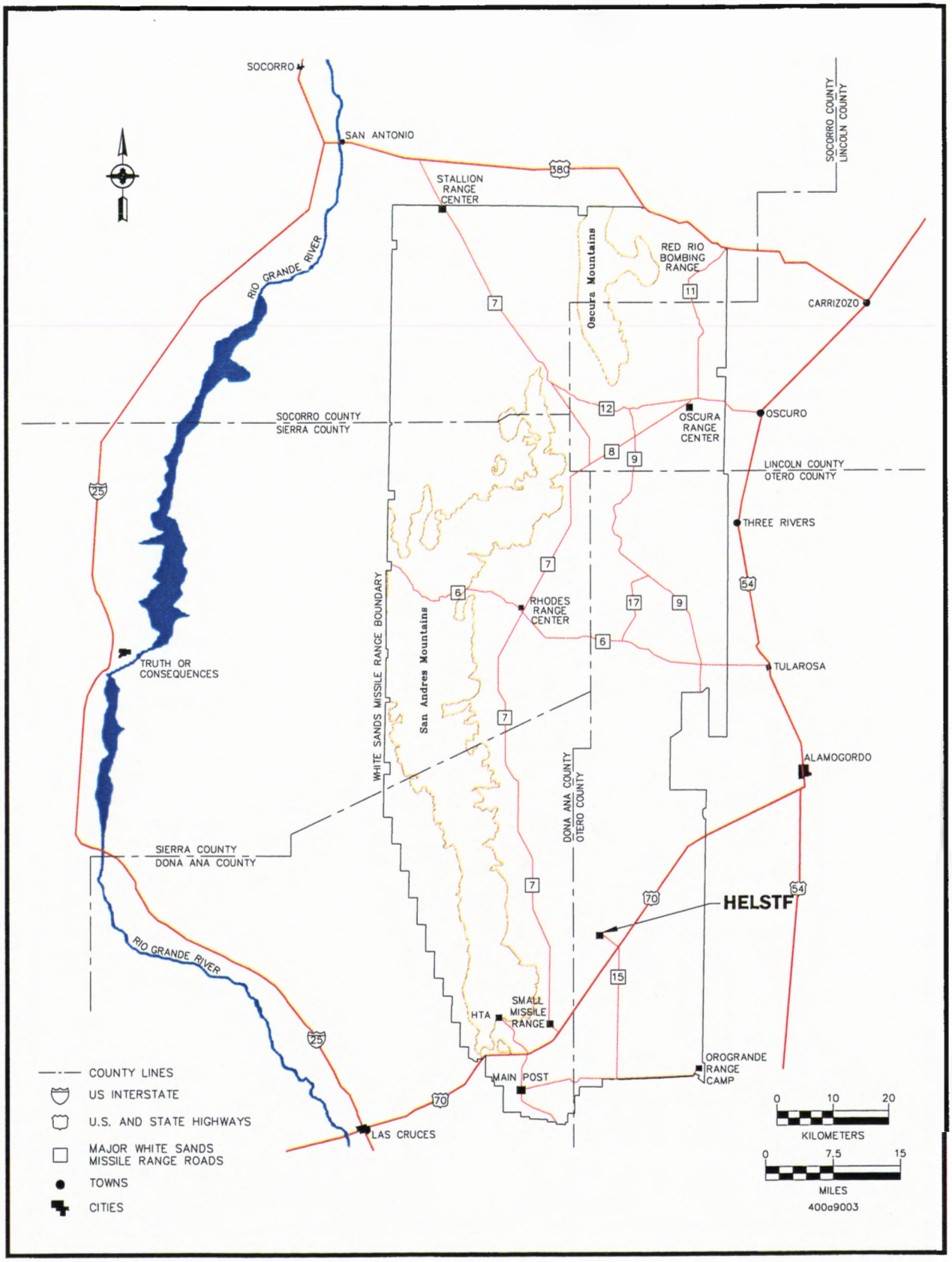



**Figure 1-1. HELSTF Location.**

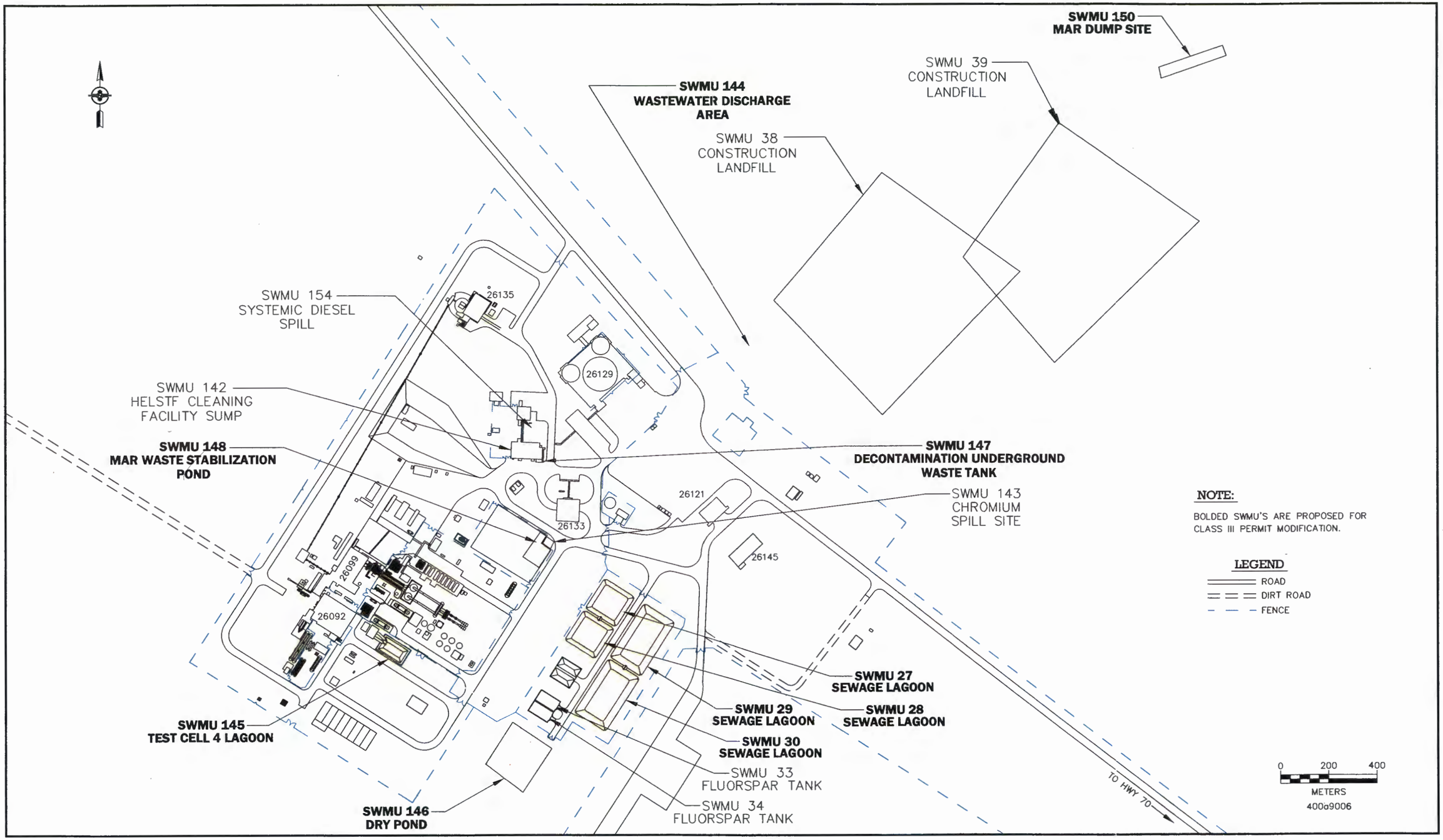



**Figure 1-2. HELSTF Solid Waste Management Units.**

## 2.0 DATA EVALUATION

The accuracy and usefulness of a CSM is proportional to the quality and quantity of data from which it is constructed. As such, the Data Evaluation phase of the HELSTF CSM comprised a very important part of the overall modeling effort. The Data Evaluation phase for this study consisted of the following elements:

- Development of the Data Review Plan;
- Review of data; and
- Evaluation of data.

Each of the elements are described in the following sections.

### 2.1 Data Review Plan

Past RCRA Facility Assessments (RFAs), RFIs, and various characterization studies conducted for areas within HELSTF have resulted in volumes of physical and chemical data that are potentially relevant for this study. The Data Review Plan was developed to provide a systematic approach for evaluating this data through development of data quality objectives (DQOs). The approach was designed to ensure that each data set was reviewed consistently, applying objective metrics wherever possible. Specifically, the Data Review Plan outlined the following four primary objectives:

- Identify the quantity and quality of data available to support construction of the CSM and preliminary risk screening to be used for making closure decisions;
- Prioritize data sets according to DQOs for entry into the database;
- Identify significant data gaps that could affect the CSM; and
- Assess the overall ability of data sets to support site closure decisions.

The data review plan outlines a method by which all reported data could be screened to meet the stated objectives. To facilitate the data review, Report Evaluation Forms were developed. A copy of the Data Review Plan and a blank Report Evaluation Form are provided in Appendix A. These forms, developed with a checkbox-style format, offer a simple and consistent means of gathering detailed information from any report or data-source being reviewed. Upon completion, each data review form summarized general information about the report or data source, which SWMUs were addressed, numbers and types of environmental samples reported, and other information reported, i.e., hydrographic and geologic information. In addition, each of the data elements was ranked on the Report Evaluation Forms according to the level of detail or quality of the data.

The Data Review Plan provides a decision tree (Figure 2-1) that outlines the general approach for determining a "Data-Use Level" for sets of environmental data from the reviewed reports and data sources. Data-Use Levels were classified as Level 1, Level 2, or Level 3. Level 1 data meets the lowest burden of quality, and can be used for building the CSM database and visualization tool. Level 2 data meets higher quality standards than Level 1 data, and can be used for modeling purposes and remedial design. Level 3 data meets stringent QA/QC standards and is therefore suitable for use in a quantitative risk assessment.

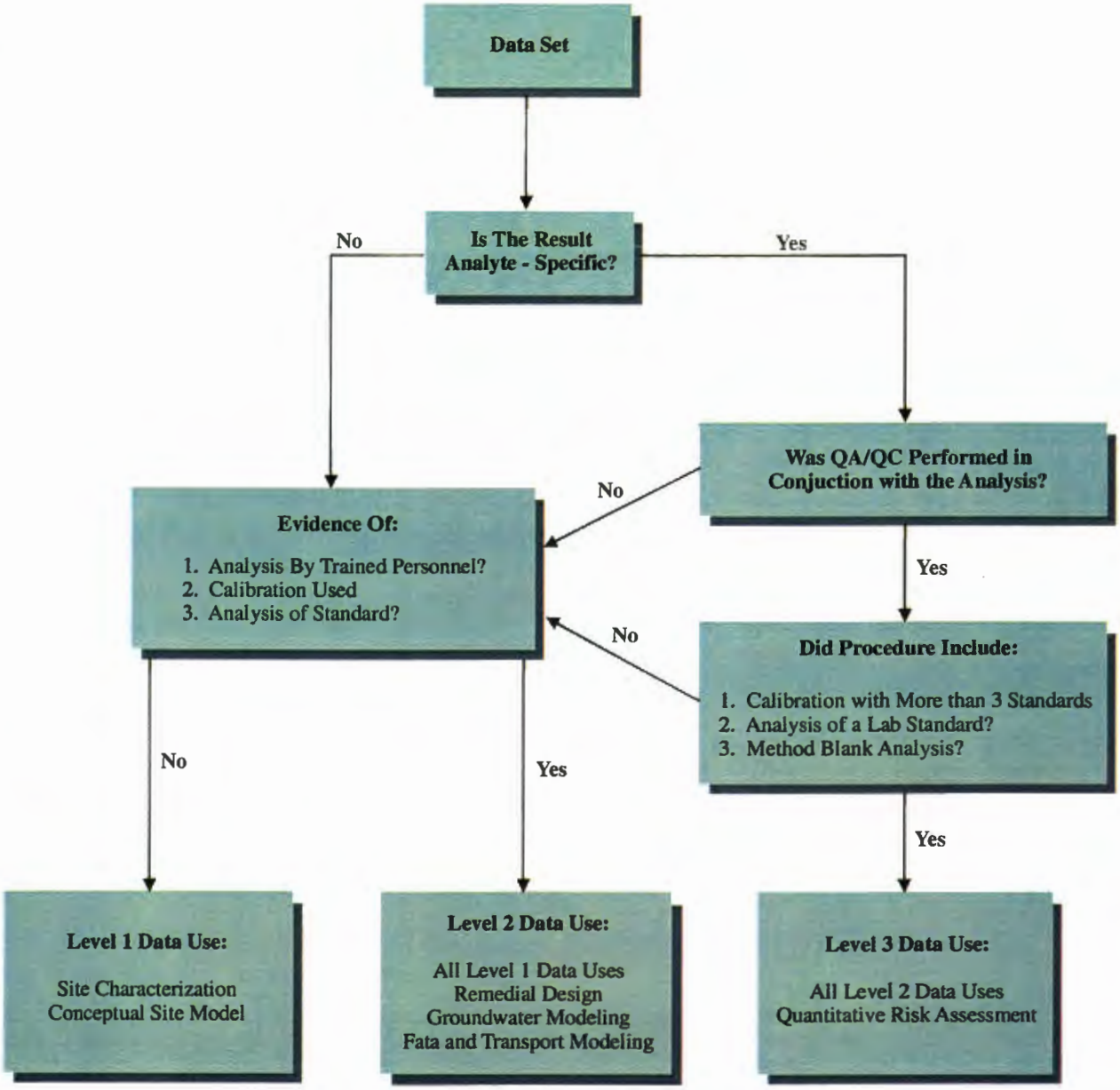



**Figure 2-1. Data Review Plan Decision Tree.**

## 2.2 Data Review

In total, 48 reports or data sources were reviewed and screened for applicability to the CSM. These documents are listed in chronological order in Table 2-1. Of these 48 reports and data sources, 22 passed an initial screening by project team members and were included in a more detailed evaluation in the data review phase. As described in the Data Review Plan, each of the 22 reports was reviewed independently by a chemist and risk assessor for analytical data content, and by the project hydrologist for spatial and geophysical data content. Each report was reviewed for type, quality, and amount of data in a consistent manner following the method outlined in the Data Review Plan.

**Table 2-1.**
**Reports Reviewed for Data Review Phase.**

| Report Name | Date | Author |
|---|---|---|
| RCRA Part B Permit Application for Hazardous Waste Management Facilities, WSMR, NM | Oct-84 | US Army Engineer District |
| RCRA Facility Assessment | Aug-88 | AT Kerney |
| RCRA Part B Permit | Sep-89 | NMED |
| Regulatory Inquiry | Jan-90 | Lockheed Engineering & Sciences Co. |
| RCRA Facility Investigation (RFI) Work | Aug-90 | The Edge Group |
| Draft Statement of Work For APP II & III, Draft Statement of Work For APP IV, Final RFI Workplan for APP iV SWMUs | May-91 | US Army Corp of Engineers |
| Vol II: Field Sampling Plan RCRA Facility Permit Appendix II & III Sites | Aug-91 | The Edge Group |
| Draft RCRA Facility Investigation (RFI) Report Appendix I Sites Volume II | Oct-91 | International Technology Corporation |
| Interim Remedial Measures Work Plan for the Systemic Diesel Spill (SWMU 154) | Dec-91 | Lockheed Engineering & Sciences Co. |
| Draft Final RCRA Facility Investigation (RFI) Report Appendix I Sites Vol. I | Dec-91 | International Technology Corporation |
| Final RCRA Facility Investigations (RFI) | Mar-92 | International Technology Corporation |
| RCRA Facility Investigation (RFI) Appendices Appendix II,III, and IV Sites Vol. 2 | Aug-92 | International Technology Corporation |
| Groundwater Sampling and Analysis Plan for the High Energy Laser System Test Facility, WSMR, NM | Nov-92 | Lockheed Engineering & Sciences Company<br>Lockheed Environmental Office, HELSTF |
| Final RCRA Facility Investigation (RFI) Report Appendix II, III, & IV Sites | Dec-92 | International Technology Corporation |
| Final HELSTF Groundwater Assessment | Dec-92 | International Technology Corporation |
| Draft Phase II Addendum to the RCRA Facility Investigations Work Plans- Appendix I, II, III, IV sites | Mar-93 | Sverdrup Environmental, Inc. |
| Effluent Tracking Experiment | Mar-93 | HELSTF, WSMR, NM |
| Soils Analytical Data | Jun-93 | International Technology Corporation |
| SWMU'S For WSMR | Oct-93 | Sverdrup Environmental, Inc. |
| The HELSTF Cleaning Facility RCRA Well Installation Data Report | Nov-93 | Advanced Sciences Incorporated |
| Groundwater Sampling and Analysis Plan for the HELSTF Cleaning Facility | Nov-93 | Advanced Sciences, Inc. |
| Phase II RCRA Facility Investigation Work Plans for HELSTF | Nov-93 | Advanced Sciences, Inc. |
| Systemic Diesel Spill, SWMU 154 HELSTF Cleaning Facility Volume I Final Interim Report | Dec-93 | International Technology Corporation |
| Systemic Diesel Spill, SWMU 154 HELSTF Cleaning Facility Volume II Final Interim Report | Dec-93 | International Technology Corporation |
| Systemic Diesel Spill, SWMU 154 HELSTF Cleaning Facility Volume III Final Interim Report | Dec-93 | International Technology Corporation |
| HELSTF Interim Remediation Measures Phase One Report for the Systemic Diesel Spill (SWMU 154) | Jul-94 | Advanced Sciences Incorporated |
| Site Specific Health And Safety Plan Interim Remediation Measures HELSTF Diesel Spill Draft | Jul-94 | Advanced Sciences, Inc. |

**Table 2-1. (*concluded*)**
**Reports Reviewed for Data Review Phase**

| Report Name | Date | Author |
|---|---|---|
| Phase II RCRA Facility Investigation Appendix I, II, III & IV Sites | Sep-94 | Sverdrup Environmental Inc. |
| Ground-Water Monitoring at HELSTF Cleaning Facility RCRA Monitoring Well Sampling Data Report March 10, 14, 15, 1995 Sampling | May-95 | US Geological Survey, Water Resource Division |
| Interim Remedial Measures (IRM) Final Report Systemic Diesel Spill, SWMU 154 Free Product Recovery | May-95 | Tetra Tech Incorporated |
| Product Recovery System For The HELSTF Systemic Diesel Spill (SWMU 154) Operations & Maintenance Manual | May-95 | Tetra Tech, Inc. |
| SWMU Inventory Report at WSMR | Sep-95 | MEVATEC Corp. |
| Rational National Standards Initiative Presentation of Screening Levels And Remedial Action Cost Draft Report | Mar-96 | Radian International LLC and Mevatec Corp. |
| Draft Groundwater Quality Investigation for the Monitoring Well Program at WSMR, NM | Apr-96 | Environmental Science and Engineering, Inc. |
| Solid Waste Management Unit Inventory Report | May-96 | MEVATEC Corp. |
| Phase II HELSTF Perched Groundwater Remediation Work Plan SWMU'S 143 & 154 Chromium Spill Site & Systemic Diesel Spill | Jul-96 | Tetra Tech, Inc. |
| Rational National Standards Initiative Presentation Of Screening Levels And Remedial Action Cost Final Report | Sep-96 | Radian International LLC and Mevatec Corp. |
| SWMU 147 Underground Waste Tank (SUMP), WSMR, NM | Jan-97 | DOW Environmental |
| SWMU 150 Mar Dump Site, WSMR, NM | Jan-97 | DOW Environmental |
| SMWU Groundwater Monitoring Program | Apr-97 | MEVATEC Corporation |
| Treatability Study Report For Groundwater Remediation HELSTF SWMU'S 142, 143, 154 | Apr-97 | Tetra Tech, Inc. |
| Solid Waste Management Unit Inventory Report | Apr-97 | MEVATEC Corp. |
| Final Groundwater Remedial Action Plan HELSTF-SWMU's 142,143, 154 | Jun-97 | Tetra Tech, Inc. |
| Results of Laboratory Characterization | Jun-97 | MEVATEC Corp. |
| Letter report re slug test data results | Jun-97 | Tetra Tech, Inc. |
| Installation Restoration Program Action Plan (Draft) | Sep-97 | Directorate of Environmental Safety, WSMR |
| Installation Restoration Program Action Plans | Jan-98 | MEVATEC Corp. |
| Installation Action Plan for WSMR | Feb-98 | MEVATEC Corp. |

### 2.2.1 Analytical Data

Soil and groundwater sampling data were classified by the following analyte groups: volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), metals, hexavalent chromium, cyanide, diesel range organics (DRO), gasoline range organics (GRO), and total petroleum hydrocarbons (TPH). Table 2-2 provides a summary of the analytical information for the reports reviewed. Relative priority rankings were assigned to each reviewed report based on the chemist's assessment of data quality and quantity. In total, 13 reports were found to contain relevant analytical data necessary for constructing the site model. Reports that presented no unique or useful data were placed below priority ranking number 13. In general, more recent reports and those containing data for numerous wells or borings were ranked higher than older and less comprehensive reports. In addition, reports containing data for hexavalent chromium and cyanide were considered to be of particular interest.

### 2.2.2 Spatial and Geophysical Data

Results of the review of spatial and geophysical data are summarized in Table 2-3. Reports on the review list were screened by a project hydrologist for data relevant to the following criteria: survey, monitor wells, piezometers, boreholes, slug/pump tests, and lithology. Reports identified as having such data were ranked from 1 to 13. It should be noted that those reports (numbers 1-13) were ranked independently of the analytical data and therefore have different rankings. Reports ranked below 13 were reserved for potential use as supplemental data to fill data gaps found during the data visualization.

Priority rankings were established qualitatively by considering the following factors: spatial extent of information (e.g., how many HELSTF SWMUs were addressed by data); amount of information (e.g., how many wells/borings were data provided for); and quality of data (e.g., how detailed were lithologic descriptions and how reliable were slug/pump tests). Survey data was compiled to check for consistency between reports.

## 2.3 Data Evaluation

All of the analytical data from the reports ranked on the review list (Table 2-1) were determined to be adequate for development of the CSM. Results of analyses that did not measure a specific compound (e.g., diesel range organics, total recoverable petroleum hydrocarbons, or total dissolved solids) were all categorized as Level 2 data, as described in Section 2.1. As such, these data could be used for evaluation of remedial alternatives, engineering design, and most types of modeling in addition to site characterization and development of the conceptual model. With few exceptions, analyte-specific data (volatiles, semivolatiles, metals, etc.) were deemed adequate for performing risk assessment and all types of modeling (Level 3).

**Table 2-2.**
**Analytical Data Ranking.**

| Priority Ranking | Report Name | Date | Author | SWMUs | Electronic Data Available | Lab | Lab Reports | VOC | SVOC | Metals | $Cr^{+6}$ | Cyanide | DRO/GRO/ TPH | Other Analyses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Phase II RCRA Facility Investigation Appendix I, II, III & IV Sites | Sep-94 | Sverdrup Environmental Inc. | 27-30, 38-39, 143-148 | No | JH Carr | N | X | X | X | * | | * | Some pest/PCB, TDS, fluoride |
| 2 | Final RCRA Facility Investigation (RFI) Report Appendix II, III, & IV Sites | Dec-92 | International Technology Corporation | All but 27-30 | No | ITAS | N | X | X | X | * | | * | Pesticides at some sites |
| 3 | Final RCRA Facility Investigations (RFI) | Mar-92 | International Technology Corporation | 27-30 | No | ITAS | N | X | X | X | | X | | |
| 4 | Draft Groundwater Quality Investigation for the Monitoring Well Program at WSMR, NM | Apr-96 | Environmental Science and Engineering, Inc. | 27-30, 38-39, 142-144, 147 | UK | ESE Peoria | Y | X | X | X | * | * | X | Some pest/PCB, radio-chem, water quality |
| 5 | SMWU Groundwater Monitoring Program | Apr-97 | Mevatec Corporation | 27-30, 38-39, 142-144 | Y | PDP | N | X | X | X | | | | Explosives, water quality |
| 6 | Systemic Diesel Spill, SWMU 154 HELSTF Cleaning Facility Volume I Final Interim Report | Dec-93 | International Technology Corporation | 154 | UK | ITAS | Y | X | X | X | * | * | X | Some appendix IX, anions |
| 7 | HELSTF Interim Remediation Measures Phase One Report for the Systemic Diesel Spill (SWMU 154) | Jul-94 | Advanced Sciences Incorporated | 154 | N | Lockheed | Y | * | | * | | | X | |
| 8 | Ground-Water Monitoring at HELSTF Cleaning Facility RCRA Monitoring Well Sampling Data Report March 10, 14, 15, 1995 Sampling | May-95 | US Geological Survey, Water Resource Division | 38-39, 142, 152 | UK | Quanterra RMAL | Y | X | X | X | | X | X | Anions, water quality |
| 9 | Interim Remedial Measures (IRM) Final Report Systemic Diesel Spill, SWMU 154 Free Product Recovery | May-95 | Tetra Tech Incorporated | 154 | UK | Westech, El Paso | Y | X | | X | | | X | |
| 10 | The HELSTF Cleaning Facility RCRA Well Installation Data Report | Nov-93 | Advanced Sciences Incorporated | 142, 154 | N | ITAS | Y | X | X | X | X | * | X | Appendix IX on water, including dioxins and furans |

**Table 2-2. (*concluded*)**
**Analytical Data Ranking.**

| Priority Ranking | Report Name | Date | Author | SWMUs | Electronic Data Available | Lab | Lab Reports | VOC | SVOC | Metals | $Cr^{+6}$ | Cyanide | DRO/GRO/TPH | Other Analyses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Interim Remedial Measures Work Plan for the Systemic Diesel Spill (SWMU 154) | Dec-91 | Lockheed Engineering & Sciences Co. | 154 | N | UK | N | X | | X | | | | |
| 12 | SWMU 147 Underground Waste Tank (SUMP), WSMR, NM | Jan-97 | DOW Environmental | 147 | UK | Talem, Inc. | N | X | X | | | | X | Pest/herb/TCLP on sump contents |
| 13 | SWMU 150 Mar Dump Site, WSMR, NM | Jan-97 | DOW Environmental | 150 | Y | Talem, Inc. | N | X | | | | | X | Pest/PCB, TCLP metals |

X = analysis performed on most samples
Y = Yes
UK = Unknown/not verified
* = analysis performed on some samples
N = No
Blank Cell = Data not in report

**Table 2-3.**
**Spatial and Geophysical Data Ranking.**

| Priority Ranking | Report Name | Date | Author | SWMUs | Boring Lithology | Survey Data | Slug/Pump Test Data | Hydraulic Conductivity | Storativity | Other | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Phase II RCRA Facility Investigation Appendix I, II, III & IV Sites | Sep-94 | Sverdrup Environmental Inc. | 38-39, 143, 144, 145, 146, 148 | X | X | X | X | | | 5 |
| 2 | Final RCRA Facility Investigation (RFI) Report Appendix II, III, & IV Sites | Dec-92 | International Technology Corporation | 33-34, 38-39, 141-146, 148, 149, 151, 152, 154 | X | X | X | X | | Some geophys transects | 4 |
| 3 | Ground-Water Monitoring at HELSTF Cleaning Facility RCRA Monitoring Well Sampling Data Report March 10, 14, 15, 1995 Sampling | May-95 | US Geological Survey, Water Resource Division | 38-39, 144 | X | X (vert) | X | X | X | | 4 |
| 4 | Final RCRA Facility Investigations (RFI) | Mar-92 | International Technology Corporation | 27-30 | X | X | X | X | | | 5 |
| 5 | SMWU Groundwater Monitoring Program | Apr-97 | Mevatec Corporation | 27-30, 38-39, 142-144 | | X | | | | | 5 |
| 6 | Systemic Diesel Spill, SWMU 154 HELSTF Cleaning Facility Volume I Final Interim Report | Dec-93 | International Technology Corporation | 154 | X | X | X | X Well 1 | | | 4 |
| 7 | Interim Remediation Measures Work Plan for the Systemic Diesel Spill (SWMU 154) | Dec-91 | Lockheed Engineering & Sciences Co. | 154 | X | X | | | | | 5 |
| 8 | HELSTF Interim Remediation Measures Phase One Report for the Systemic Diesel Spill (SWMU 154) | Jul-94 | Advanced Sciences, Inc | 154 | X | X | | | | | 4 |
| 9 | The HELSTF Cleaning Facility RCRA Well Installation Data Report | Nov-93 | Advanced Sciences Incorporated | 142, 154 | X | X | | | | | 5 |
| 10 | Draft Groundwater Quality Investigation for the Monitoring Well Program at WSMR, NM | Apr-96 | Environmental Science and Engineering, Inc | 142, 143, 27-30, 144 | | X (wsel) | | | | | NA |
| 11 | Interim Remedial Measures (IRM) Final Report Systemic Diesel Spill, SWMU 154 Free Product Recovery | May-95 | Tetra Tech Incorporated | 154 | X | | | | | LNAPl thickness data | 3 |
| 12 | RCRA Facility Assessment | Aug-88 | AT Kearney | General WSMR | | X (vert) | | | | Old well data | 1 |
| 13 | Letter report reslug test data results | Jun-97 | Tetra Tech Incorporated | 154 | | | X | X | | | 2 |

X = data present
wsel = water (potentiometric) surface elevations
Blank Cell = data not in report
vert = vertical survey data only
NA = not applicable

The quality and extent of spatial and geophysical data reviewed were suitable to support development of the CSM for HELSTF (Level 1). Surveying information, in particular, was needed for spatial placement of the analytical information within the CSM. Ultimately, horizontal GPS surveying data that had been collected were used for spatial reference within the GIS visualization model for the CSM. Lithologic information from borings provided a general description of site geology and hydrogeology. Due to the nature of the previous investigations, there are specific areas within HELSTF that had more concentrated data than others. The spatial and geophysical data for such sites (primarily SWMU 154-systemic diesel spill, and SWMU 143 chromium release site) were identified as being adequate to support development of localized remedial alternatives (Levels 2).

## 3.0 DEVELOPMENT AND POPULATION OF THE DATA MANAGEMENT SYSTEM

After review, evaluation, and ranking of the analytical, hydrological, and geo-spatial data, the following step in development of the HELSTF Groundwater Study and CSM entailed development and population of the data management system. This section describes the overall approach taken to complete the design, population, and quality assurance/quality control (QA/QC) of the HELSTF environmental database. In addition, the incorporation of data into the visualization system and the spatial referencing of data are described. The Database Development phase for this study consisted of the following elements:

- Database Design;
- Database Design Guide;
- Data Loading;
- Spatial Referencing Data; and
- Database Quality Control Checking.

Each of the elements is described in this section.

### 3.1 Database Design

The data management system was designed to integrate the data identified during the data evaluation phase into a logical, manageable set. Functionally, the completed database would serve as a repository for the spatial and analytical data, while allowing users to easily query data based on defined areas and/or SWMUs, depths, times, specific contaminants, analyte groups, or combinations thereof. The database was developed in MS Access® 97 to provide easy interaction with ArcView® GIS version 3.1 and other visualization tools. A database design meeting was held by project team members to identify and discuss the database design criteria. Criteria for data input incorporated into the final design include the following:

- Table and field names are less-than, or equal to 10 characters in length;
- Underscores "_" are used instead of blanks within table and field names;
- Table and field names do not begin with numbers; and
- Filenames follow the "8.3" format for server compatibility.

## 3.2 Database Design Guide

Following development of the database, and prior to full data population, a Database Design Guide was prepared and reviewed at the database design review meeting. The Database Design Guide offers an extensive discussion of all design aspects of the database including relational design, naming schemes, table and field definitions, and primary key field definitions. A copy of the Final HELSTF Database Design Memo is included in this report in Appendix B.

## 3.3 Data Loading

Following the Design Review Meeting, the emphasis of the project switched to acquiring the data for the data-loading task. At the Database Design Review Meeting, project team members decided that the best balance between budget and project needs would be achieved by inputting data from the four most important reports (as identified in the Data Review Working Memorandum of July 29, 1998). In addition, quarterly data from the USGS Groundwater Monitoring at HELSTF Cleaning Facility Report would also be included in the database. Table 3-1 lists the reports from which data were taken for population of the database.

**Table 3-1. Reports Used for Data Entry.**

| Report | Author | Date |
|---|---|---|
| Phase II RFI | Sverdrup Env. Inc. | 9/94 |
| Phase I RFI | I.T. Corp. | 12/92 |
| Groundwater Quality Investigation for the Groundwater Monitoring Program at WSMR | ESE | 4/96 |
| SWMU Groundwater Monitoring Program | MEVATEC | 4/97 |
| Groundwater Monitoring at HELSTF Cleaning Facility | USGS | 5/95-4/97 |

Only analytical data from one report, the SWMU Groundwater Monitoring Program (MEVATEC, 1997), was available electronically. Data from the four other sources were input by hand into spreadsheet templates and subsequently moved into the database tables. In total, over 65,000 records of analytical data were incorporated into the Results table of the database. All other tables were also populated during this subtask, including all well location information, analyte and CAS number data, and potentiometric surface data. Additional potentiometric surface data were incorporated into the database by hand-entry as they became available throughout the project.

## 3.4 Spatial Reference Data

Horizontal GPS survey data for 96 wells at HELSTF were provided by MEVATEC for use in the database and site visualization model. Of those, analytical data were available for 55 wells from the reports listed in Table 3-1. Analytical data were also available from 134 other locations including soil borings, sediment samples, effluent samples and surface water samples. Horizontal survey information was acquired for all but 12 of the relevant HELSTF environmental sampling locations. Coordinates for sampling locations were obtained by scaling distances from known landmarks on maps provided in the reports.

For consistency with the GPS data, horizontal survey coordinates in the database are kept in the Universal Transverse Mercator (UTM) system (zone 13) using the NAD83 datum in units of meters. Coordinates have been converted from New Mexico State Plane (NMSP) coordinates using the program CORPSCON version 4.11 developed by the U.S. Army Topographic Engineering Center. All locations have been checked, at least qualitatively, for accuracy.

Vertical survey information was obtained from the reports where possible. Ground surface elevations were defined for 138 of the 189 sample points. The elevations stored in the database are referenced to the National Geodetic Vertical Datum (NGVD) 1988 datum. Due to the variability of the reported data for elevations, vertical data in the database has an estimated accuracy of approximately plus or minus one foot for most sampling locations. This error was determined to have not adversely affected the overall goal of the project.

### 3.5 Database Quality Control Checking

The backbone of the database is the Results Table with over 64,000 individual data records of results of analyte-specific analyses. Due to the importance of this data set to the overall project goals, the quality control effort was concentrated on those records within the Results Table that were hand entered. A query was designed to allow for easy comparison of analyte "hits" (positive identifications) in the database with the reports. This type of checking was conducted at a frequency ranging between 5 and 10 percent for all of the hand-entered data. During this check, the results tables were also reviewed for any obvious inconsistencies in units of measure, sample name, and sample collection date.

Qualitative quality control checking was conducted on the spatial coordinate data for the sampling locations. This consisted of plotting scaled distances of the sample locations, and checking them for consistency with report figures. The GPS location data for the wells were also checked against coordinates listed in reports. The GPS data was found to be within 2 meters of the reported values.

## 4.0 HELSTF CONCEPTUAL SITE MODELING

### 4.1 Location And Description Of Project Area

#### 4.1.1 Regional Setting

White Sands Missile Range is located within the Tularosa Basin in south central New Mexico. The Tularosa Basin is a north-trending intermontane basin encompassing approximately 16,839 square kilometers (6,500 square miles). It is bounded on the west by the Organ and San Andreas Mountains and on the east by the Sacramento Mountains. The northern boundary is the Chupadera Mesa, and a subtle topographic rise south of the Range Headquarters comprises the southern boundary.

The climate of the Tularosa Basin is typical for the southwestern United States, averaging about seven inches of rainfall yearly. The higher elevations of the mountain ranges bounding the basin receive about 63.5 centimeters (25 inches) yearly. This precipitation occurs during late summer as localized thunderstorms. The heavier events activate intermittent streams and playas, transporting sediments from the surrounding mountain ranges to the central portion

of the basin. Water in the playas evaporates forming alkali flats that are rich in evaporite minerals. Sediments within the Tularosa Basin are unconsolidated eolian and lacustrine deposits with high evaporite mineral content. Surficial deposits are generally characterized as originating from eolian redeposition of dessicated lacustrine sediments. Lacustrine sediments consisting of sands, silts and clays underlie the surface soils. These sediments are discontinuous in lateral extent and in their composition (Basabilvazo, et al, 1994). Due to the variability of the layers, correlation of the individual units is extremely complicated; therefore analyses of these units has been performed by characterizing the influence that multiple sedimentary layers exert over the general subsurface conditions.

Groundwater within the Tularosa Basin is recharged predominantly from the mountain fronts via outcrops of sedimentary units. As groundwater migrates towards the basin axis through the sediments, it becomes more mineralized by dissolving the sediments. Groundwater quality ranges from less than 1,000 parts per million (ppm) along the mountain fronts to over 10,000 ppm beneath the basin axis.

### 4.1.2 HELSTF Geology and Hydrogeology

HELSTF is located near the axial center of the Tularosa Basin. Surficial deposits at HELSTF are described by Seager, et al. (1987) as eolian dunes composed of gypsum sands with well-developed gypsum crusts. Basabilvazo, et al. (1994) characterized the upper 4.6 to 6.1 meters (15-20 feet) of the soil profile as varved gypsiferous sands and silts underlain by lacustrine basin-fill sediments (alternating layers of sands, silts, and clays). The lacustrine deposits are locally discontinuous making correlation of individual units difficult.

Groundwater occurs at several distinct horizons beneath HELSTF. The regional groundwater table is encountered from 21 to 22.8 meters (70 - 75 feet) below ground level (bgl), capped by a stiff, moist, brown to gray clay. Basabilvazo, et al. (1994) described the regional aquifer as leaky-confined within the study area. Regional groundwater quality is representative of the central basin groundwater, with total dissolved solids (TDS) content generally exceeding 10,000 mg/L.

Regional groundwater at HELSTF is overlain by two perched water-bearing units. These perched units were initially described by IT Corporation (1992) and Sverdrup Environmental (1994) as local features originating from various discharges to groundwater at the site. These discharges include distilled de-ionized water production overflow, cooling system condensate, and possibly leakage from the sewage lagoons.

## 4.2 Initial Data Visualization

This task entailed compilation of all of the data gathered for the database into a set of physical and chemical two- dimensional data visualization slides. Initial descriptive interpretations of the data were also developed. Project team members reviewed and finalized the findings of the Initial Data Visualization.

The presentation report for the Initial Data Visualization meeting consists of a series of slides that describe the groundwater characteristics and contamination at HELSTF. The Initial Data Visualization presentation is provided in Appendix C of this report.

The CSM has evolved since the Initial Data Visualization meeting to include updated sampling data and output from more sophisticated three-dimensional visualization. General findings of the CSM are presented in this section.

## 4.3 Conceptual Site Model

Based on analyses of selected data sets from previous investigations at HELSTF, the CSM comprises a synopsis of all pertinent lithologic, hydraulic, and analytical data. The groundwater system at the study area was examined as a whole rather than how it is related to the distinct SWMUs. Analyses of the data from this perspective allowed investigators to thoroughly examine each water-bearing zone independently along with their interconnected influences.

The hydrogeological features of the CSM include a system of stacked saturated zones beneath HELSTF. Generally, the CSM identifies three separate systems, an upper-perched saturated zone from 3.7 to 6.1 meters (12 - 20 feet) bgl, a lower perched saturated zone from 10.6 to 18.2 meters (35 - 60 feet) bgl, and the regional aquifer that occurs below approximately 21 meters (70 feet) bgl (Figure 4-1). The confining lithological layers (aquitards), the general size and shape, and the water quality of each of these units is described in the following sections.

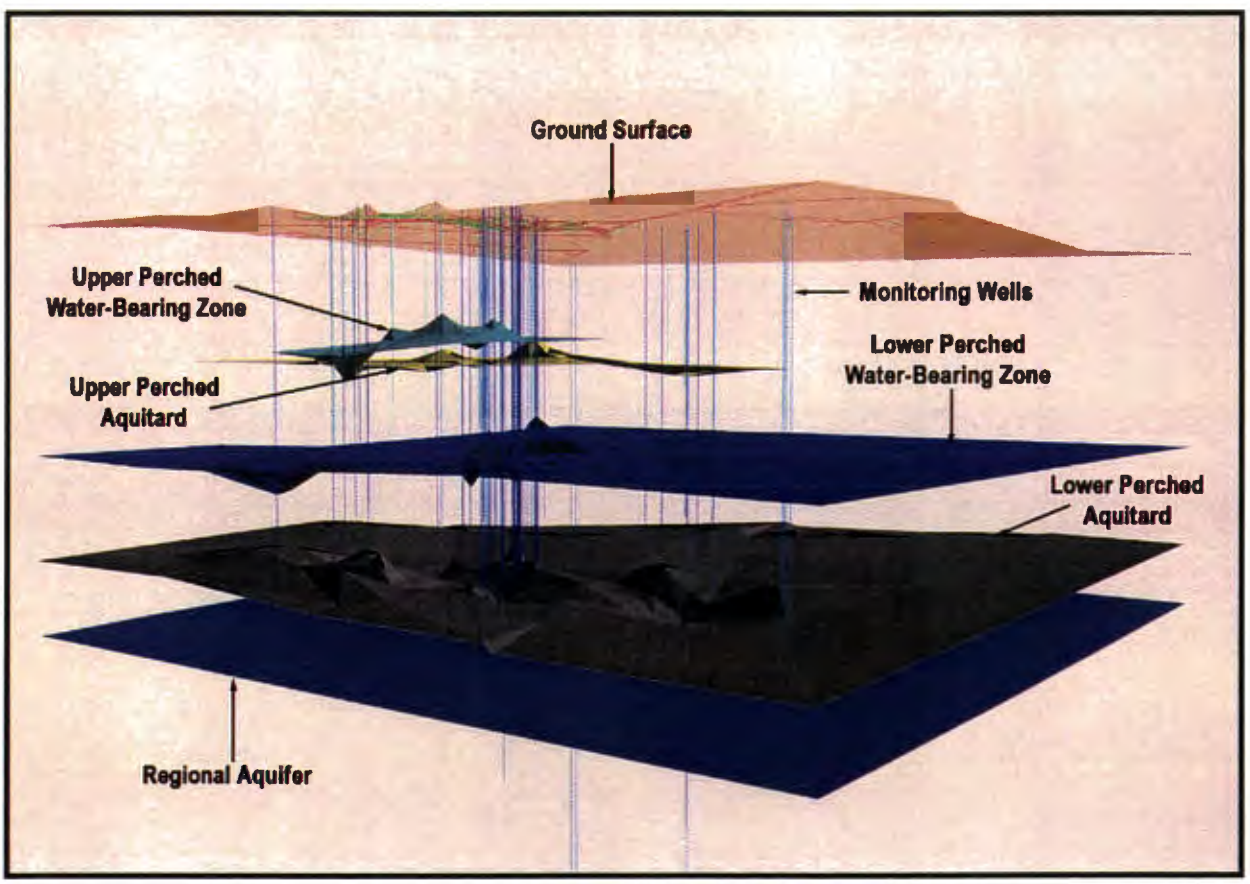



**Figure 4-1. HELSTF Groundwater System.**

### 4.3.1 Perched Upper Water-Bearing Zone

***Aquitard Occurrence***

Centered beneath SWMUs 27-30 (HELSTF sewage lagoons), the perched upper zone rests on an interpreted aquitard encountered from 5.2 to 7.6 meters (17 - 25 feet) bgl. This aquitard was described as clayey silt during soil boring/well installation activities for wells HMW01 through HMW05, HMW17, HMW19, HMW20, HMW22, HMW24, HMW36, and HMW40 (Figure 4-2 on the following page). The referenced lithologic (drilling) logs described a clayey silt layer of approximately the same composition at this depth beneath the lagoons. The drilling logs also described saturated sand overlying this layer, and moist to dry sand immediately beneath it, indicating that it functions as an aquitard. Evidence of the clayey silt layer in the borings and the observation of free water in monitoring wells screened at this interval were used to interpret the extent of the aquitard beneath the upper-perched water-bearing zone.

***Occurrence of Groundwater***

The perched upper water-bearing zone is generally described as a groundwater mound beneath the sewage lagoons. Saturated thickness, as measured in completed monitoring wells, is up to 2.1 meters (7 feet) beneath the lagoons, and pinches out laterally away from the mound center. Groundwater extends laterally from 15.2 meters (50 feet) east to 30.5 meters (100 feet) west of the lagoons. Perched groundwater at this depth is not observed outside of this area. The groundwater may flow through vertical breaches, or around the lateral boundary of the upper aquitard. In either of these cases, the groundwater from the perched upper unit will resume vertical migration and serve as recharge to deeper groundwater.

***Groundwater Quality***

The CSM reflects the quality of perched upper groundwater to be highly variable, with Total Dissolved Solids (TDS) concentrations ranging from 2,854 to 63,840 mg/L. Figures 4-3 and 4-4 illustrates TDS levels in the upper-perched water-bearing zone. The high TDS concentrations are due to the quality of water recharging perched upper groundwater (i.e. sewage effluent from the lagoons), and/or the upper sedimentary layers through which this water migrates. These sediments have high concentrations of evaporite salts and minerals that will dissolve rapidly in water. There is ample surficial evidence of solution cavities and sinkholes that suggest that dissolution of sediments is occuring.

### 4.3.2 Perched Lower Water-Bearing Zone

***Aquitard Occurrence***

As with the perched upper aquitard, identification of the perched lower aquitard was performed by analyses of drilling logs completed during soil boring and monitor well installation activities. The perched lower aquitard is characterized as a gray or brown silty clay layer. The top of the lower perched aquitard is encountered at depths of 16.7 to 20.7 meters (55 - 68 feet) bgl. This wide range of depths suggests that the perched lower aquitard is very undulous, with up to 4.5 meters (15 feet) of elevation difference across the site.

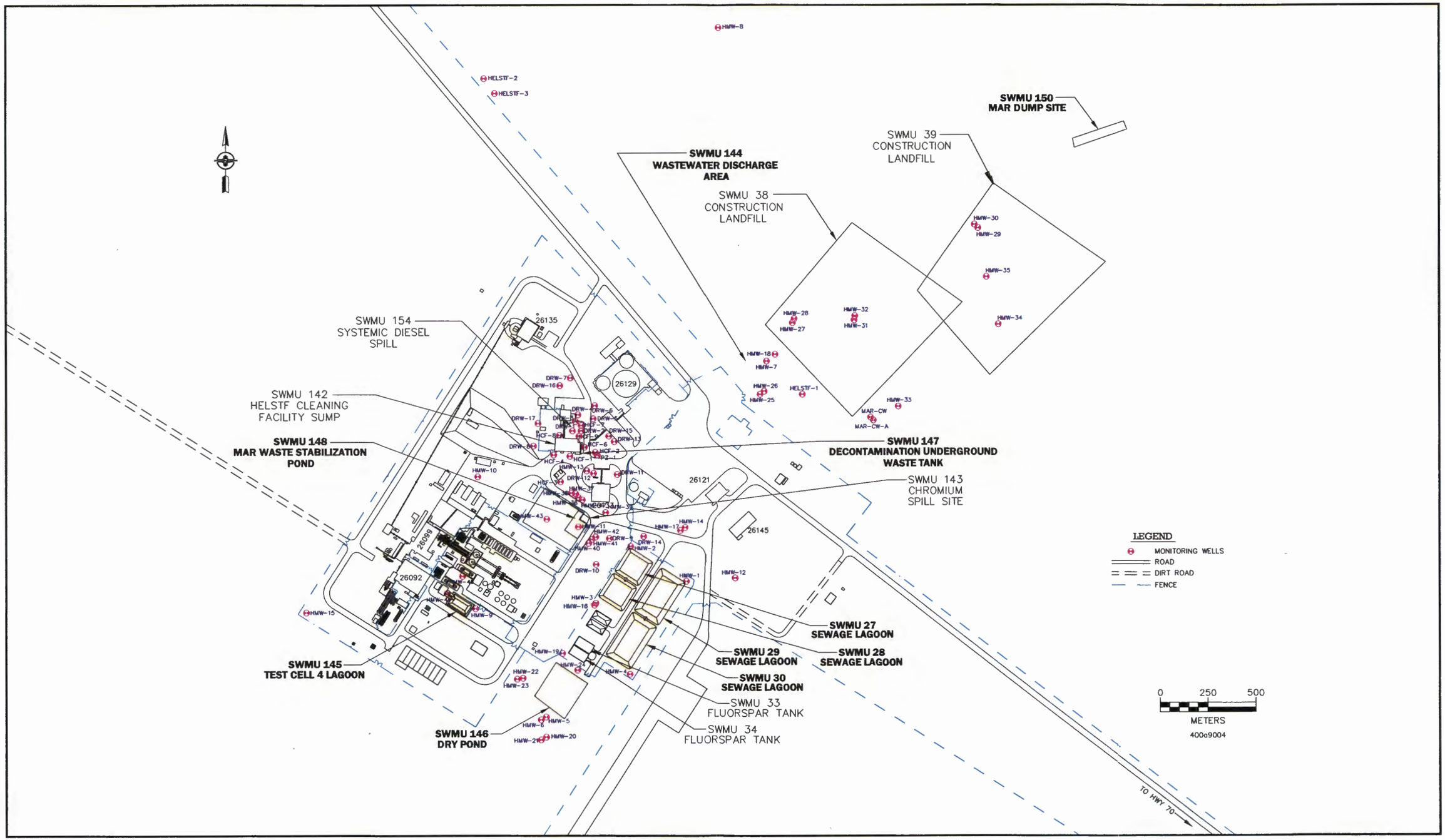



**Figure 4-2. HELSTF Monitoring Wells.**

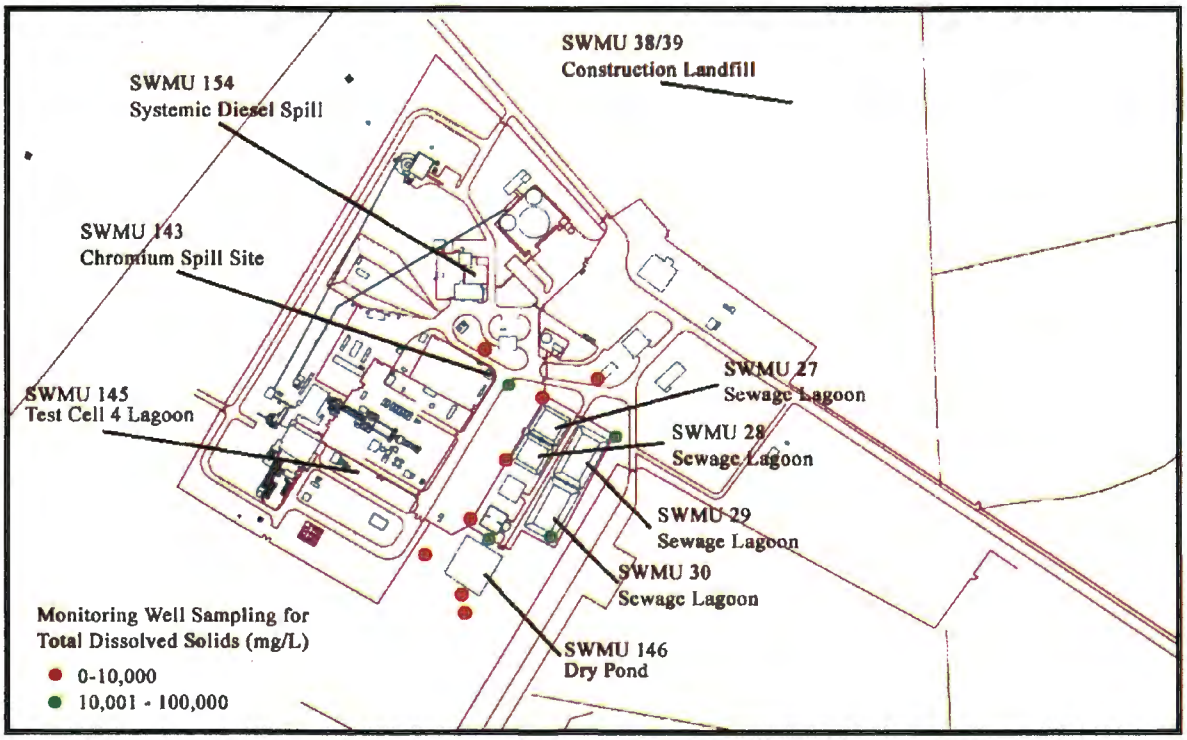



**Figure 4-3. TDS Concentrations in Upper Perched Water-Bearing Zone.**

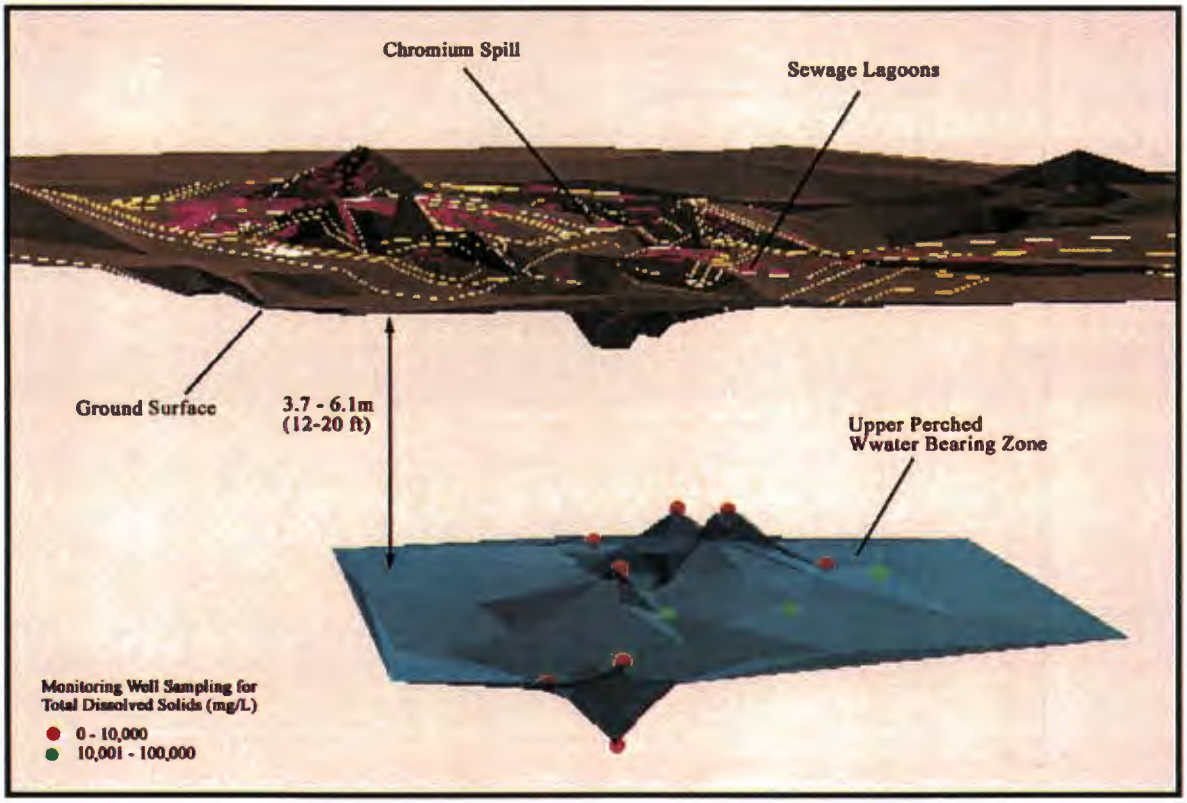



**Figure 4-4. TDS Concentrations in Upper Perched Water-Bearing Zone.**

Beneath the Chromium Spill Site (SWMU 143), existence of the perched lower aquitard is not confirmed by drilling logs. Analyses of drilling logs suggest a pinch-out of this aquitard beneath the northwest corner of the storage yard. Communication of the perched lower and regional groundwater may occur beneath SWMU 143. The potentiometric surface suggests an apparent groundwater "sink" beneath the Chromium Spill Site. Lack of evidence for the presence of the lower aquitard implies communication occurs between the perched lower unit and regional groundwater in this "sink" area.

***Occurrence of Groundwater***

Saturated thickness of perched lower groundwater ranges from 4.8 to 10.7 meters (16 - 35 feet). The elevation of the perched lower potentiometric surface varies up to 3.8 meters (12.5 feet) over the spatial extent of the unit. The potentiometric surface undulates, and reflects no distinct flow direction.

Previous investigations included the installation of regional monitoring wells (HMW42 and HMW47) at SWMU 143. These wells were constructed with surface casing to seal perched groundwater from the regional aquifer. Since preliminary findings of the CSM raised concerns of communication between saturated zones via these regional wells, White Sands performed a Voluntary Corrective Action (VCA) to address this possible route of communication during May 1999. The VCA consisted of plugging and abandoning (P&A) wells HMW42 and HMW47. Subsequent measurements of the potentiometric surface have indicated that a breach in the lower perched aquitard still contributes to leakage from the lower perched zone to the regional aquifer.

***Groundwater Quality***

The CSM reflects the quality of groundwater within perched lower groundwater to be highly variable, with TDS concentrations ranging from 376 to 56,644 mg/L. TDS concentrations in the lower perched unit are shown in Figures 4-5 and 4-6. As with the upper-perched unit, high TDS concentrations are attributable to the initial quality of the recharge water, and/or mineralization of the infiltrate in the vadose zone.

### 4.3.3 Regional Aquifer

As previously described by Basabilvazo, et al. (1994) and McLean (1970), aquifer materials consist of interbedded clay, silt, and fine- to medium-grained sand. Lithologic units in the study area are discontinuous, exerting local influences in occurrence of groundwater. The aquifer is described as leaky-confined, but may act as a water-table aquifer in localized areas according to lithologic units present. Previous studies of regional aquifer characteristics have reported aquifer hydraulic properties in the range of fine-grained sand or silty-sands. Basabilvazo, et al. (1994) performed aquifer tests during and after installation of three regional test wells (HELSTF-1, HELSTF-2 and HELSTF-3) at the study area. Well locations are shown in Figure 4.2. Reported aquifer hydraulic properties are listed in Table 4.1.

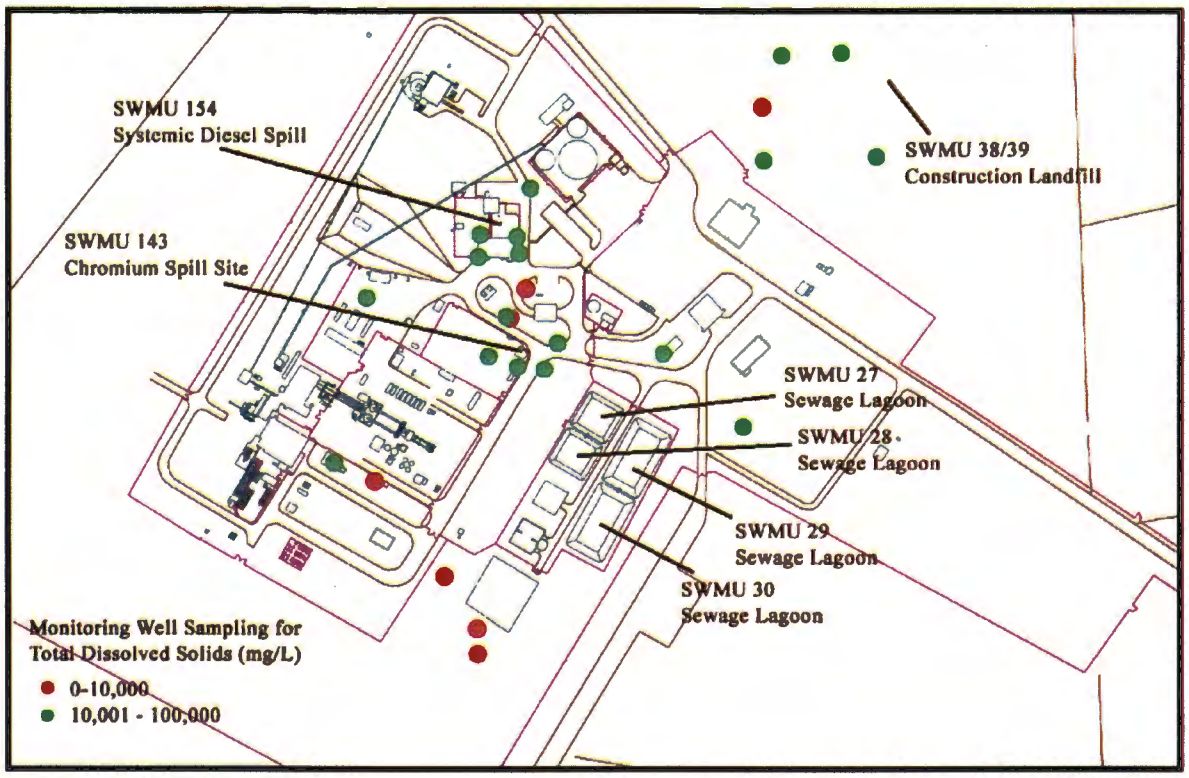



**Figure 4-5.**
**TDS Concentrations in Lower Perched Water-Bearing Zone.**

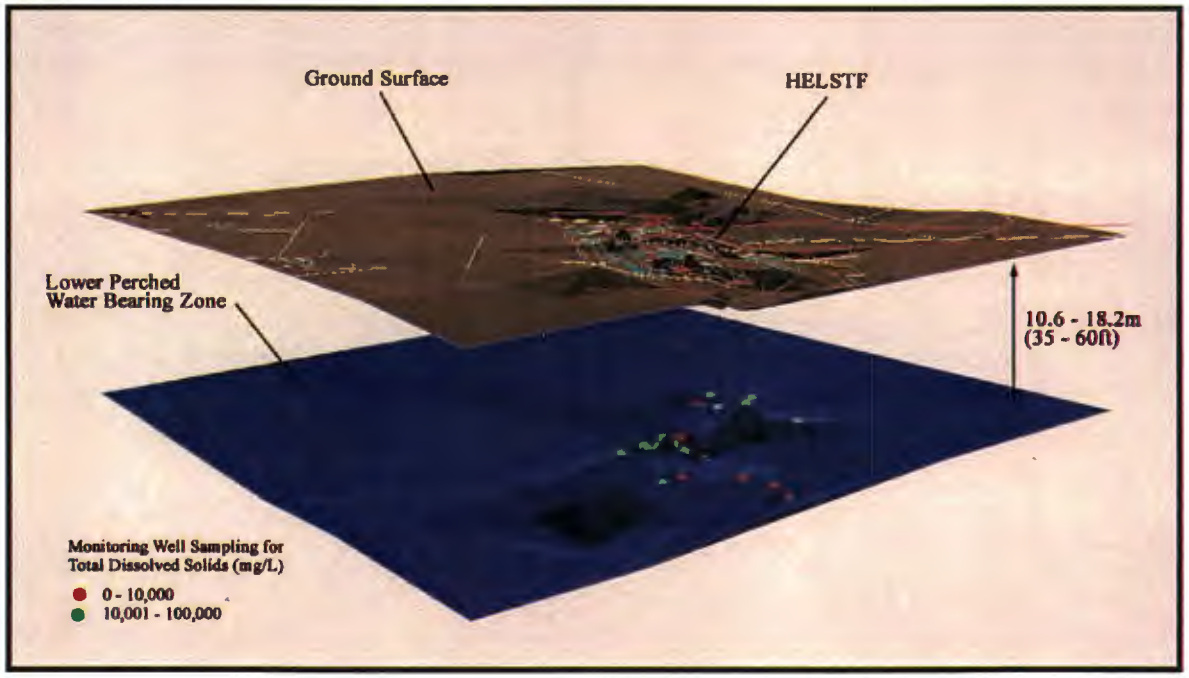



**Figure 4-6. TDS Concentrations in Lower Perched Water-Bearing Zone.**

**Table 4-1. Regional Aquifer Properties.**

| Analysis Method | Well Number | Pumping Rate (cu.ft./day) | Transmissivity ($ft.^2$/day) | Storage Coefficient | Hydraulic Conductivity (ft./day) | Remarks |
|---|---|---|---|---|---|---|
| Theis | HELSTF-1 | 50,053 | 780 | $3.1 \times 10^{-3}$ | 6.0 | Theis non-equilibrium type-match |
| Cooper-Jacob | HELSTF-2 | 50,053 | 730 | $3.8 \times 10^{-3}$ | 5.6 | Time (t) when u=0.01 occurs in 893 minutes |
| Cooper-Jacob | HELSTF-3 | 50,053 | 750 | | 5.8 | Production well; no value for distance between production well and observation well |

***Regional Groundwater Quality***

Sampling results summarized for the CSM reflect the quality of groundwater within the regional aquifer to range from 9,122 to 44,128 mg/L in TDS concentrations. TDS concentrations in the regional aquifer below HELSTF are illustrated in Figures 4-7 and 4-8 on the following page.

Basabilvazo, et al. (1994) described the quality of regional groundwater throughout the Tularosa Basin. That study reported that higher groundwater quality occurs at the mountain front recharge areas, and becomes more saline as it moves toward the basin axis (see Figure 4-9). The study indicates that groundwater in the upper sections of the aquifer ranges from 3,000 to 10,000 mg/L TDS and becomes more saline with increased depth.

### 4.3.4 Selected Contaminants

The volume of selected analytical data (currently over 65,000 records) prohibits in-depth discussion of all groundwater contamination at HELSTF. During development of the CSM, the project team selected specific contaminants for discussion that are representative of each contaminant source at the site and drive risk screening and risk assessment efforts. These contaminants include hexavalent chromium ($Cr^{+6}$), trichloroethylene (TCE) and benzene. Hexavalent chromium is representative of the source at the Chromium Spill Site (SWMU 143) and landfill (SWMU 38-39) areas. TCE is representative of the Cleaning Facility (SWMU 142) source area and benzene is representative of the Diesel Spill (SWMU 154) source area.

Generally, the highest levels of contamination occur within the perched lower water-bearing zone. Groundwater sampling performed since the initial data visualization meeting indicates that there have been no significant changes to contaminant concentrations previously reported.

Due to the continuity of contaminant concentrations over time, figures included in this section are those developed during Initial Data Visualization.

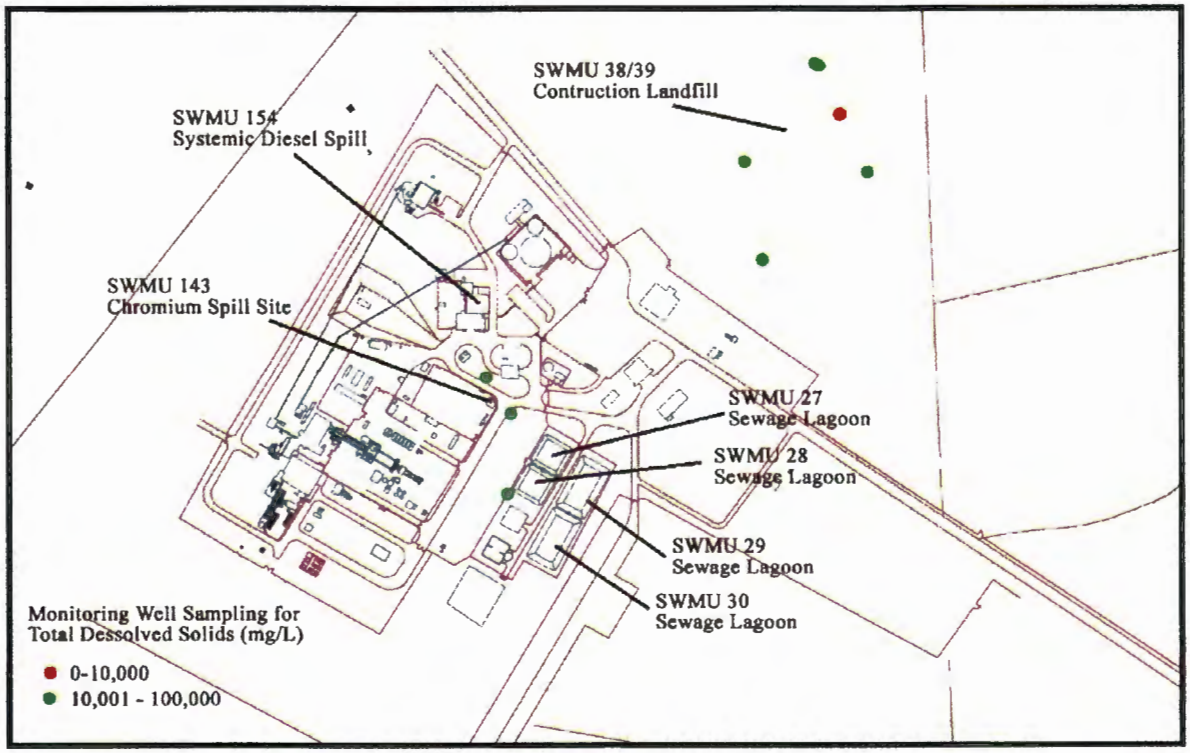



**Figure 4-7. TDS Concentrations in Regional Aquifer.**

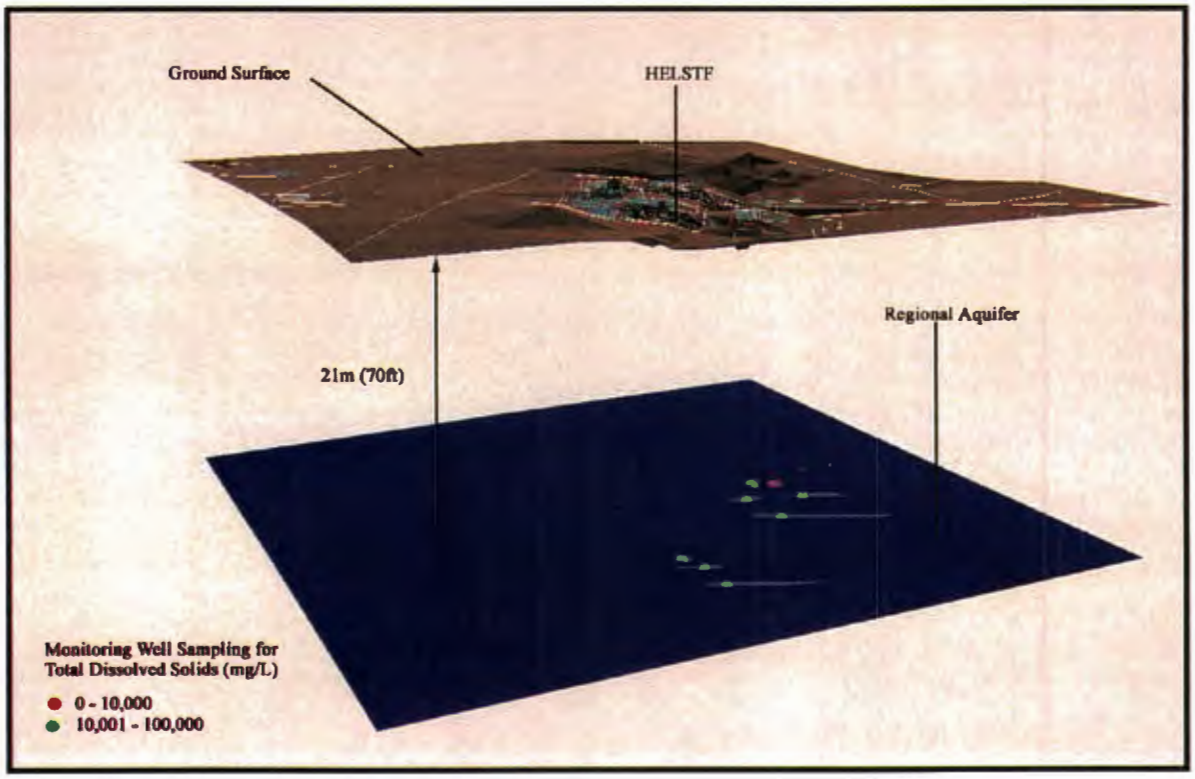



**Figure 4-8. TDS Concentrations in Regional Aquifer.**

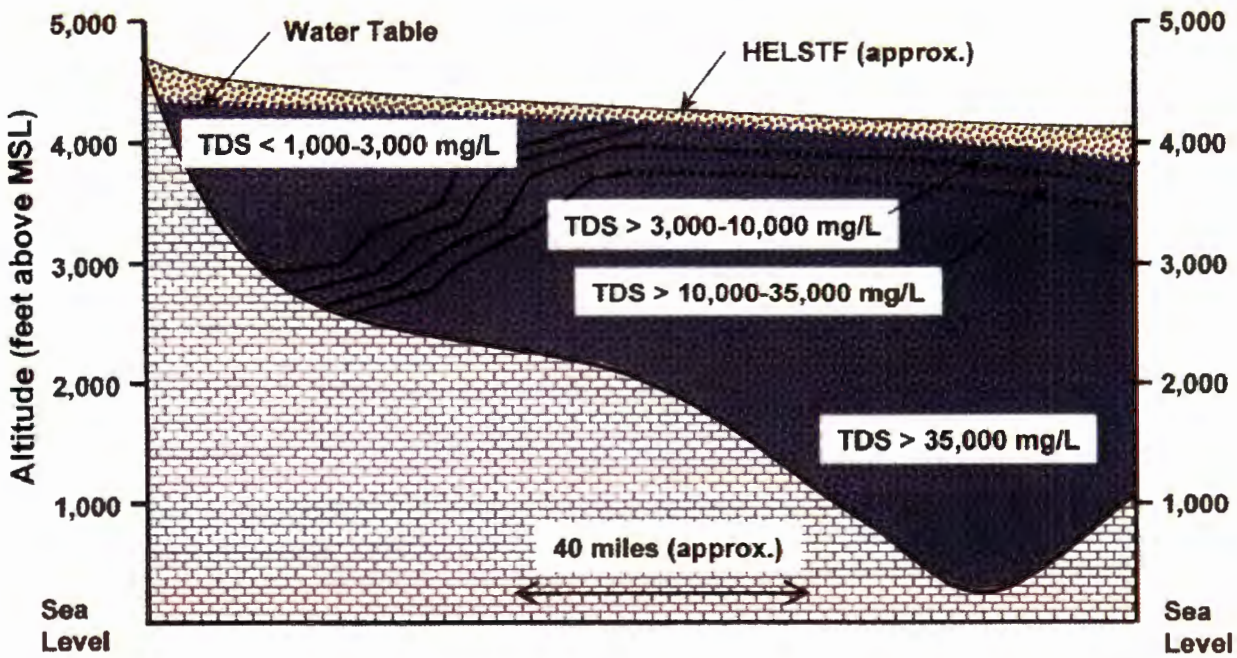



**Figure 4-9. Diagrammatic Water Quality Section at HELSTF.**

***Hexavalent Chromium***

The EPA Maximum Contaminant Level (MCL) for $Cr^{+6}$ is 100 micrograms per liter (ug/L). Hexavalent chromium has been detected in groundwater samples from the perched water-bearing zones below the following areas:

- SWMU 143 – Chromium Spill Site;
- SWMU 27-30 – Sewage Lagoons;
- SWMU 146 – Dry Pond;
- SWMU 38/39 – Construction Landfill; and
- SWMU 145 – Test Cell 4 Lagoon.

The perched upper groundwater zone contains $Cr^{+6}$ below the MCL at the sewage lagoons, the chrome site and the landfill (Figures 4-10 and 4-11). The perched lower groundwater zone contains $Cr^{+6}$ beneath all SWMUs listed above, with concentrations exceeding the MCL only at the chrome site and the landfill (Figures 4-12 and 4-13). Regional groundwater contains $Cr^{+6}$ beneath the landfill at levels below the MCL (Figures 4-14 and 4-15). The latest data from the fall of 1999 sampling event indicate no significant deviations to these concentrations.

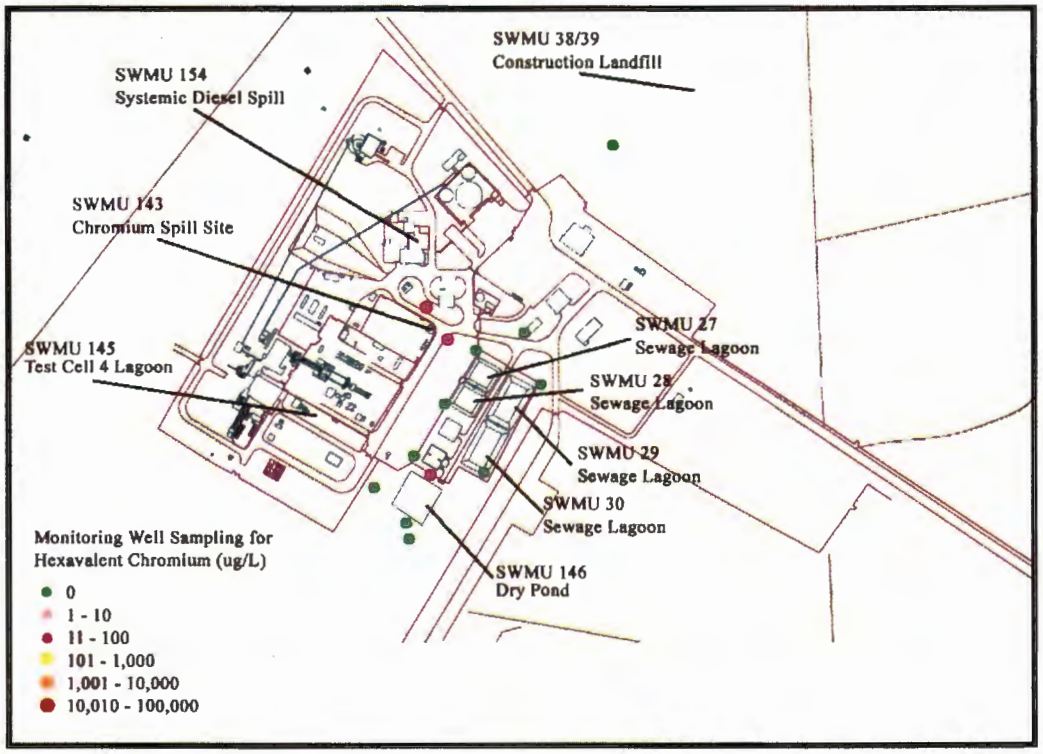



**Figure 4-10.**
**Hexavalent Chromium Concentrations in Upper Perched Water-Bearing Zone.**

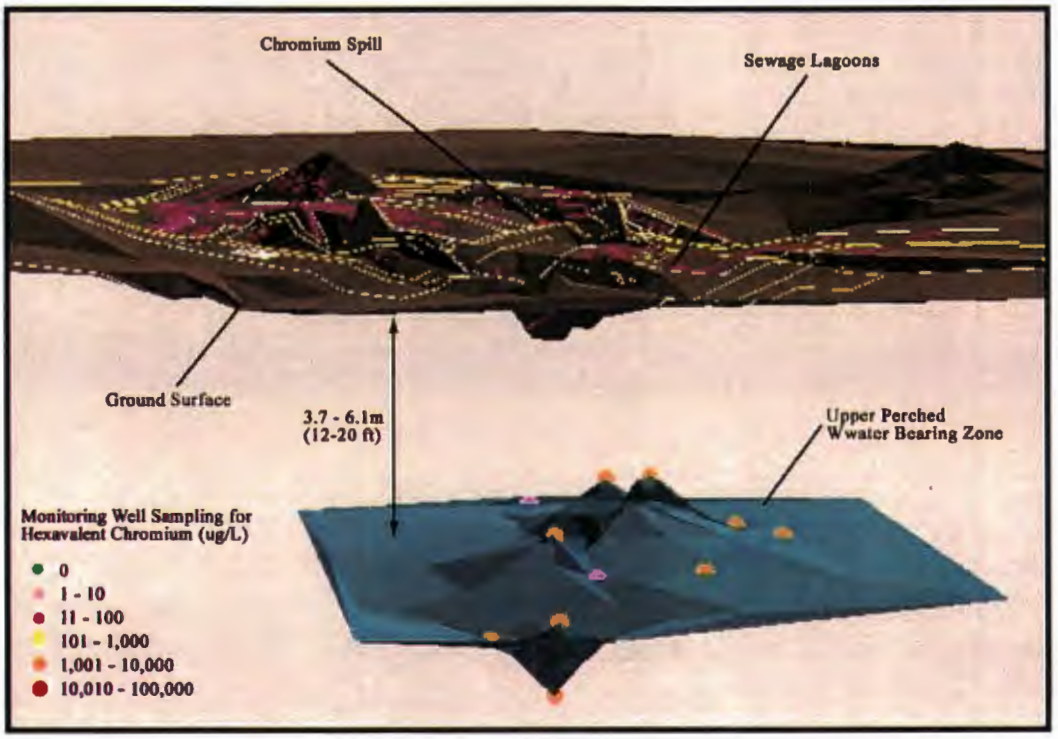



**Figure 4-11.**
**Hexavalent Chromium Concentrations in Upper Perched Water-Bearing Zone.**

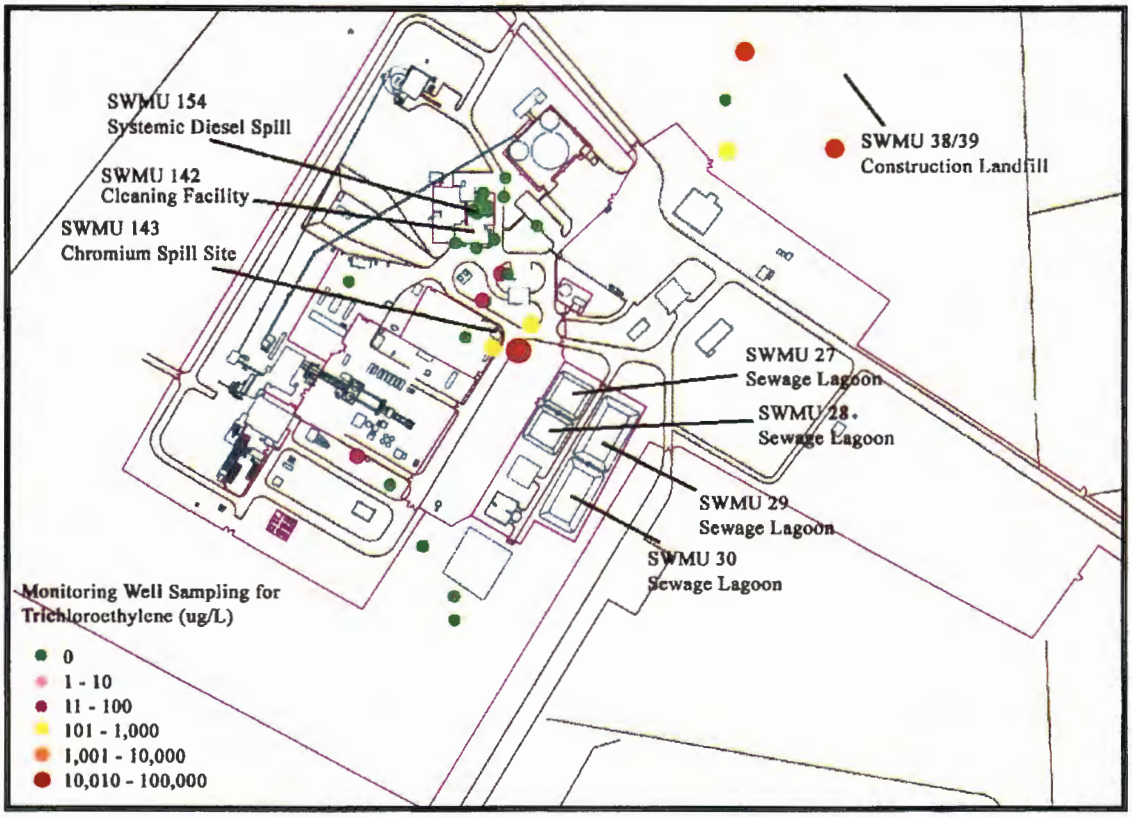



**Figure 4-12.**
**Hexavalent Chromium Concentrations in Lower Perched Water-Bearing Zone.**

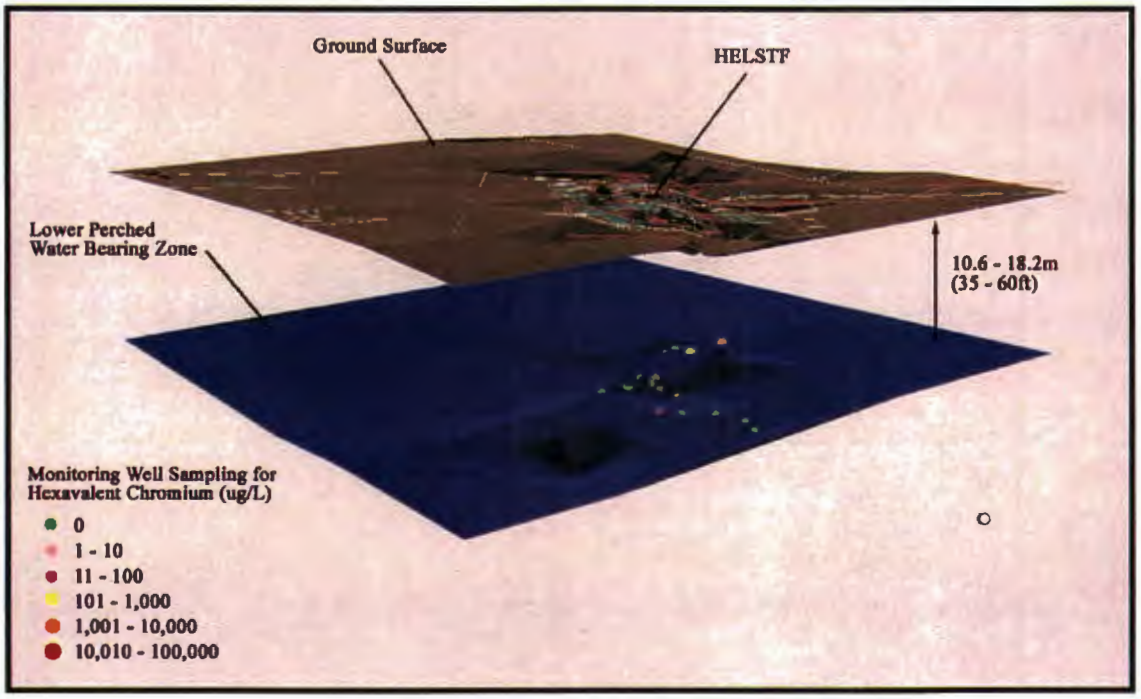



**Figure 4-13.**
**Hexavalent Chromium Concentrations in Lower Perched Water-Bearing Zone.**

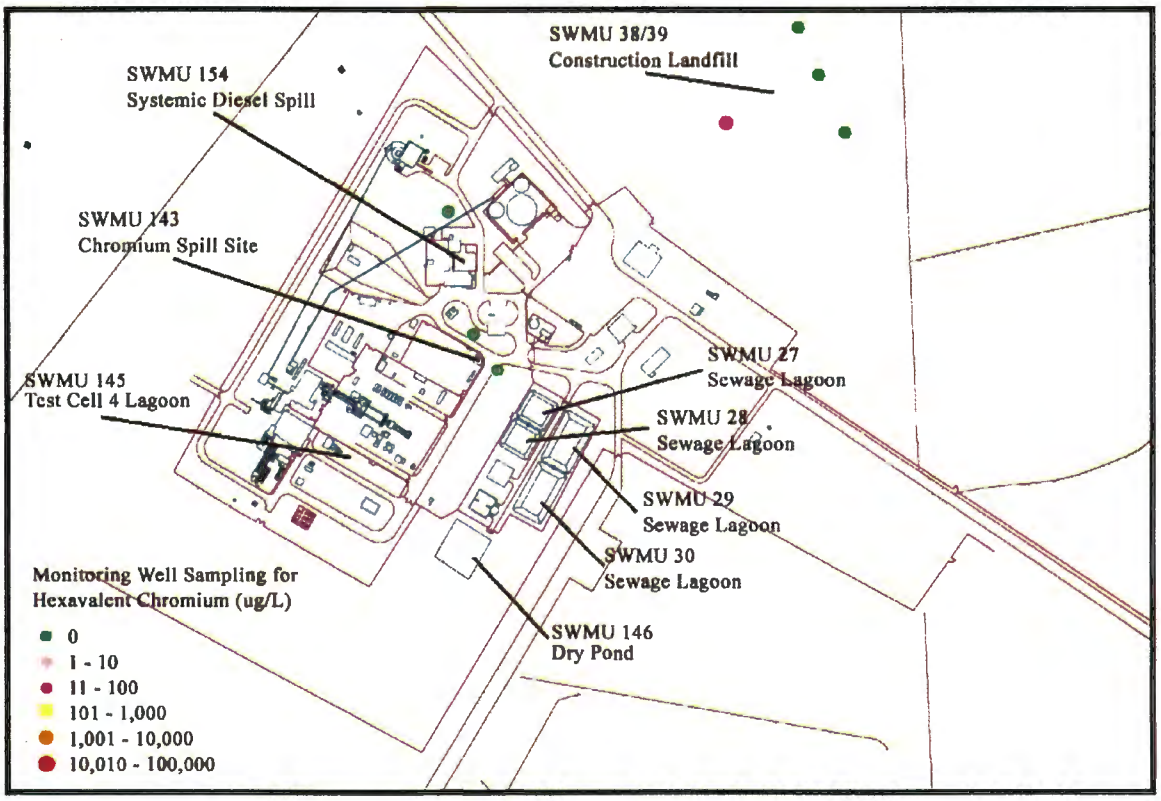
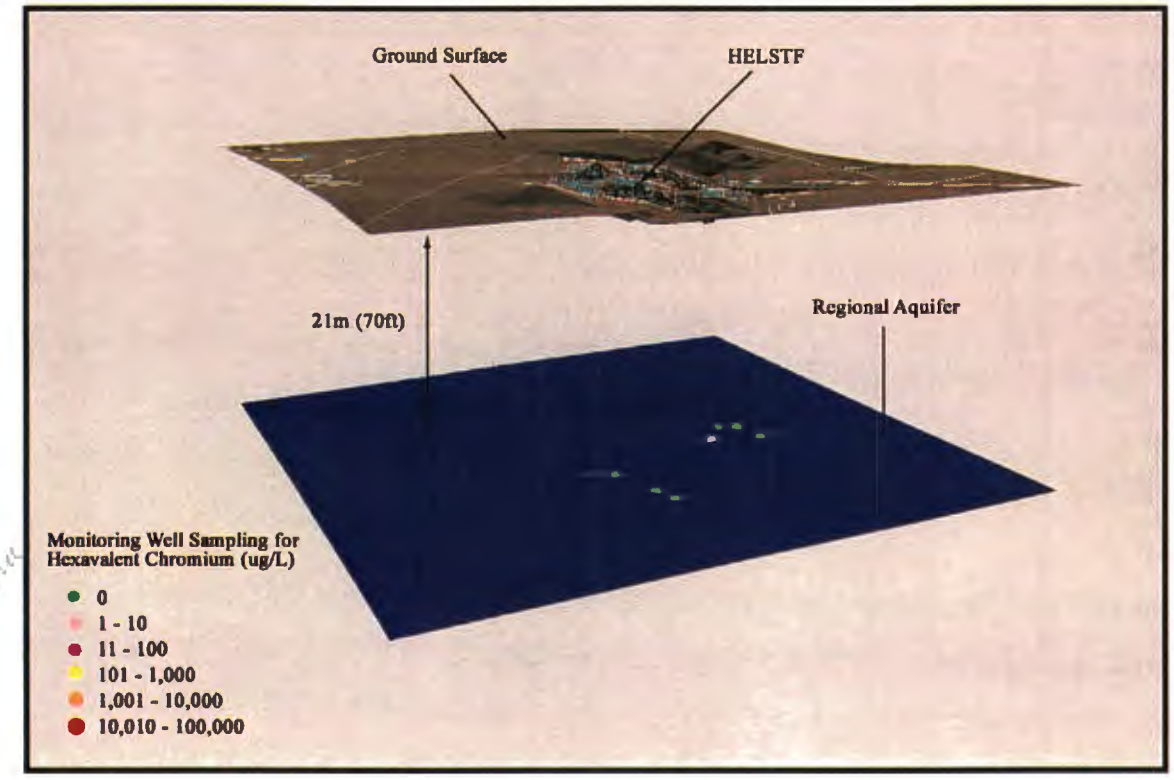



**Figure 4-14. Hexavalent Chromium Concentrations in Regional Aquifer.**




50 ug/L WQBC for Chromium

**Figure 4-15. Hexavalent Chomium Concentrations in Regional Aquifer.**

***Trichloroethylene***

The EPA Maximum Contaminant Level (MCL) for TCE is 5 ug/L. Groundwater samples from the perched groundwater unit indicate the presence of TCE at:

- SWMU 142 – Cleaning Facility Sump;
- SWMU 143 – Chromium Spill Site; and
- SWMU 38/39 – Construction Landfill.

One of the 54 samples collected from the upper-perched water-bearing zone had a detected level of 0.001 ug/L TCE (which equaled the method detection limit [MDL] for that sample). This sample was collected from well HMW01 and analyzed during September 1996. Groundwater samples from this well have not contained TCE in any prior or subsequent sampling events. Field or laboratory contamination must be considered as the cause for this reported hit.

The perched lower groundwater unit contains the highest concentrations of TCE (Figures 4-16 and 4-17). Samples collected from the construction landfill had concentrations of TCE approaching the MCL (0.003 ug/L). Samples from the lower water-bearing zone beneath the cleaning facility and chrome site have consistently had concentrations of TCE above the MCL, as confirmed through several sampling events.

The Regional aquifer had detectable levels of TCE in 3 of 21 samples (Figures 4-18 and 4-19). Two samples from this aquifer below the chrome site (collected during the fall of 1996) contained detectable levels of TCE, one of which exceeded the MCL. The third sample, collected west of the diesel spill site during the fall of 1998, contained TCE at half the MCL.

***Benzene***

The EPA MCL for benzene is 5 ug/L. Analyses of groundwater samples from all of the saturated zones below HELSTF indicate that benzene contamination is limited to the perched lower unit, and centered beneath the cleaning facility and diesel spill area (SWMUs 142 and 154). The highest reported concentration is beneath the cleaning facility, at 220 ug/L from a March 1998 sample event. Results of benzene sampling from the lower perched zone are shown in Figures 4-20 and 4-21. Detectable benzene concentrations in the lower perched water-bearing zone are confirmed throughout all sample events.

***Free Product Diesel***

Discovered in 1990 during the Phase I RFI, diesel fuel originating from a leaking underground storage tank and piping was observed as a light non-aqueous phase liquid (LNAPL) residing on perched lower groundwater. The original estimate of 100,000 gallons of diesel released to the subsurface was based on interviews with site personnel. A pilot study was performed during 1993 consisting of an LNAPL skimming test and vacuum enhanced pumping test. Following findings and recommendations of these tests, a vacuum enhanced diesel recovery system (VEDRS) was installed at the site in 1995. The VEDRS has been continuously operated since installation and has recovered approximately 6,000 gallons of diesel.

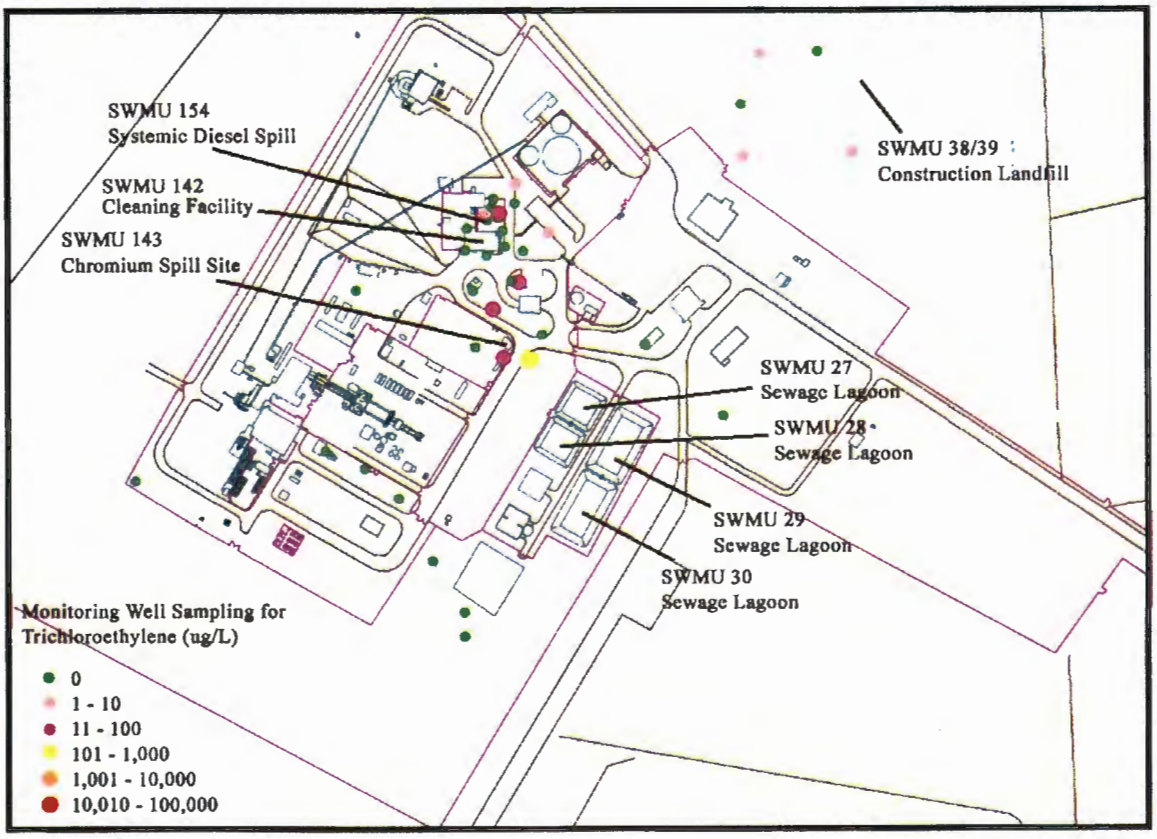



**Figure 4-16. Trichloroethylene Concentrations in Lower Perched Water Bearing Zone.**

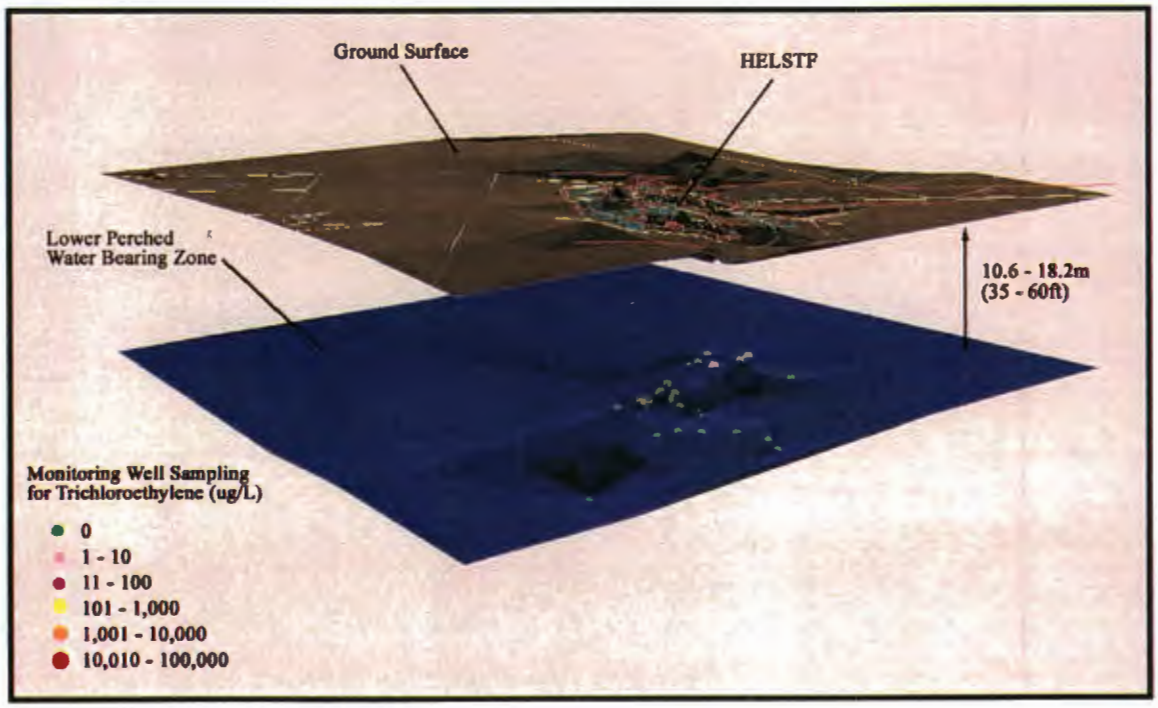



**Figure 4-17. Trichloroethylene Concentrations in Lower Perched Water Bearing Zone.**

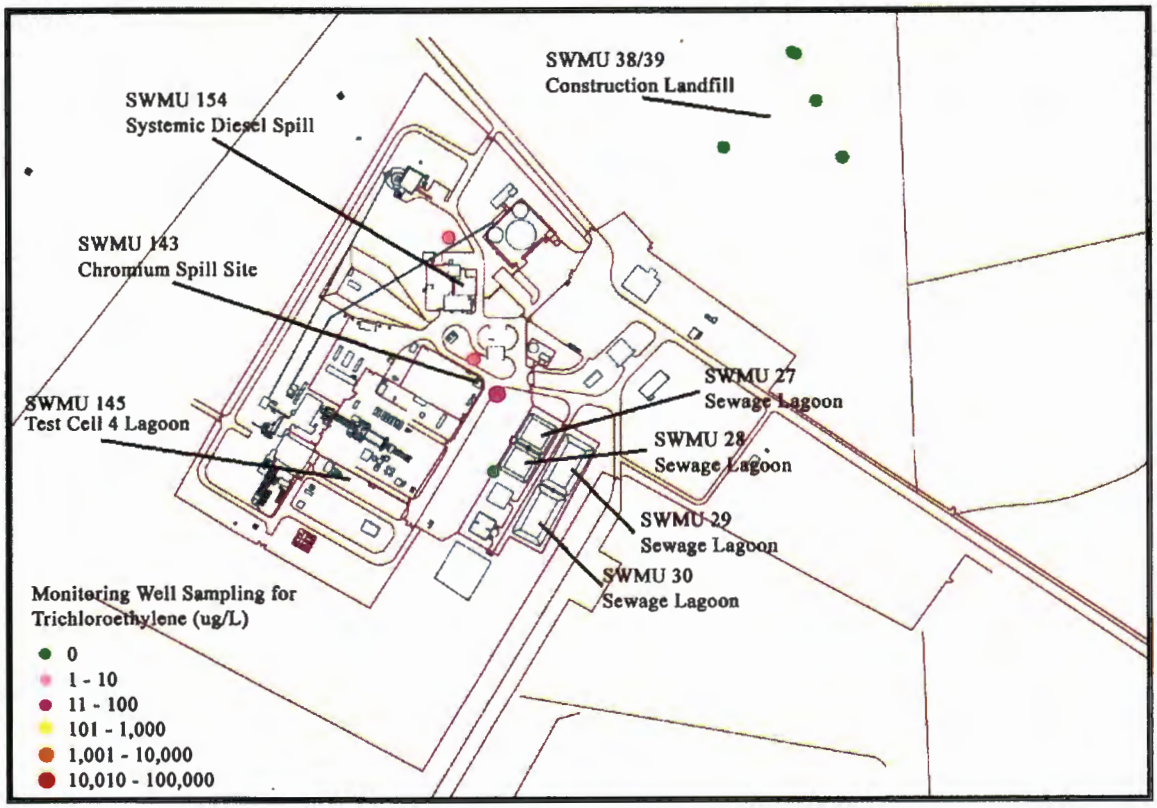



**Figure 4-18. Trichloroethlene Concentrations in the Regional Aquifer.**

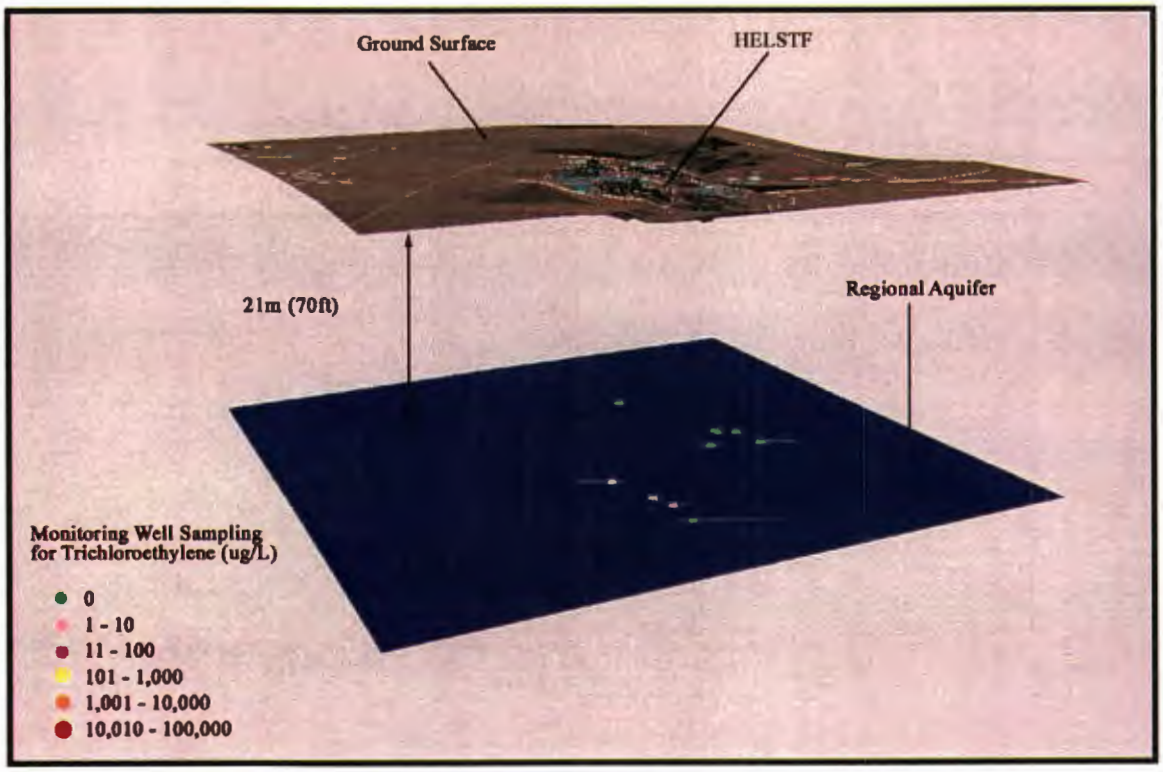



**Figure 4-19. Trichloroethlene Concentrations in the Regional Aquifer.**

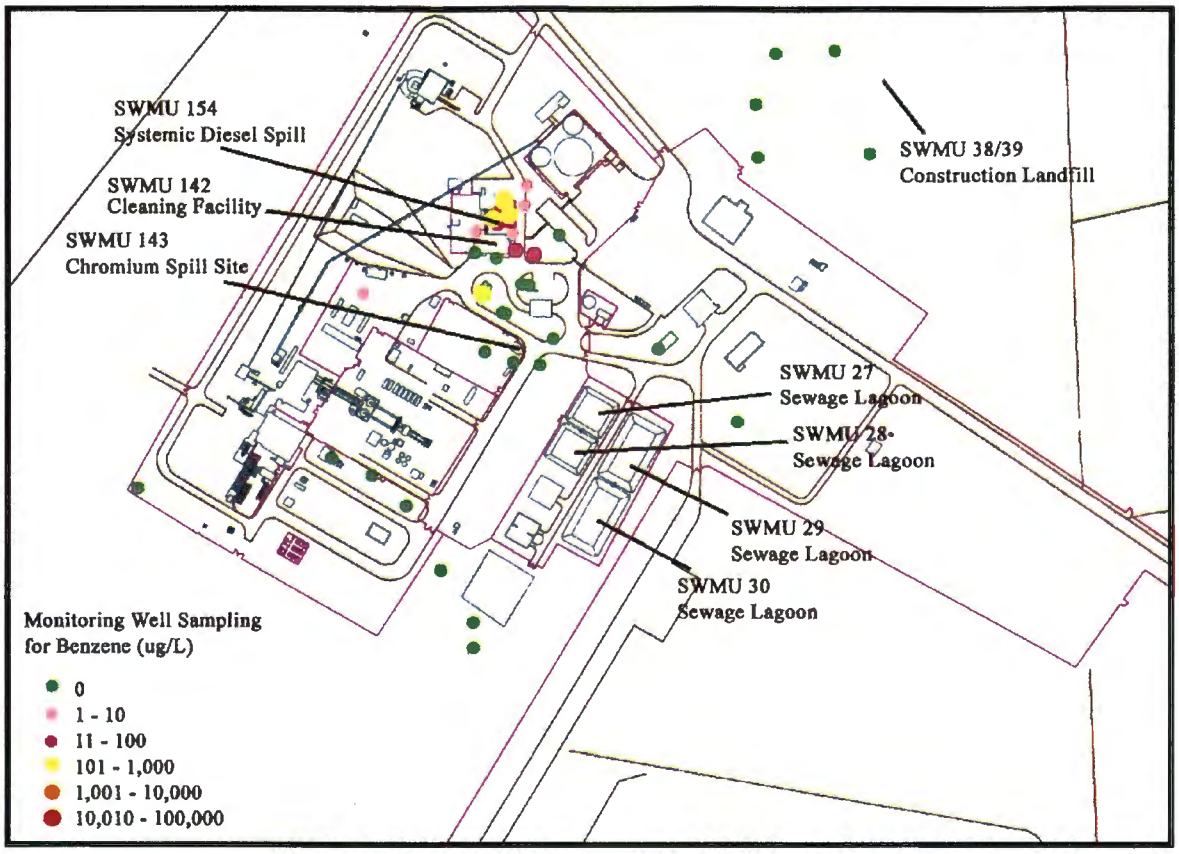



**Figure 4-20. Benzene Concentrations in Lower Perched Water-Bearing Zone.**

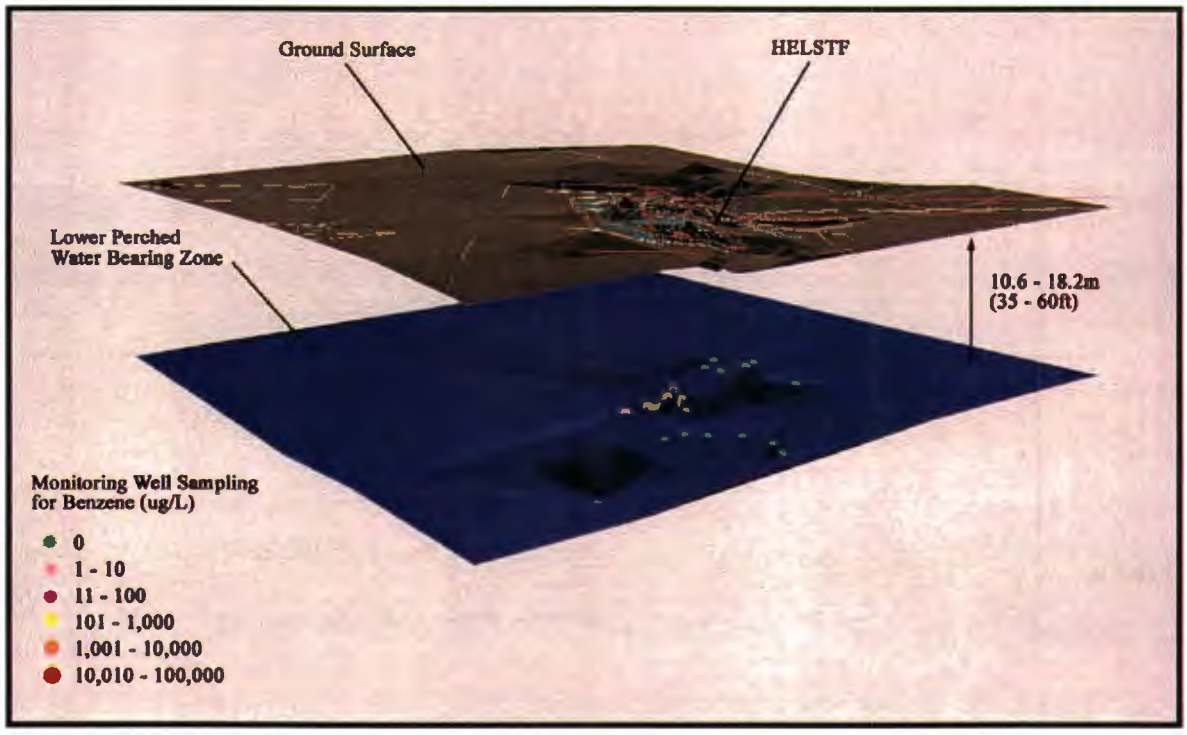



**Figure 4-21. Benzene Concentrations in Lower Perched Water-Bearing Zone.**

Product thickness measurements have been collected continuously during operation of the VEDRS. Initial product thickness measurements reported up to 4 meters (14 feet) of free-phase diesel at the center of the pool. The most recent measurements (March 2000) show the pool thickness to be less than 3 meters (10 feet) at the center. The diesel pool has also steadily decreased in areal extent throughout operation of the VEDRS. Original pool dimension estimates of 24 meters (80 feet) (east-west) by 55 meters (180 feet) (north-south) have decreased to approximately 20 meters (65 feet) (east-west) by 37 meters (120 feet) (north-south).

The diesel acts as a continual source for dissolved-phase groundwater contamination in the lower perched unit. The VEDRS is currently being evaluated to determine if system enhancements and/or upgrades may be performed to increase diesel recovery rates.

## 5.0 RISK EVALUATION

A preliminary risk screening was conducted for the combined HELSTF SWMUs for this project. For the preliminary screening, hydrogeological contaminant transport characteristics were considered along with potential downgradient risk receptor locations. An important finding of the CSM was that the aquifers beneath HELSTF contain TDS concentrations that average 21,000 mg/L, 15,000 mg/L and 14,000 mg/L in the upper and lower perched water-bearing zones, and regional aquifer, respectively. As such, water quality standards for domestic or agriculture water supply do not apply to aquifers with TDS levels of 10,000 mg/L or higher.

Figure 5-1 illustrates the location of HELSTF with respect to the nearest existing potential groundwater extraction point. Potentiometric surface data from the CSM indicate that the regional gradient below HELSTF is directed toward the southeast. However, Basibilvazo et al. (1994) describes the regional gradient in the general area of HELSTF to be largely southerly. The THEL1 well is located over 3.2 kilometers (2 miles) away from HELSTF and is somewhat cross gradient with respect to these potential groundwater flow directions. Water from the THEL 1 well is used for construction purposes and for a fire suppression system and is not potable because of the high TDS.

Preliminary groundwater flow calculations made for this CSM indicate an estimated transport velocity of 1.4 to 3.4 meters (4.8 - 11.2 feet) per year in the regional aquifer below HELSTF. This calculation was based on reported values of hydraulic conductivity, average values of the potentiometric gradient as described from data in the CSM, and an estimated value of the aquifer porosity. These estimated transport velocities are conservative in that they do not include retardation of the contaminant due to chemical sorption to the aquifer materials. Based on these preliminary calculations, a conservative, worst case scenario would have contaminants introduced in the regional aquifer from HELSTF impacting the THEL1 well no sooner than 940 years after their release. This timeframe and travel distance would likely provide ample opportunity for the mechanisms of natural attenuation to effectively lower contaminant concentrations below any target risk levels that may be derived.

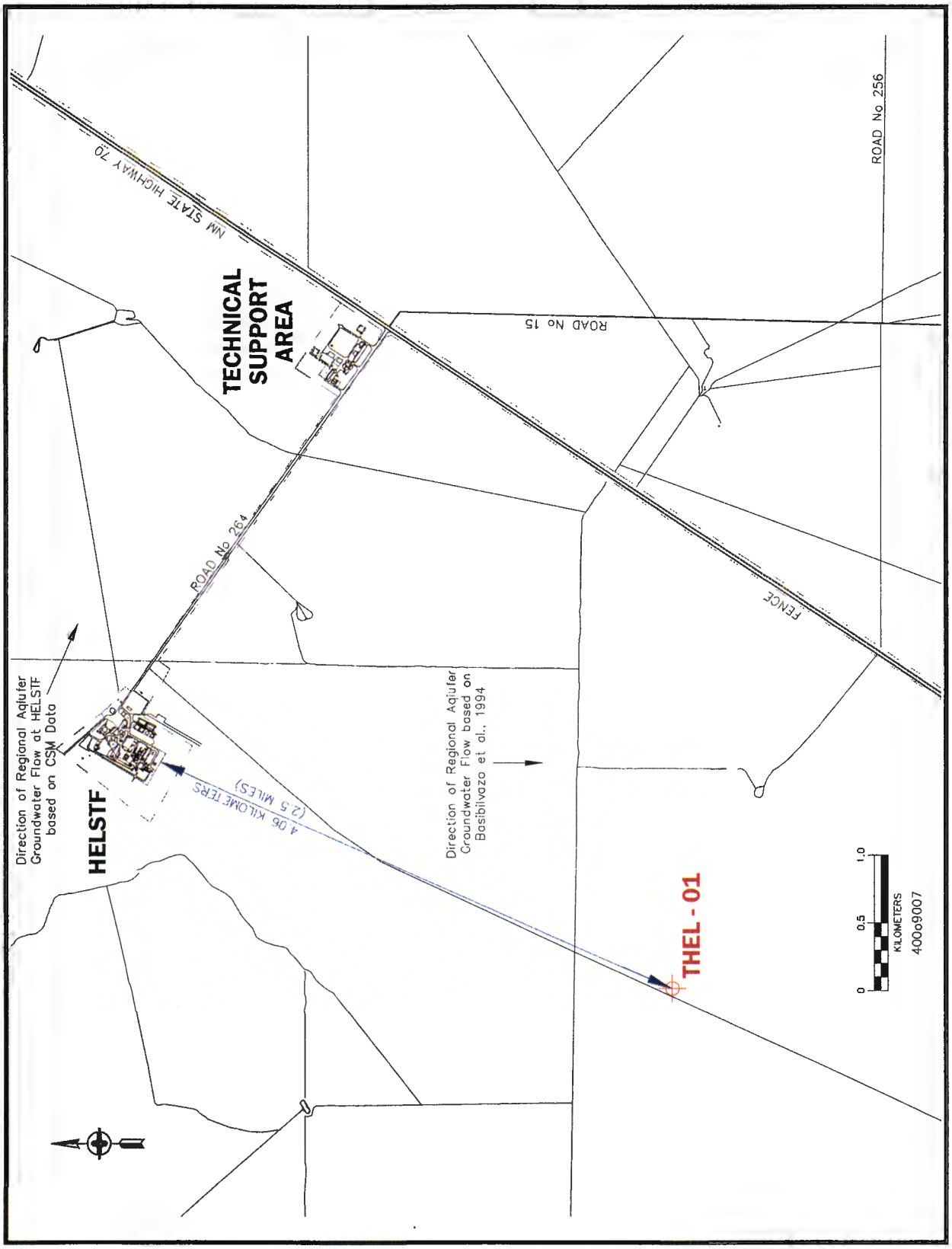



**Figure 5-1. Nearest Groundwater Extraction Point to HELSTF.**

As identified for this preliminary review, there is no risk to human health or the environment associated with ingestion of contaminated groundwater at HELSTF since there are no completed risk pathways. Groundwater quality at HELSTF is not usable for residential or agricultural applications because of the high TDS. Any uses of groundwater within or adjacent to HELSTF warrants a detailed risk analysis for the planned activities. This preliminary risk screening does not address potential exposures associated with soil contamination at HELSTF, or potential indoor air contamination that could arise in subsurface structures located on or near HELSTF. These potential pathways will be considered during the Corrective Measures Study (CMS) to be completed during fiscal year 2001.

## 6.0 SUMMARY

Operations at HELSTF have resulted in the release of contaminants that have impacted soils and groundwater at varied depths and locations. Multiple studies and investigations were performed over the last 12 years to characterize contamination at HELSTF. These studies have resulted in copious analytical and geophysical data that were spatially and temporally disjointed, and were not presented in the context of HELSTF as a single, interrelated site. The HELSTF CSM was developed to address following objectives:

- To review and compile the best available subsurface environmental data into a single, geographically-referenced relational database;
- To develop two- and three-dimensional visualizations of relevant hydrogeological and environmental data at the site; and
- To provide recommendations that will facilitate site closure, based on the site as a whole, rather than individual SWMUs.

Following the data review and evaluation phases, identification of the nature and extent of contamination and groundwater at HELSTF comprised the majority of the effort for the CSM. Following is a synopsis of the findings of the CSM with regard to this objective.

Groundwater occurs at HELSTF primarily in three water-bearing units that are separated by depth, including a regional aquifer and two perched zones. The two perched water-bearing units are likely a result of operations at the facility, and are not representative of the regional hydrology of the Tularosa Basin. Each of the three saturated groundwater zones below HELSTF contains average TDS concentrations greater than 10,000 mg/L. The State of New Mexico water quality standards for potential domestic or agricultural water supply do not apply to aquifers containing TDS levels of 10,000 mg/L (one percent) or higher. Therefore, National Primary Drinking Water MCLs were used for a comparison tool in the CSM, but do not represent applicable abatement standards for groundwater at HELSTF.

Three contaminants were chosen as being representative of the known, primary historic releases at HELSTF. These contaminants include TCE, $Cr^{6+}$, and benzene. The CSM provided a detailed evaluation of the distribution of each of these contaminants with respect to the three water-bearing zones. In addition, the extent of free-phased diesel fuel on the lower perched water-bearing zone was evaluated. Salient findings of these evaluations include the following:

- The upper-perched water-bearing zone contains $Cr^{6+}$ at concentrations below the MCL (0.1 mg/L) beneath the HELSTF Sewage Lagoons, the Chromium Spill Site, and the Construction Landfill. Benzene, TCE, and diesel are not detected in the upper-perched water-bearing zone.

- The lower perched water-bearing zone is the most contaminated groundwater zone at HELSTF. $Cr^{6+}$ is widely distributed in this zone, and concentrations exceed the MCL below the Chrome Spill Site and the Construction Landfill. Concentrations of TCE approach the MCL (0.005 mg/L) in this zone below the Construction Landfill, and exceed the MCL below the Cleaning Facility Sump and the Chrome Spill Site. Benzene is present in the lower perched zone and is concentrated below the Cleaning Facility and Diesel Spill Area in levels that are on the order of a magnitude higher than the MCL (0.005 mg/L). Free product diesel fuel up to 1.2 meters (4 feet) in thickness continues to be removed with the VEDRS from the lower perched groundwater unit.

- The regional aquifer is the least contaminated groundwater zone. Hexavalent chromium has been detected below the Construction Landfill at levels below the MCL. There has been limited detection of TCE in the regional aquifer, with one sample from below the Chrome Spill Site in 1996 that exceeded the MCL. Benzene has not been detected in the regional aquifer.

## 7.0 RECOMMENDATIONS

This section briefly outlines recommendations that will move the HELSTF site SWMUs towards the overall goal of closure, or a finding of No Further Action (NFA), while ensuring protection of human health and the environment and weighing the interests of White Sands. Recommendations for corrective action and further study at HELSTF fall under two main categories; containment of potential contaminant source areas and implementation of a corrective measure, or NFA.

It is anticipated that viable closure options at HELSTF will include limited corrective actions or management practices to address source containments. Towards the goal of source area containment, the following actions are recommended:

- Surface treatment at the Construction Landfills. This remedial action would minimize the potential for further leaching of contaminants from the landfills. This could include retarding and compaction of surface soils in the area of the landfills to maximize and redirect surface runoff. Alternatively, this could be accomplished with installation of a geomembrane or geosynthetic cover to minimize infiltration through the landfills.

- Continued operation of the VEDRS to address free product diesel on the lower perched groundwater unit, or, as recommended through study, implementation of efficient alternative methods of diesel fuel recovery. Passive skimming technology might be employed to save on operational costs.

- Abandonment of wells HMW 42 and HMW 47 to ensure that they are not providing a migration pathway between the lower perched water-bearing unit and the regional aquifer. This recommendation was implemented following the Initial Data Visualization Meeting.

Considered as a whole, the SWMUs at HELSTF are well suited for the remedial approach of monitored natural attenuation (MNA). There are no residential or ecological populations affected by contamination at HELSTF, and planned development of the site does not include the use of groundwater resources for residential or industrial applications. Furthermore, groundwater at the site averages TDS well above 10,000 mg/L, and its location on a U.S. Army installation lends itself to implementation of institutional controls. With regard to contaminant remediation at HELSTF, the following are recommended in support of pursuing NFA or implementing MNA:

- To insure human health for workers at HELSTF, a more detailed risk assessment should be conducted to further evaluate potential exposures from soil contamination throughout the site. Presence of volatile contaminants in the subsurface could impact indoor air quality in buildings that have basements below grade. Development of a groundwater fate and transport model might be warranted to elucidate the potential for downgradient exposures.

- A CMS is recommended to further quantify potential risks and to illustrate the efficacy of proposed future option/activities at the site.

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# APPENDIX A

## Data Review Materials

# Phase I Data Review Plan

## 1.0 Introduction

White Sands Missile Range has conducted multiple investigations of soil and groundwater contamination at the High Energy Laser Systems Test Facility (HELSTF). The area consists of approximately 15 acres containing multiple solid waste management units (SWMUs), contamination release areas, and co-mingled plumes, making it a complex site. Volumes of physical and chemical data varying in quality, usability, and relevance have been collected over more than 10 years. These reports contain critical information for understanding and making decisions about closing the site; however, the volume and variability of the data is overwhelming. The goal of the project is to build a conceptual model using the best available data to facilitate closure of the sites.

### 1.1 Project Overview

The objective of this project is to create and visualize the site model based on the best available data collected to date. This will allow the project team to make informed decisions regarding cleanup and closure of the sites at HELSTF. The project begins with a thorough inventory and review of all existing data for quality and quantity. This review will be used to identify the data sets available to construct the conceptual model. This also includes prioritizing the identified data sets for entry into the database, based on their relevance to the conceptual site model and ability to support cleanup and closure decisions. In the second phase, the data management system will be designed and constructed to visualize the selected data. The third phase consists of using the data management system to visualize the conceptual model of the site and identify the additional steps required to close the sites. Finally, training will be provided on management and use of the data visualization system.

Because of the complexity and volume of the data associated with the HELSTF sites, a systematic approach is necessary to ensure that the review and evaluation is cost-effective and efficient. A systematic approach is especially important when evaluating data sets from multiple sources that contain different types of information. Evaluating data sets methodically ensures that data are reviewed consistently and that the same process filters each data set. This Data Review Plan was prepared to describe the process that will be used during Phase 1 to review and evaluate data. Section 2 discusses the data review checklist and the information that will be gathered during the data review, as well as how the review will be implemented. Section 3 outlines the data evaluation process. Finally, Section 4 provides a project schedule for Phase 1 activities.

## 2.0 Data Review Checklist

Four objectives have been identified for this task:

- Identify the quantity and quality of data available to support construction of a conceptual site model and ultimately closure;
- Prioritize data sets for entry into the model;
- Identify significant data gaps that could affect the conceptual model; and,
- Assess overall ability of data set to support site closure.

The key to successfully reviewing the data and meeting these objectives is a comprehensive checklist that captures all necessary information. The checklist that has been developed for this project is provided as Attachment 1. The first page of the checklist is designed to gain an overview of each report containing data. The pages following the report evaluation form collect chemical, physical, and spatial data on an individual SWMU basis. All of the SWMU-specific pages from a single report will be attached to the report evaluation form for that document. All of the data collected for a single SWMU will be used to assign the data set an overall data use category. Section 2.1 provides an explanation of the data use categories. Section 2.2 describes the Report Evaluation Form. Sections 2.3 and 2.4 identify how chemical data and spatial/physical data will be evaluated.

### 2.1 Data Use Categories

There are multiple steps in cleaning up or closing the SWMUs at HELSTF (i.e., conceptual model, corrective measures, risk assessment). For some of these steps, such as risk assessment, data quality and quality assurance/quality control (QA/QC) documentation is a critical factor. Other steps require large amounts of data, but can use data sets that are more qualitative or have not undergone intense QA/QC procedures. For this reason, each data set is assigned a data use category that identifies what the data set can be used for. These data use categories are described below:

- **Conceptual Site Model/Site Characterization:** All data deemed to be relevant to the site may be used to develop the conceptual site model. This includes data such as field-screening results or analyses performed using portable instruments. This category may also include results that are not compound specific such as total petroleum hydrocarbons (TPH), total organic carbon (TOC) or soil-gas surveys.

- **Corrective Measures Design and Implementation:** Data sets that can help provide a better understanding of the subsurface geology, hydrogeologic conditions, and extent of soil and groundwater contamination are valuable in evaluating remedial alternatives. Physical and chemical data that provide insight into nature and extent of contamination as well as soil and groundwater properties can also be used for groundwater modeling and fate and transport modeling. The combination of data visualization and modeling aid in developing a comprehensive groundwater model of multiple commingled sites and ultimately form the basis for evaluating remedial alternatives.

- **Risk Assessment:** Risk assessment is a key component in identifying areas that require corrective measures and developing cleanup goals for remediation. Risk assessment can significantly reduce the cost of cleanup; however, data sets must meet strict QA/QC standards in order to be used for risk assessment.

## 2.2 Report Information

The first major section of the checklist is designed to obtain information about the report that is being evaluated. This section will allow the reviewers to understand the context of the report and the reason it was prepared. In this section, the reviewer will identify all of the SWMUs or sites that are addressed in the report. A table will be completed with all of the SWMUs or sites included in that report to help define the types and quantities of data that were collected. Historical context or additional considerations for the investigation or report are recorded at the bottom of the page. If the status of electronic data is known, this will also be noted. Finally, the reviewer responsible for completing the Report Evaluation Form will be noted along with the number of pages that follow for SWMU-specific evaluations.

## 2.3 Chemical Data

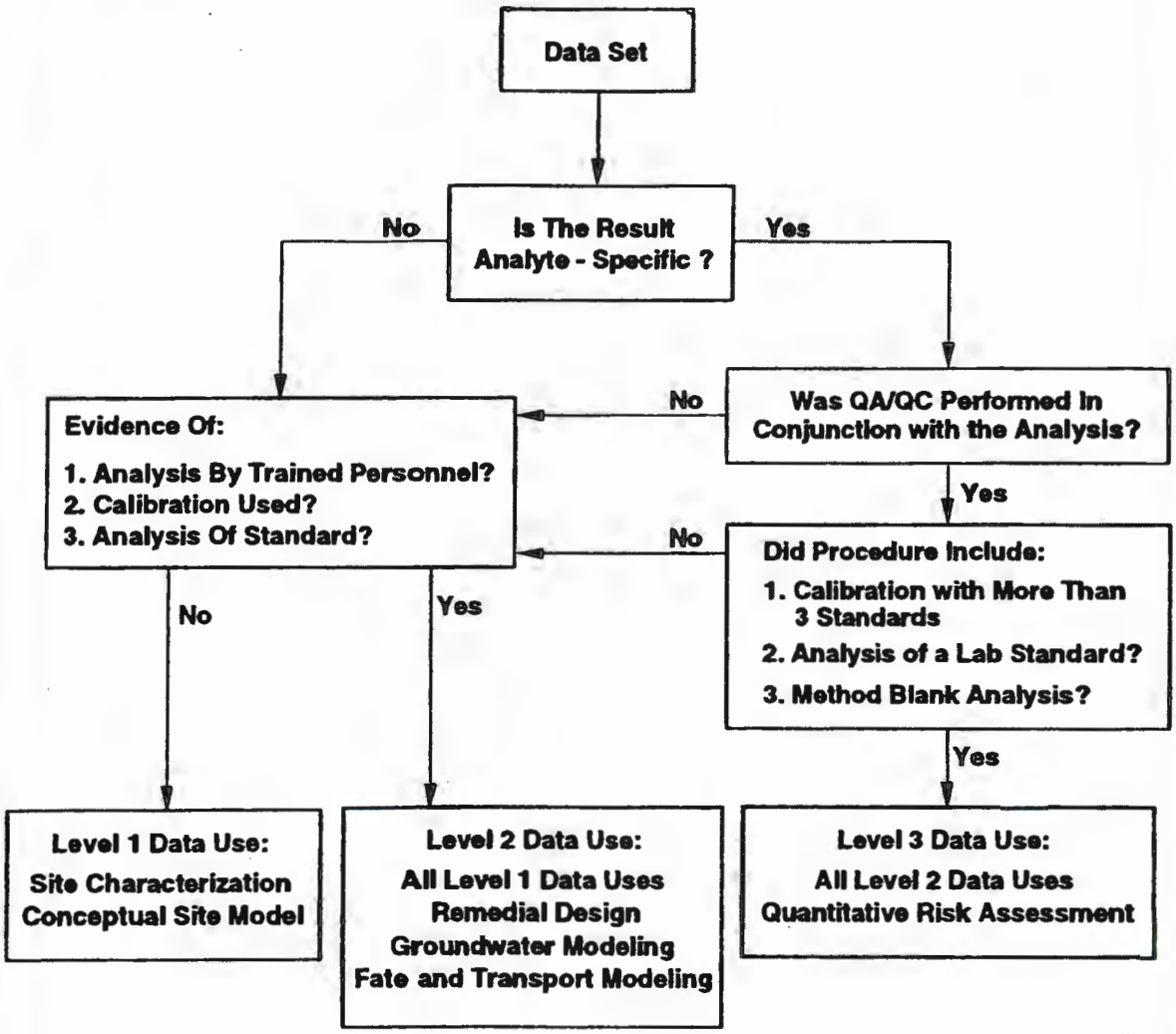
The chemical data review section is designed to identify the analytical parameters that were evaluated and assign a data quality level for each of the analyses. The data quality levels relate closely to data use categories, which may become important in later stages of the project. The data quality levels and their corresponding data use categories are described below:

- Level 1 data consists of field screening or analyses using portable instruments. Results are often not compound specific and may not be quantitative. Level 1 data sets may be used for site characterization and development of a conceptual site model.

- Data sets are categorized as Level 2 if there is evidence suggesting that qualified people performed analyses, calibration techniques were used, and appropriate standards were analyzed. Level 2 data can be used for evaluation of remedial alternatives, engineering design and most types of modeling, in addition to site characterization and development of the conceptual model.

- For data sets to be categorized as Level 3, data analysis procedures must have included calibration (or linearity check) with more than 3 standards; analysis of a lab standard (calibration check); and analysis of a method blank (or equivalent). Data sets that meet these criteria may be used for quantitative risk assessment and all types of modeling in addition to the uses described above for Level 1 and 2.

A flow diagram guiding the reviewers through this decision process is provided as Figure 2-1. Reviewers will identify the analytical methods that were used and the laboratory or laboratories performing the analysis. Any comments regarding the methods or QA/QC levels will also be noted.

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## 2.4 Spatial and Physical Data

The Spatial and Physical Data Review Form is designed to capture types of data other than chemical. Spatial data includes survey coordinates and elevations of wells and samples. This information will be required to accurately locate sample points and visualize the associated chemical data in the conceptual site model. Physical data encompass geologic and hydrologic parameters that will help in understanding contaminant distribution across the sites. Results from aquifer pumping tests, slug tests, and boring logs are all classified as physical data. Reviewers will rank the quality and completeness of the data on a scale of 1 to 5, with 1 being the most general and 5 being the most detailed, then describe the basis for the ranking.

# 3.0 Implementation

The data review team will be made up of a geologist and chemist experienced in the review of complex site data and staff familiar with the sites and existing data. Table 3-1 summarizes the steps that will be followed to implement the data review process.

**Table 3-1 Data Review Implementation**

| Task | Radian Activities | MEVATEC Activities |
|---|---|---|
| Data Review Plan | Draft plan; revise and finalize following MEVATEC comment | Provide input and review for draft plan |
| Compile documents for review | -- | Compile all relevant reports and documents; assess availability of electronic data |
| Document Review | Review, inventory and define document contents on checklists | Provide historical site information and review checklists as completed |
| Data Use Categories | Assess overall data usability and assign data use category | Participate in data use category assignment and review |
| Data Evaluation | Compile checklists; organize data according to data use categories; identify significant data gaps that could affect the conceptual model | Assist in prioritizing data for entry into the database and identifying data gaps |
| Data Review Meeting | Present findings of Data Evaluation; preliminary database design | Identify additional fields for database design; discuss Data Evaluation findings |
| Data Review Summary Report | Summarize review and evaluation tasks and meeting | Review and provide input |

Project team members familiar with the site history will complete the Report Evaluation Form. This will be handed off to the project chemist or project geologist. The project geologist will evaluate all data sets in the report for spatial parameters and assess the completeness and quality of the physical data. This information will be recorded on the Spatial and Physical Data Review Form. One form will be filled out for each SWMU or site within the report. The project chemist will review the same report and evaluate the chemical data sets using the decision logic flow in Figure 2-1. The project chemist will record the findings on a Chemical Data Review Form. Once both team members have completed their review, the SWMU-specific forms will be attached to the Report Evaluation Form. A copy of the completed set of forms will be attached to the document. A second copy of each completed set will be collected for data evaluation and data use category determination. These forms will serve as the basis for discussion and decision-making at the data evaluation meeting. A Data Review Summary Report will be prepared documenting the findings of the data review.

## 4.0 Evaluation of Phase I Data Review

Once the data review task is completed, a set of all completed forms will be compiled. The project team will assign each data set one data use category. The forms will be categorized according to data use categories then prioritized for entry into the database based on the unique information they provide for visualizing the site. The completed set of forms will provide an understanding of the completeness of the data set available to support the data uses, and identify the data gaps associated with them. The entire project team will then meet to discuss the adequacy of the data set for each of the proposed data uses and determine the next step based on these discussions. The objectives of this meeting will be to:

- Determine data use(s);
- Identify which data sets will be manually entered into the database;
- Discuss preliminary database design; and,
- Discuss schedule and budget for the next task.

Once the data uses have been finalized, the data sets available to support the chosen direction will be examined for entry into the database. This meeting will also serve as the kickoff for the database design task so initial database fields will be discussed in light of the chosen data sets. Finally, the project team will discuss the schedule and budget for the database design and construction task.

## 5.0 Schedule

Attachment 2 provides the schedule for Task 1, Data Review and Evaluation. The schedule will be updated, as necessary and additional tasks will be added to the schedule as the project progresses.

ATTACHMENT 1

# Report Evaluation Form

Report Title_____

Prepared by_____

Date of Report_____ Date Reviewed_____

Name of Reviewer_____

Objective of Report: _____

_____

_____

**SWMUs/Sites Covered:**

| SWMU or Site | Number of Borings | Number of Wells | Number of Samples | | | Analyte Groups |
|---|---|---|---|---|---|---|
| | | | Soil | GW | Other _____ | |
| | | | | | | |
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| | | | | | | |
| | | | | | | |

General Comments on Report or Investigation: _____

_____

Status of Electronic Data: _____

Reviewed by MEVATEC: _____

Number of Pages Attached: _____

# Chemical Data Review Form

SWMU or Site: _____

Report: _____

Reviewer: _____ Date: _____

| Analyte List | Results Reported? | QA/QC Level* | | | Comments |
|---|---|---|---|---|---|
| Volatile Organic Compounds (8260/8240) | Yes / No | 1 | 2 | 3 | |
| Semivolatile Organic Compounds (8270) | Yes / No | 1 | 2 | 3 | |
| Gasoline Range Organics | Yes / No | 1 | 2 | 3 | |
| Diesel Range Organics | Yes / No | 1 | 2 | 3 | |
| RCRA metals (6010) | Yes / No | 1 | 2 | 3 | Dissolved / Total |
| Other metals | Yes / No | 1 | 2 | 3 | Dissolved / Total |
| Field Parameters (dissolved $O_2$, redox, pH) | Yes / No | 1 | 2 | 3 | |
| Other (dissolved solids, TOC, TPH) | Yes / No | 1 | 2 | 3 | |
| | Yes / No | 1 | 2 | 3 | |
| | Yes / No | 1 | 2 | 3 | |
| | Yes / No | 1 | 2 | 3 | |
| | Yes / No | 1 | 2 | 3 | |

Laboratory Analysis Conducted By: _____

# Spatial and Physical Data Review Form

SWMU or Site: _____

Report: _____

Reviewer: _____ Date: _____

Are survey coordinates available for sample locations? Yes / No _____%

Sample Elevation? Yes / No _____%

Contains lithologic description (boring logs)? Yes / No

Level of Detail or Quality? ( 1 2 3 4 5 ) (1 is general; 5 is complete USCS description)

Comments: _____

_____

_____

Contains relevant geologic/hydrogeologic information (pump test data, slug test, hydraulic conductivity, etc.)? Yes / No

If yes, describe: _____

_____

Level of Detail or Quality? ( 1 2 3 4 5 ) (1 is general; 5 is very detailed)

Comments: _____

_____

_____

## Data Evaluation Summary

Which data use category does this data set best fit into:

Conceptual Site Model _____

_____

_____

Corrective Measures Design/Implementation _____

_____

_____

Quantitative Risk Assessment _____

_____

_____

Recommendation for Data Entry _____

_____

_____

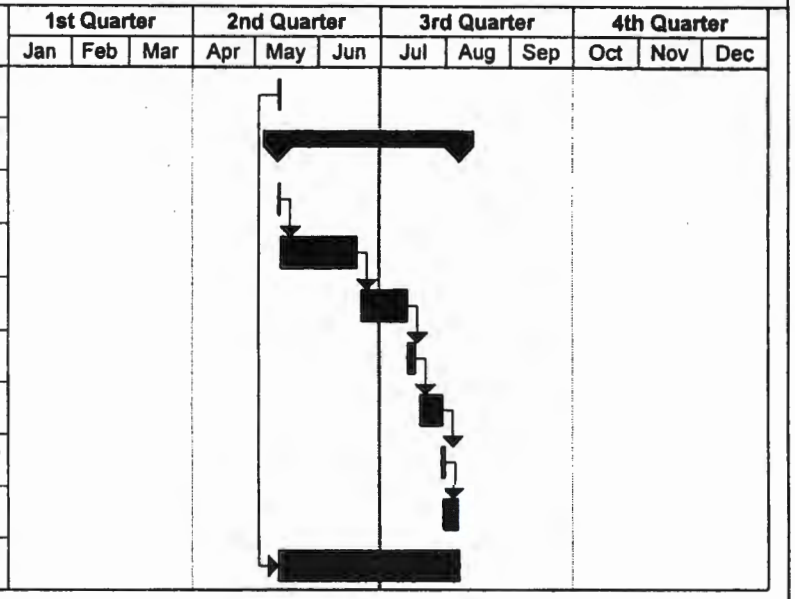
ATTACHMENT 2

MEVA

White Sands Missile Range

Groundwater Modeling Investigations

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | Kickoff Meeting | 1d | 5/13/98 | 5/13/98 |
| 2 | **Data Review and Evaluation** | **62d** | **5/13/98** | **8/7/98** |
| 3 | Kickoff Meeting | 1d | 5/13/98 | 5/13/98 |
| 4 | Prepare Draft Data Evaluation Plan | 26d | 5/14/98 | 6/19/98 |
| 5 | Review/Revise Data Evaluation Plan | 16d | 6/22/98 | 7/13/98 |
| 6 | Data Review | 4d | 7/14/98 | 7/17/98 |
| 7 | Data Evaluation | 9d | 7/20/98 | 7/30/98 |
| 8 | Data Evaluation Meeting | 2d | 7/30/98 | 7/31/98 |
| 9 | Technical Memo | 6d | 7/31/98 | 8/7/98 |
| 10 | Management | 62d | 5/13/98 | 8/7/98 |




Project: WSMR GMI - Task 1
Date: 6/30/98

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

# APPENDIX B

## Database Design Materials

RADIAN INTERNATIONAL
A DAMES & MOORE GROUP COMPANY

**To:** Kyle Williams, MEVATEC

# TECHNICAL MEMORANDUM

**From:** Tracie Lundberg, Radian

**Date:** 28 September 1998

**Subject:** **Final HELSTF Database Design Memo**

## 1.0 Introduction

This memorandum summarizes the approach taken for design of the relational database under the ongoing Groundwater Modeling Investigations at HELSTF project.

The primary goal of the database is to integrate data collected from previous investigations and on-going monitoring programs at HELSTF into a logical, manageable set. The end-product will provide a compilation of spatial and temporal information regarding all of the analytical parameters as they have been defined through previous sampling efforts. This database will allow for quick and accurate visualization that will aid in facilitating future management and design decisions at the HELSTF site. Users will be able to make logical queries based on defined areas, depths, times, specific contaminants, analyte groups, or combinations thereof. The database is being developed with MS Access version 2.0 which will provide easy interaction with ArcView GIS and other visualization tools.

## 2.0 Technical Approach

A hierarchical approach has been chosen for the database design. As illustrated in Attachment A, the top of the hierarchy is represented by the Sample table. The two other main tables, Location table and Results table, are linked to the Sample table through the location identification field and sample identification field, respectively. The Location table provides spatial and physical information about all of the sampling points, while the Results table contains the analytical results of the samples. An array of smaller tables are used to supply further descriptive information for the fields in the three main tables. In general, the architecture has been developed to minimize redundancy while allowing for efficient data storage and querying capabilities.

Each table contains one or more primary key fields (fields designated with asterisks in Attachment A). The primary key field(s) make up a unique identification for each record in a table (i.e., the contents of the primary key field(s) are never repeated in records within the same table). Tables will be indexed by the primary key and other appropriate fields to make querying

more efficient. The remaining fields within a table are non-key fields that contain descriptive information that is not necessarily unique.

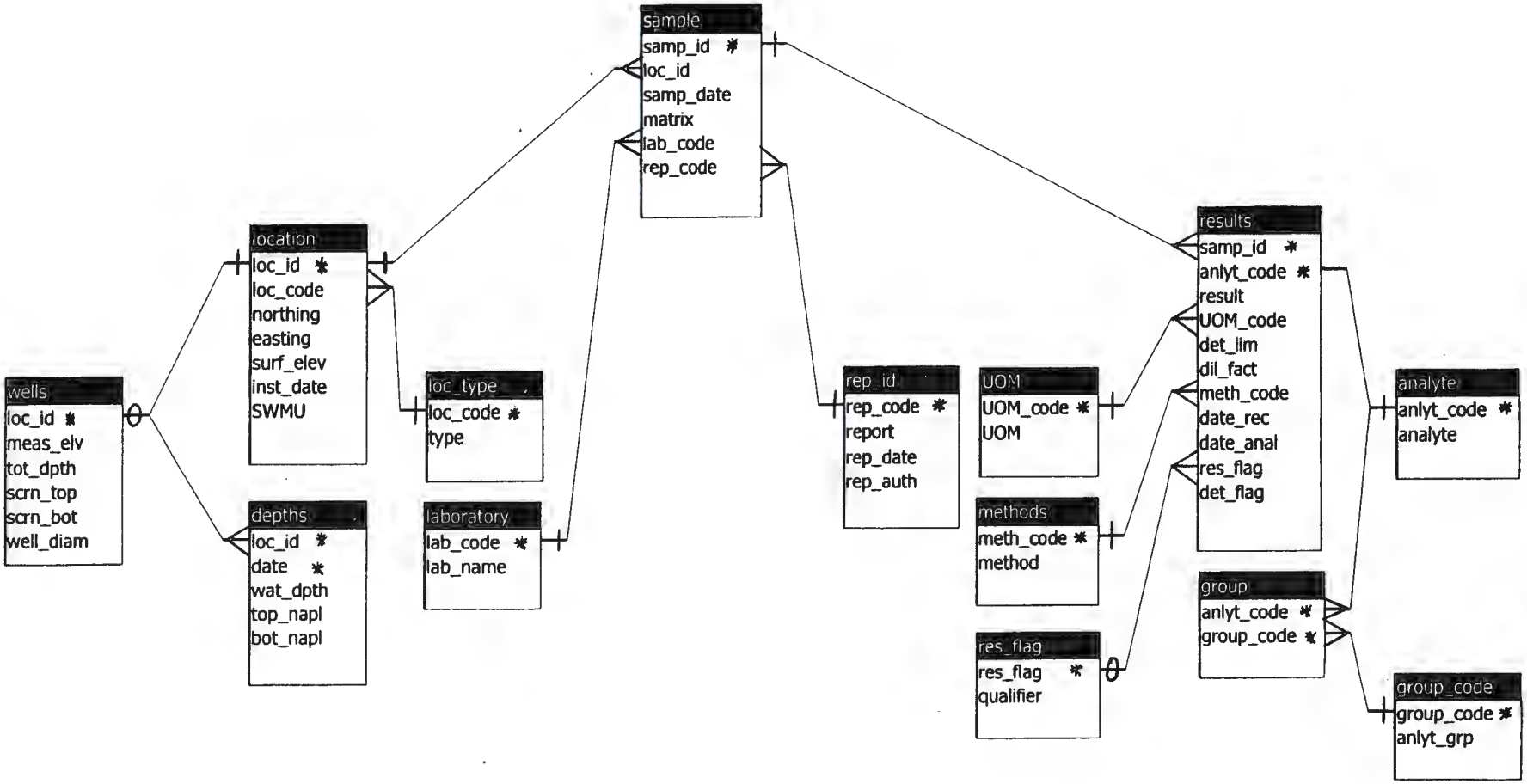
As discussed with Jim Dawson, the database follows field naming conventions used by MEVATEC. These conventions include the following:

- Table and field names are less-than, or equal to 10 characters in length;
- Underscores "_" are used instead of blanks within table and field names;
- Table and field names do not begin with numbers; and
- Filenames follow the "8.3" format for compatibility with a Novell server.

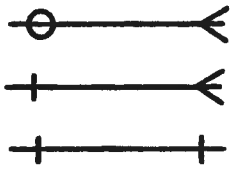
A uniform naming scheme has been used for the fields within each table. Field names ending with "_id" are identification fields that contain specific names (well and borehole names that have been consistently used in previous reports and sample names). Field names ending with "_code" are reserved for internal code integers that are related to a descriptor in another table. All other field names generally consist of a name or abbreviation of the property they describe. Table names are also representative of the type of data they store. A summary of all of the fields within the database has been created using an OLE script within MS Access. This summary is included in this memo as Attachment B. Attachment B provides a listing of all the fields within each table of the database along with descriptions and formatting information. Primary key fields are designated by bold print in Attachment B.

**Attachment A**

Relationships for wsmr2c
Monday, September 28, 1998




**KEY:**



one or zero-to-many

one-to-many

one-to-one

* primary key field

# Attachment B

**TABLE: analyte**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **anlyt_code** | **analyte id code** | **Text** | **50** |
| analyte | analyte | Text | 50 |

**TABLE: depths**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **loc_id** | **location identification** | **Text** | **50** |
| **date** | **date of measurement** | **Date / Time** | **8** |
| wat_dpth | depth to water table from measuring point | Single | 4 |
| top_napl | depth to the NAPL air interface | Single | 4 |
| bot_napl | depth to the NAPL water interface | Single | 4 |

**TABLE: group**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **anlyt_code** | **analyte id code (see analyte table for reference)** | **Text** | **50** |
| **group_code** | **analyte group code (see group-code table for reference)** | **Integer** | **4** |

**TABLE: group_code**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **group_code** | **analyte group code** | **Integer** | **2** |
| anlyt_grp | analyte group | Text | 50 |

**TABLE: laboratory**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **lab_code** | **id code for the lab that performed sample analysis** | **Integer** | **2** |
| lab_name | laboratory name | Text | 50 |

**TABLE: loc_type**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **loc_code** | **location type code** | **Integer** | **50** |
| type | type of location for loc_code | Text | 50 |

**TABLE: location**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **loc_id** | **location identification** | **Text** | **50** |
| loc_code | location type code (i.e, pump well, monitor well, borehole, etc.) defined in loc_type table | Integer | 2 |
| northing | northing in NM State Plane Coordinates (meters) | Single | 4 |
| easting | easting in NM State Plane Coordinates (meters) | Single | 4 |

| | | | |
|---|---|---|---|
| surf_elev | elevation at ground surface of sample point reference to NAVD 1988 (feet) | Single | 4 |
| inst_date | installation date of well/borehole | Date / Time | 8 |
| SWMU | specific SWMU for location | Text | 2 |

**TABLE: methods**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **meth_code** | **code for analytical method used** | **Integer** | **2** |
| method | analytical method | Text | 50 |

**TABLE: rep_id**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **rep_code** | **id code for the report of origin for sampling data** | **Integer** | **2** |
| report | title of report | Text | 200 |
| rep_date | date of report | Date / Time | 8 |
| rep_auth | author of report | Text | 50 |

**TABLE: res_flag**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **res_flag** | **code for result flag** | **Text** | **50** |
| qualifier | lab qualifier for result flag | Text | 200 |

**TABLE: results**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **samp_id** | **unique sample name** | **Text** | **20** |
| **anlyt_code** | **analyte id code (see analyte table for reference)** | **Text** | **80** |
| result | results of analysis provided in UOM units | Single | 4 |
| UOM_code | unit of measure code (see UOM table for reference) | Integer | 2 |
| det_lim | limit of detection/reporting limit | Single | 4 |
| dil_fact | lab dilution factor | Single | 4 |
| meth_code | code for analytical method used (see methods table for reference) | Integer | 2 |
| date_rec | date sample received by lab | Date / Time | 8 |
| date_anal | date sample analyzed | Date / Time | 8 |
| res_flag | results flag | Text | 50 |
| det_flag | detection flag | Text | 50 |

**TABLE: sample**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **samp_id** | **unique sample name** | **Text** | **30** |
| loc_id | location identification | Text | 50 |
| samp_date | date sample was collected | Date / | 8 |

| | | | |
|---|---|---|---|
| | | Time | |
| matrix | sample matrix | Text | 50 |
| lab_code | lab identification code (see lab_id table for reference) | Integer | 4 |
| rep_code | report id code (see rep_id table for reference) | Integer | 4 |

**TABLE: UOM**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **UOM_code** | **units-of-measure code** | **Integer** | **2** |
| UOM | units-of-measure of analysis results and detection limits | Text | 50 |

**TABLE: wells**

| NAME | DESCRIPTION | TYPE | SIZE |
|---|---|---|---|
| **loc_id** | **location identification** | **Text** | **50** |
| meas_elv | elevation of measuring point | Single | 4 |
| tot_dpth | total depth of well/boring | Single | 4 |
| scrn_top | depth of top of screened interval in feet | Single | 4 |
| scrn_bot | depth of bottom of screened interval in feet | Single | 4 |
| well_diam | diameter of well casing (inches), if applicable | Single | 4 |
| well_mat | well casing material, if applicable | Text | 50 |

# APPENDIX C

## Initial Visualization Meeting Presentation

WHITE SANDS MISSILE RANGE
BIRTHPLACE OF AMERICA'S MISSILE & SPACE ACTIVITY
High Energy Laser System Test Facility
Data Visualization
MEVATEC CORPORATION
DCM GROUP
RADIAN INTERNATIONAL
A DAMES & MOORE GROUP COMPANY

# *Overall Purpose for Meeting*

Review existing data to determine future direction at the High Energy Laser System Test Facility

# *Meeting Objectives*

- What does the site look like?
  - Spatially visualize the data
- What do the data mean?
  - Discuss what is happening at the site
- What is the next step?
  - Cost-effective options

# *Project Status*

- Goals and Progress
- Status of Database
- Status of GIS

# *Goals and Progress*

Overall Goal:

- Selection of Ultimate Remedial Action

Progress Toward Goal:

- Task 1 - Data Review and Evaluation
- Task 2 - Database Development
- Task 3 - Data Visualization and Modeling

# *Status of Database*

- MS Access database
- Database is 99% complete (QC in progress)
- Database contains over 64,000 records
  - Phase I RFI Report
  - Phase II RFI Report
  - SWMU Assessment Report
  - USGS Quarterly Monitoring
  - Groundwater Quality Investigation Report (ESE)
  - Latest LTM data (April, 1998; Oct., 1998)

# *Status of GIS*

- GIS created using ArcView
- Effective ODBC links to MS Access database
- Coverages for potentiometric surfaces
  - Upper and lower perched water-bearing zones
  - Regional aquifer
- Coverages for groundwater contaminants
  - Hexavalent chromium
  - TCE
  - Benzene (indicative of diesel)

# *Conceptual Site Model*

# *Conceptual Site Model*

What is a Conceptual Site Model (CSM)?

- Visual representation of the site
  - Connection between results and locations
  - Relationship of contamination to site features
  - Easy identification of data gaps
- Illustrates contamination and movement over time
- Identifies source areas and hot spots
- Identifies receptors and exposure pathways
- Evolves with new data

# *Preliminary HELSTF CSM*

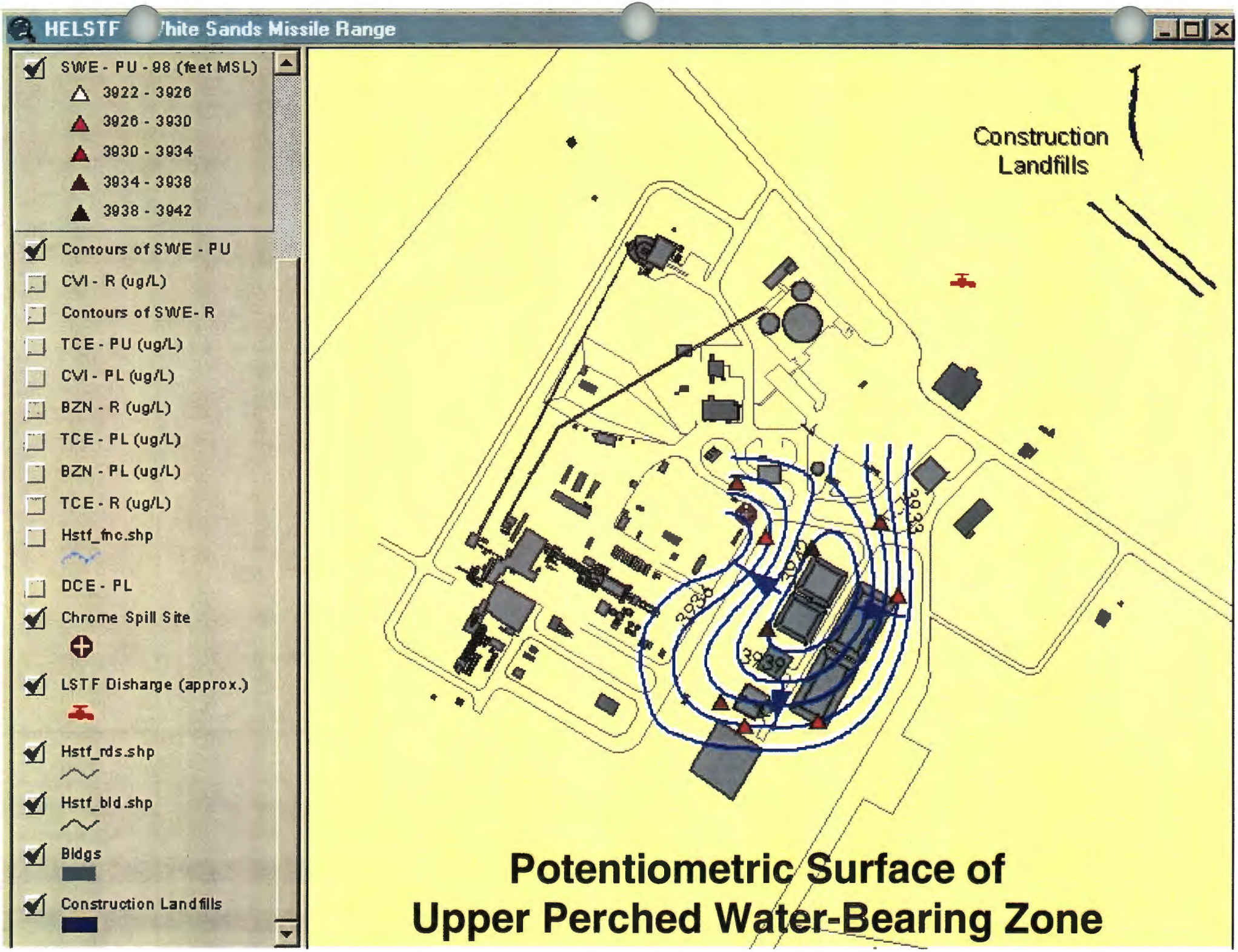
Current Features:

- Site layout (infrastructure)
  - Roads
  - Buildings
  - Boundaries
  - Well and boring locations
- Interpolation of groundwater contours
- Results of past investigations

# *Site Groundwater Features*

## Upper Perched Water-Bearing Zone

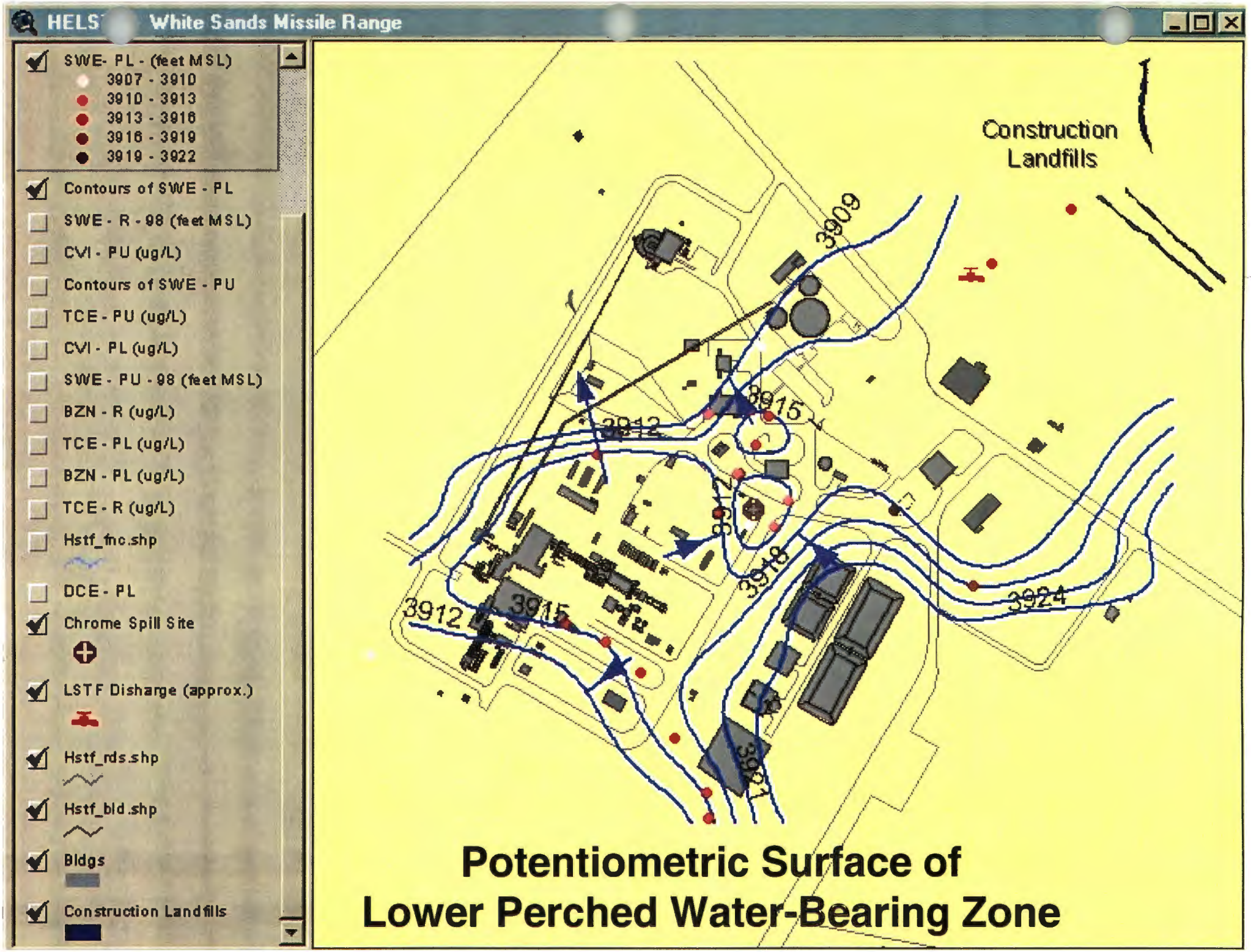
- Mound under SWMUs 27 and 28
  - Below sewage lagoons
- Flow direction: Radial flow away from mound
- Upper perched zone 13-22 feet below ground surface (BGS)
- 9 wells screened in the upper perched interval


HELSTF White Sands Missile Range
SWE - PU - 98 (feet MSL)
3922 - 3926
3926 - 3930
3930 - 3934
3934 - 3938
3938 - 3942
Contours of SWE - PU
CVI - R (ug/L)
Contours of SWE- R
TCE - PU (ug/L)
CVI - PL (ug/L)
BZN - R (ug/L)
TCE - PL (ug/L)
BZN - PL (ug/L)
TCE - R (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Dishange (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
3922
3926
3930
3934
Potentiometric Surface of
Upper Perched Water-Bearing Zone

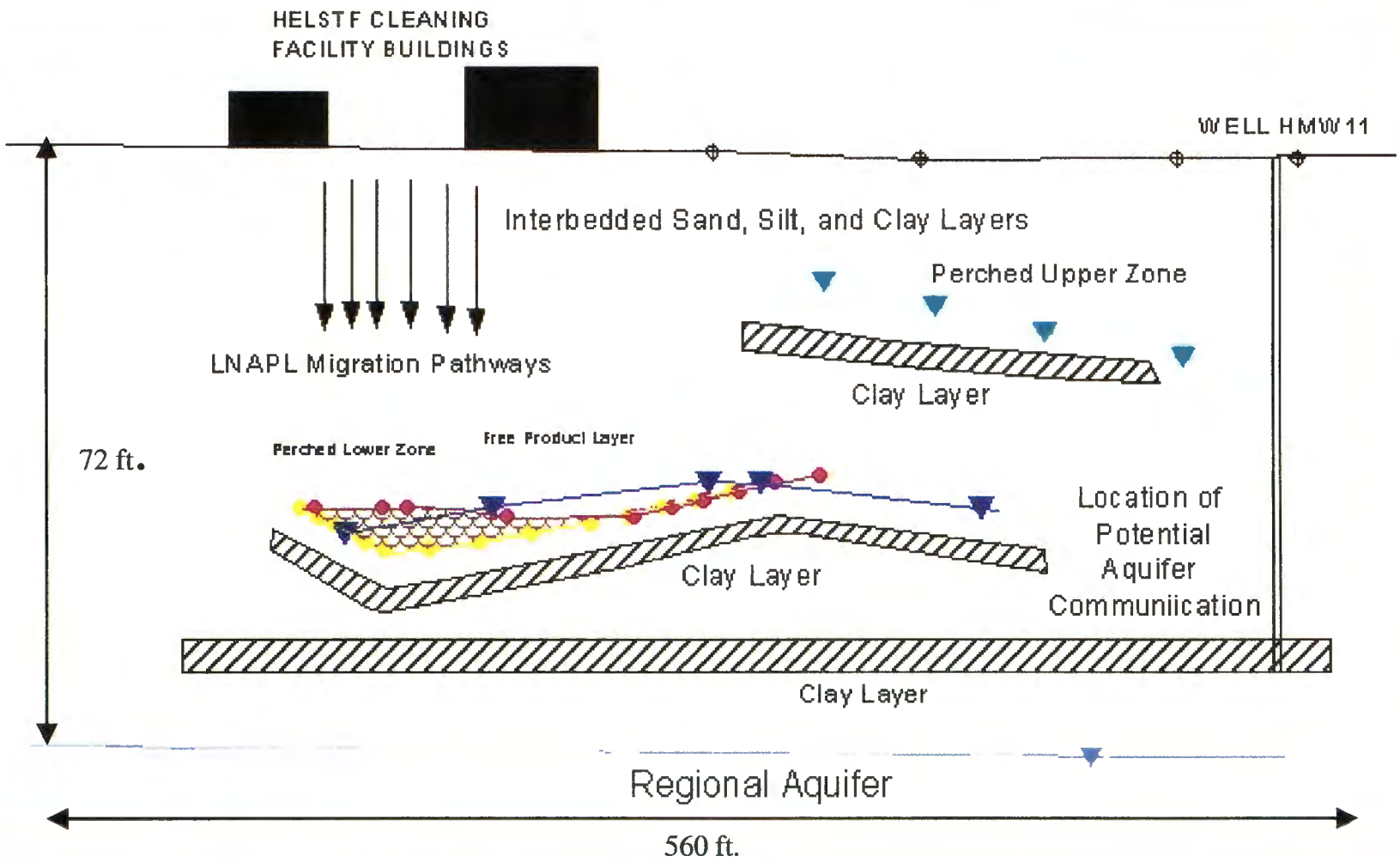
# *Site Groundwater Features*

## Lower Perched Water-Bearing Zone

- Location of lower perched zone not as well defined
- Possible groundwater sink in lower perched zone
  - Communication with regional aquifer
  - Between SWMUs 143 (Cr Spill) and 154 (Diesel Spill)
- Flow direction: No defined gradient
- Lower perched zone 40 - 50 feet BGS
- 21 wells screened in lower-perched interval


HELS
White Sands Missile Range
SWE- PL - (feet MSL)
3907 - 3910
3910 - 3913
3913 - 3916
3916 - 3919
3919 - 3922
Contours of SWE - PL
SWE - R - 98 (feet MSL)
CVI - PU (ug/L)
Contours of SWE - PU
TCE - PU (ug/L)
CVI - PL (ug/L)
SWE - PU - 98 (feet MSL)
BZN - R (ug/L)
TCE - PL (ug/L)
BZN - PL (ug/L)
TCE - R (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
3909
3912
3915
3918
3921
3924
Potentiometric Surface of
Lower Perched Water-Bearing Zone

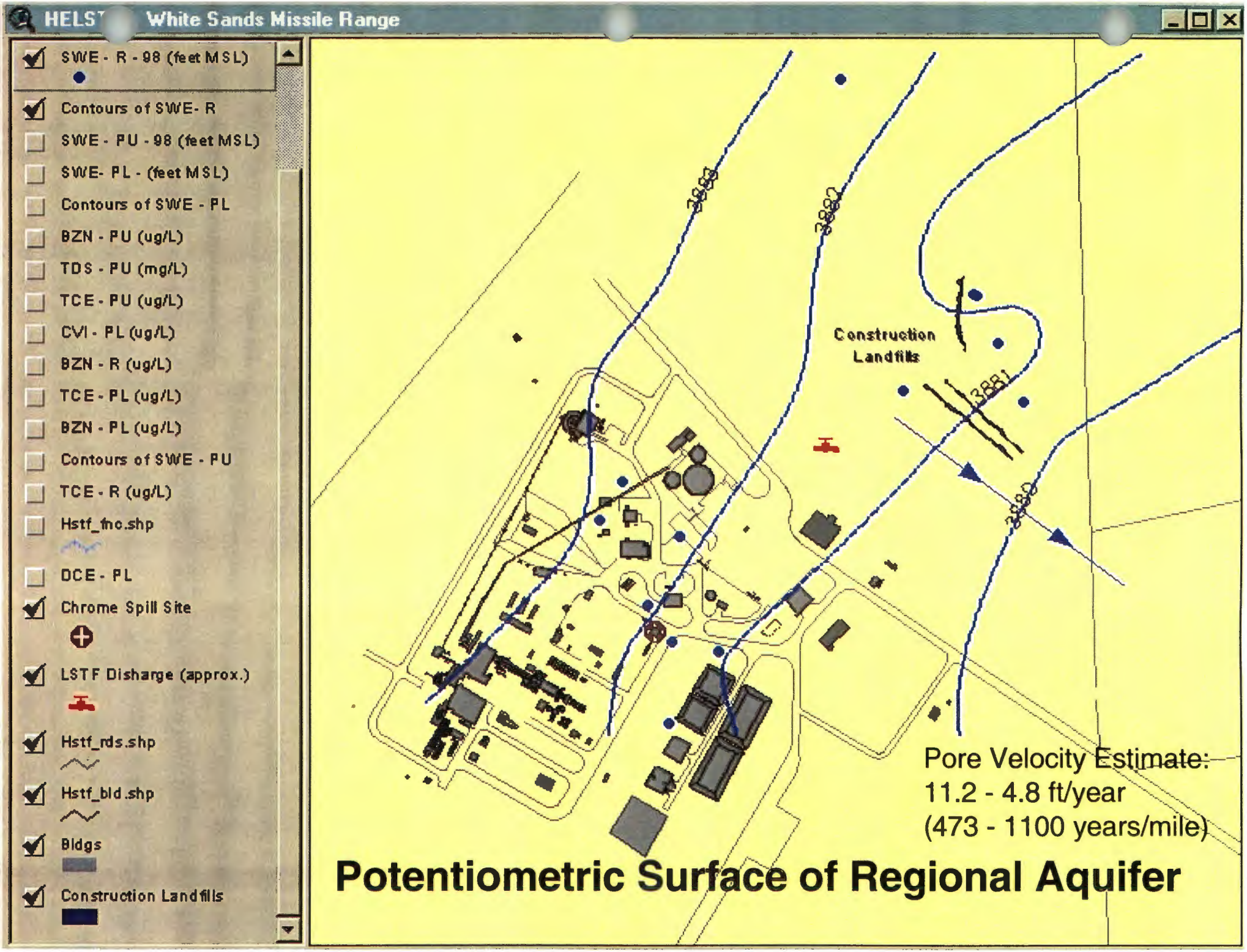
# Subsurface Cross-section - Lower Perched Unit (Diesel Spill)



# *Site Groundwater Features*

## Regional Aquifer

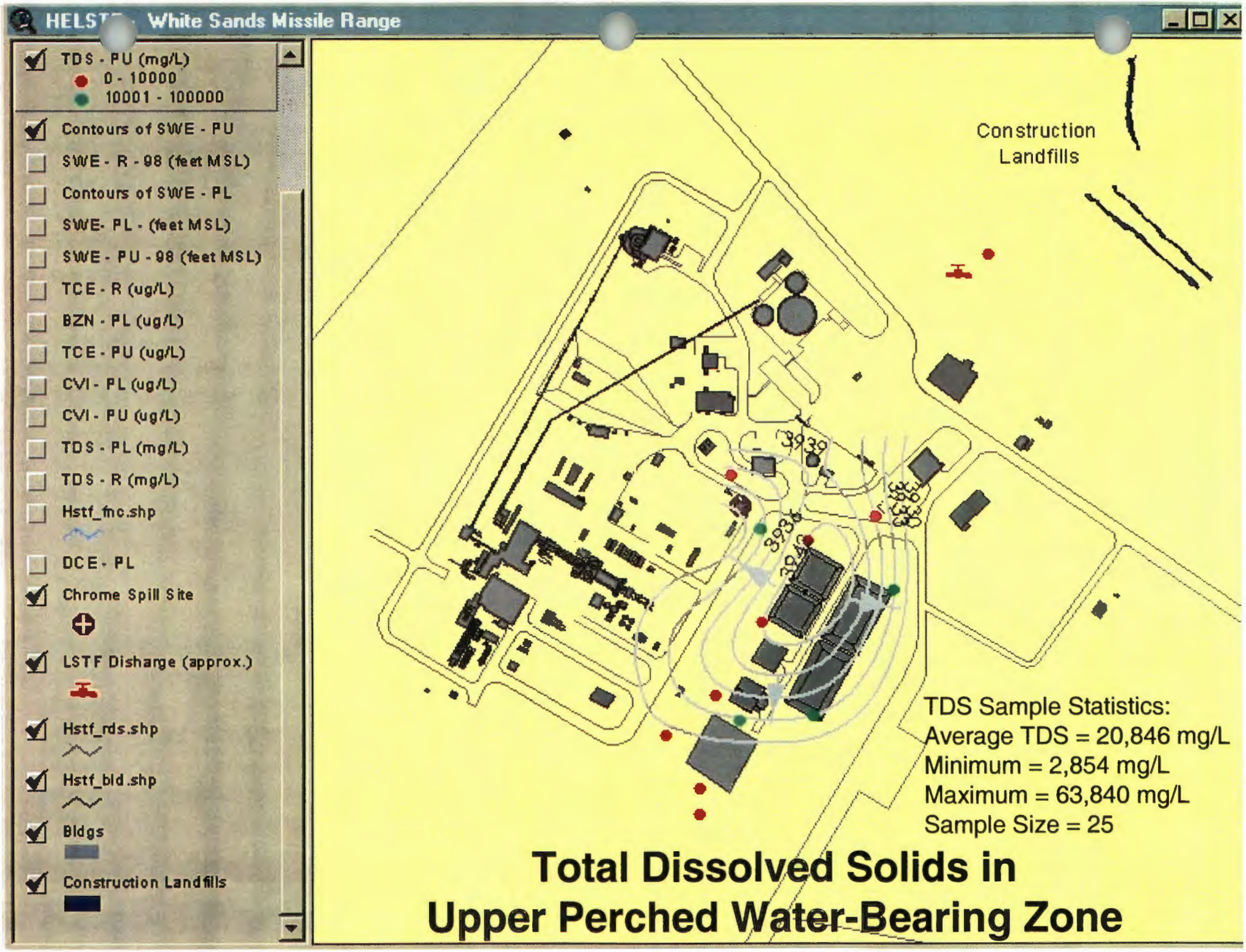
- Potentiometric surface of regional unit 75 feet BGS
- Regional flow direction: gradient is to the Southeast
- 9 wells screened in regional aquifer

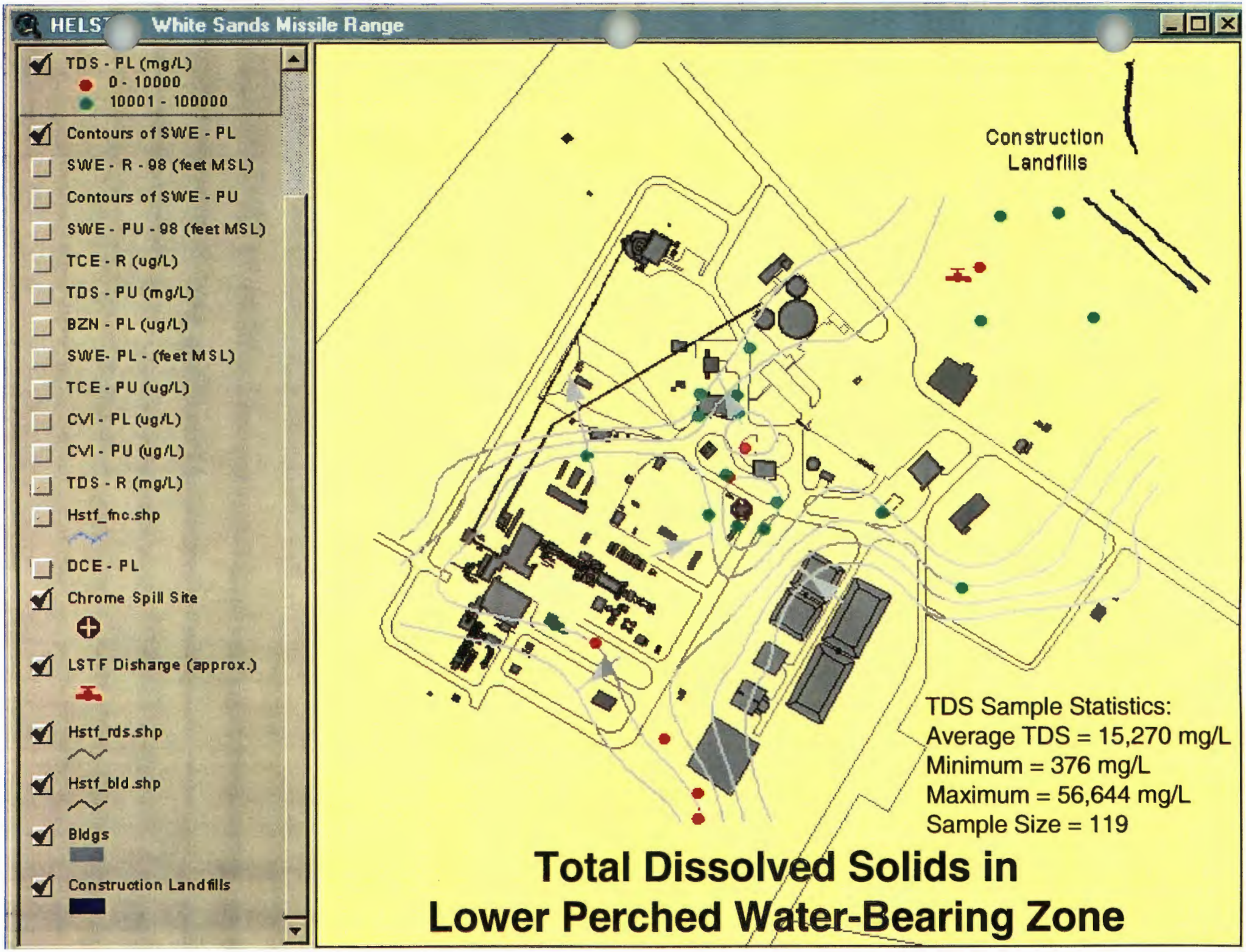

HELST
White Sands Missile Range
SWE - R - 98 (feet MSL)
Contours of SWE- R
SWE - PU - 98 (feet MSL)
SWE- PL - (feet MSL)
Contours of SWE - PL
BZN - PU (ug/L)
TDS - PU (mg/L)
TCE - PU (ug/L)
CVI - PL (ug/L)
BZN - R (ug/L)
TCE - PL (ug/L)
BZN - PL (ug/L)
Contours of SWE - PU
TCE - R (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
3883
3882
3881
3880
Construction Landfills
Pore Velocity Estimate:
11.2 - 4.8 ft/year
(473 - 1100 years/mile)
Potentiometric Surface of Regional Aquifer

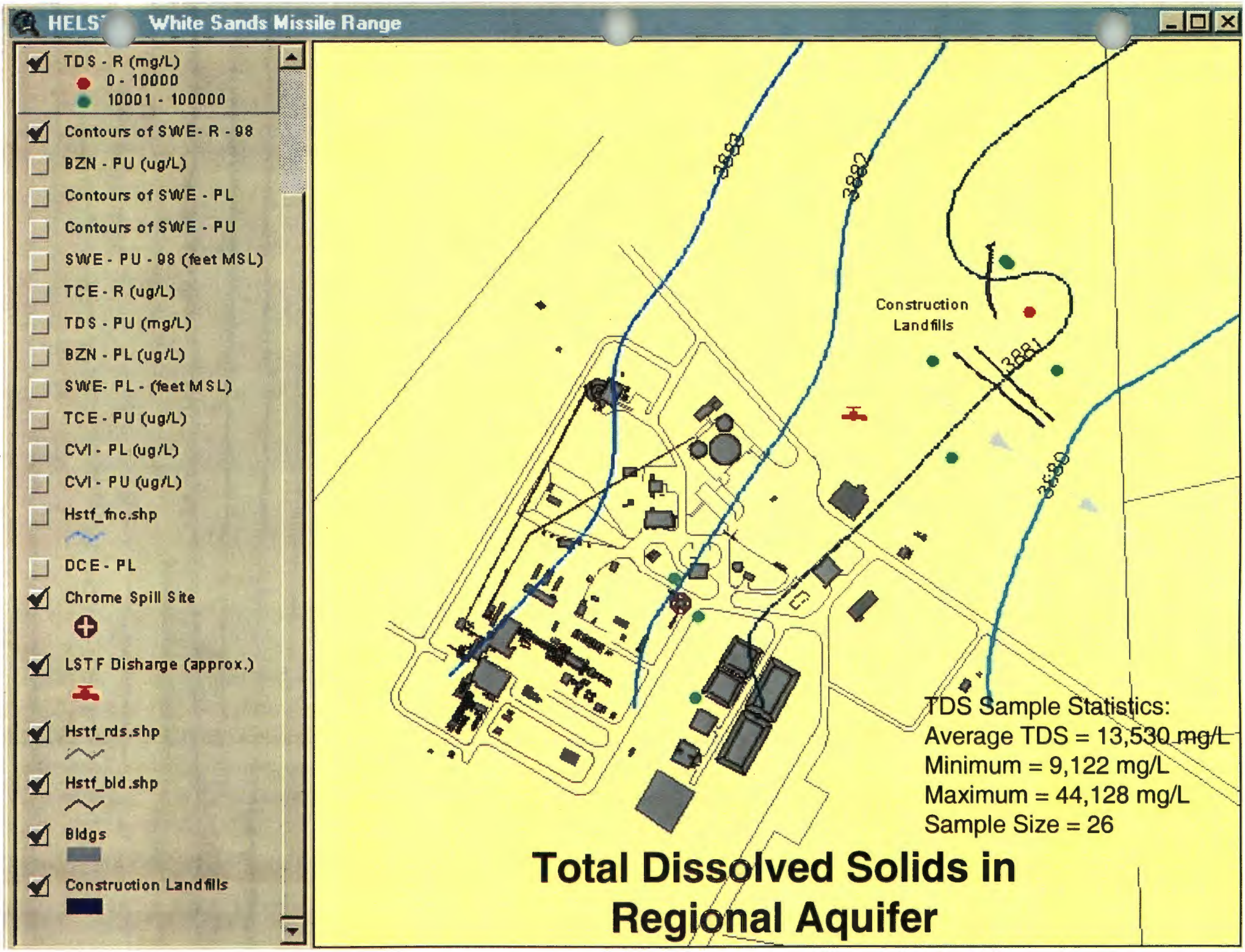
# *Total Dissolved Solids (TDS)*

TDS > 10,000 mg/L across most of site

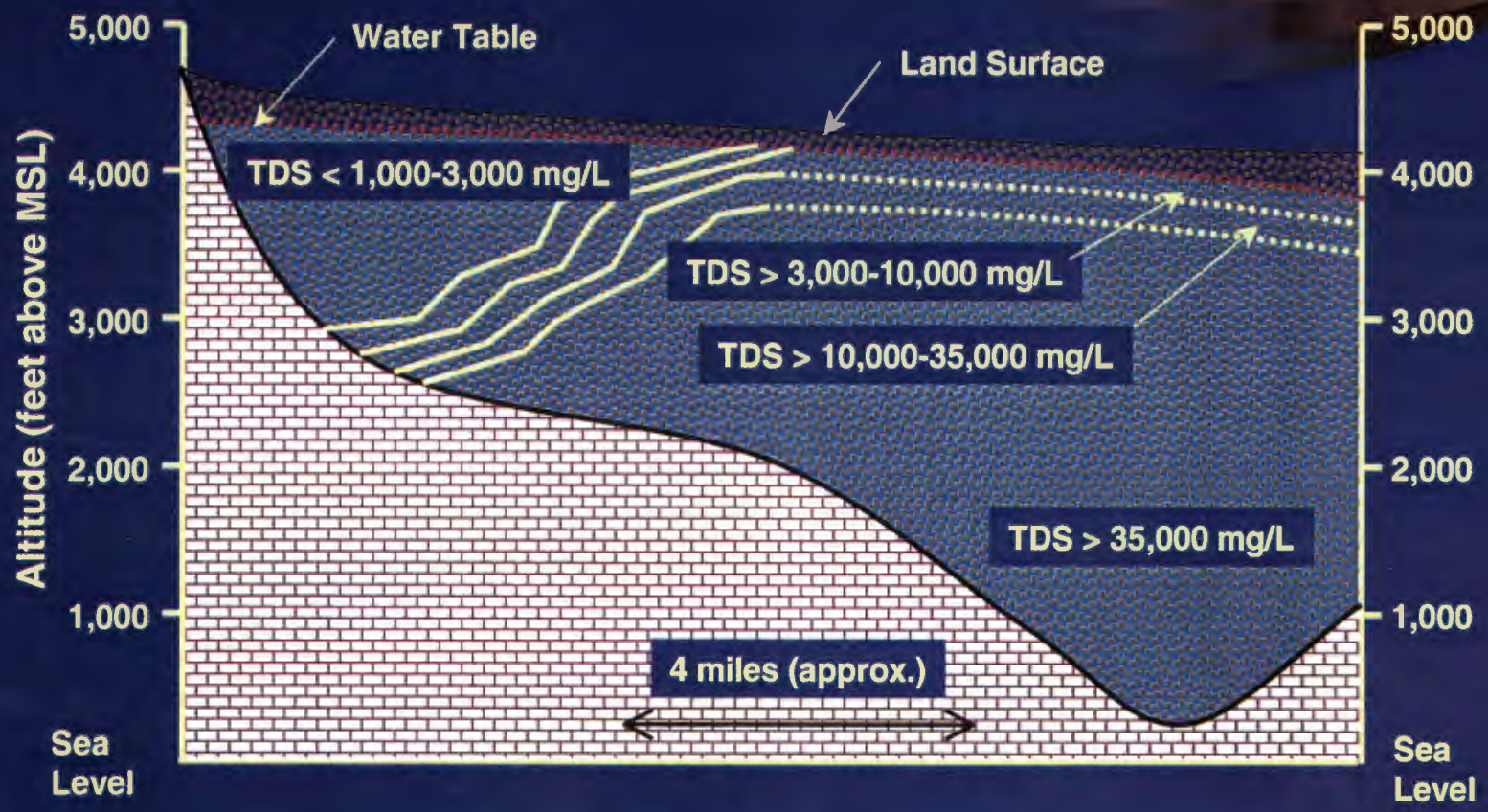
- Classifies groundwater as Class III
  - Non-potable water source
  - No drinking water pathway


HELST White Sands Missile Range
TDS - PU (mg/L)
0 - 10000
10001 - 100000
Contours of SWE - PU
SWE - R - 98 (feet MSL)
Contours of SWE - PL
SWE- PL - (feet MSL)
SWE - PU - 98 (feet MSL)
TCE - R (ug/L)
BZN - PL (ug/L)
TCE - PU (ug/L)
CVI - PL (ug/L)
CVI - PU (ug/L)
TDS - PL (mg/L)
TDS - R (mg/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction
Landfills
3939
3938
3940
TDS Sample Statistics:
Average TDS = 20,846 mg/L
Minimum = 2,854 mg/L
Maximum = 63,840 mg/L
Sample Size = 25
Total Dissolved Solids in
Upper Perched Water-Bearing Zone


HELST
White Sands Missile Range
TDS - PL (mg/L)
0 - 10000
10001 - 100000
Contours of SWE - PL
SWE - R - 98 (feet MSL)
Contours of SWE - PU
SWE - PU - 98 (feet MSL)
TCE - R (ug/L)
TDS - PU (mg/L)
BZN - PL (ug/L)
SWE- PL - (feet MSL)
TCE - PU (ug/L)
CVI - PL (ug/L)
CVI - PU (ug/L)
TDS - R (mg/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
TDS Sample Statistics:
Average TDS = 15,270 mg/L
Minimum = 376 mg/L
Maximum = 56,644 mg/L
Sample Size = 119
Total Dissolved Solids in
Lower Perched Water-Bearing Zone


HELS White Sands Missile Range
TDS - R (mg/L)
0 - 10000
10001 - 100000
Contours of SWE- R - 98
BZN - PU (ug/L)
Contours of SWE - PL
Contours of SWE - PU
SWE - PU - 98 (feet MSL)
TCE - R (ug/L)
TDS - PU (mg/L)
BZN - PL (ug/L)
SWE- PL - (feet MSL)
TCE - PU (ug/L)
CVI - PL (ug/L)
CVI - PU (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
3880
3881
Construction
Landfills
TDS Sample Statistics:
Average TDS = 13,530 mg/L
Minimum = 9,122 mg/L
Maximum = 44,128 mg/L
Sample Size = 26
Total Dissolved Solids in
Regional Aquifer

# *Basin TDS Trends*



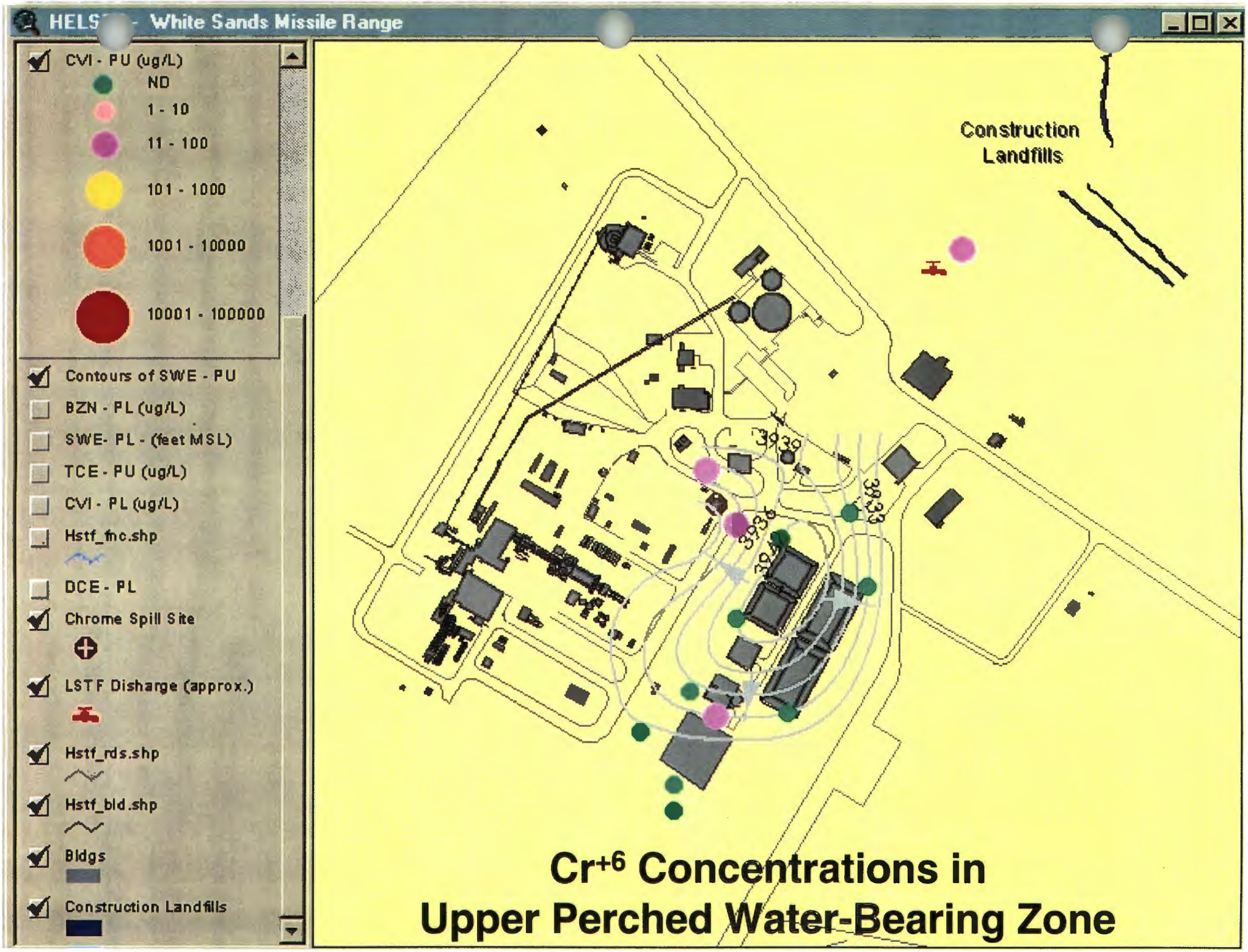

Diagrammatic Water Quality Section at HELSTF (looking North)

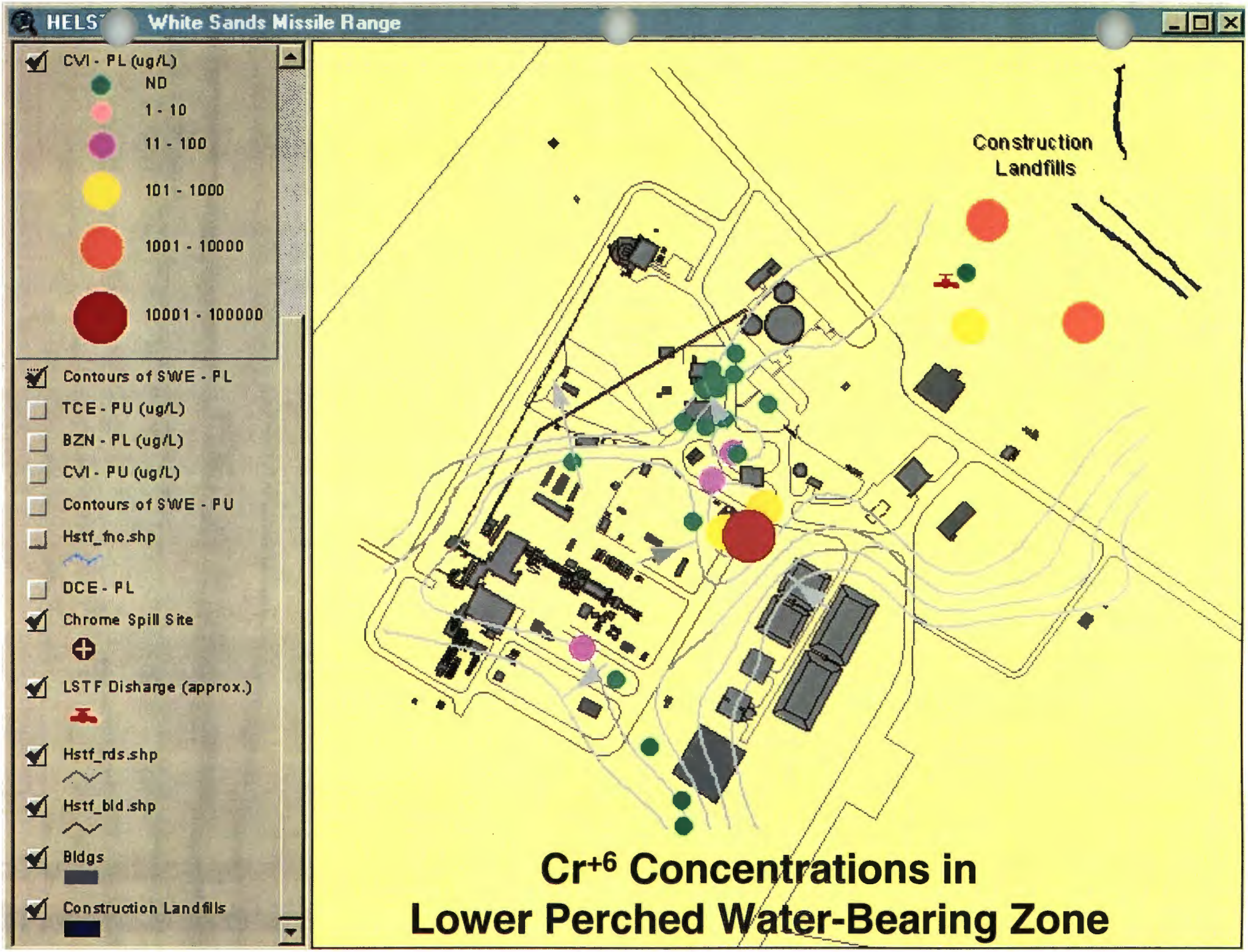
(adapted from USGS WRIR 93-4192, Basabilvazo et al., 1994)

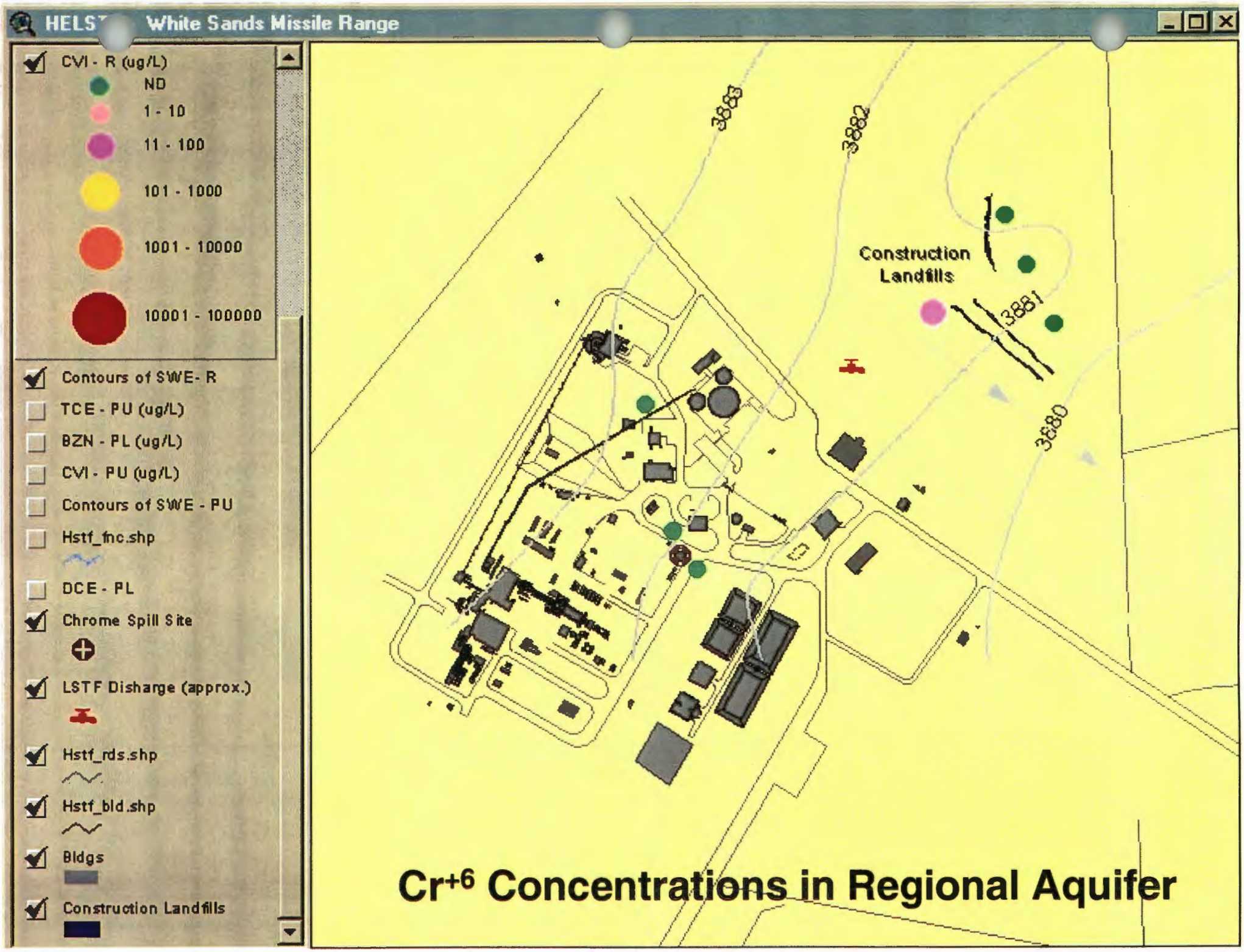
# *Groundwater Contaminants*

# *Hexavalent Chromium*

- Discrete contamination areas in perched zones
  - SWMU 143 - Chromium Spill Site
  - SWMU 38/39 - Construction Landfills
  - SWMU 146 - Dry Pond
  - SWMU 145 - Test Cell 4 Lagoon
- Highest concentrations in lower perched zone
- $Cr^{6+}$ detection in one well in regional aquifer (landfill area)
- MCL = 100 μg/L

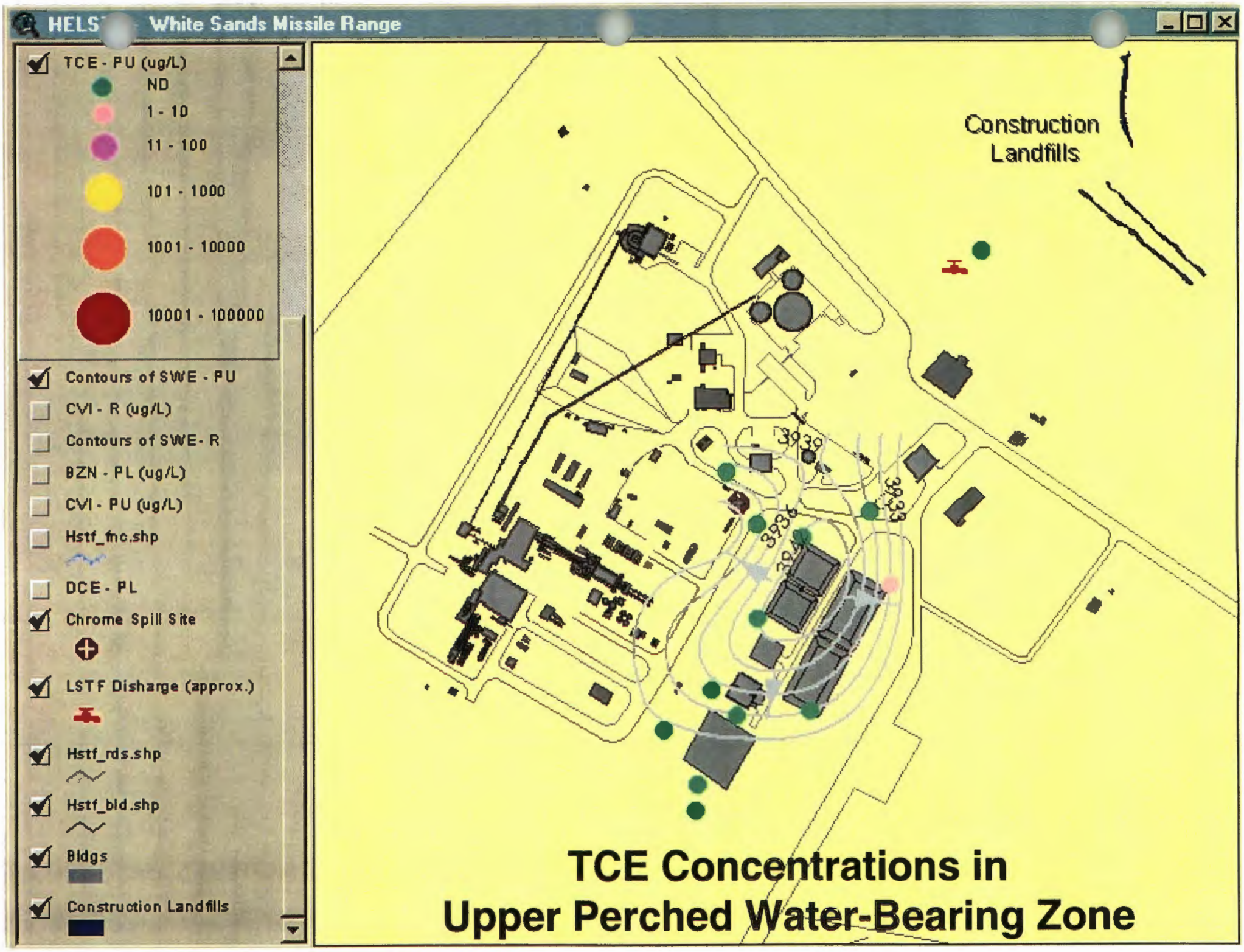

HELS - White Sands Missile Range
CVI - PU (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE - PU
BZN - PL (ug/L)
SWE- PL - (feet MSL)
TCE - PU (ug/L)
CVI - PL (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
3939
3936
3933
Cr+6 Concentrations in
Upper Perched Water-Bearing Zone

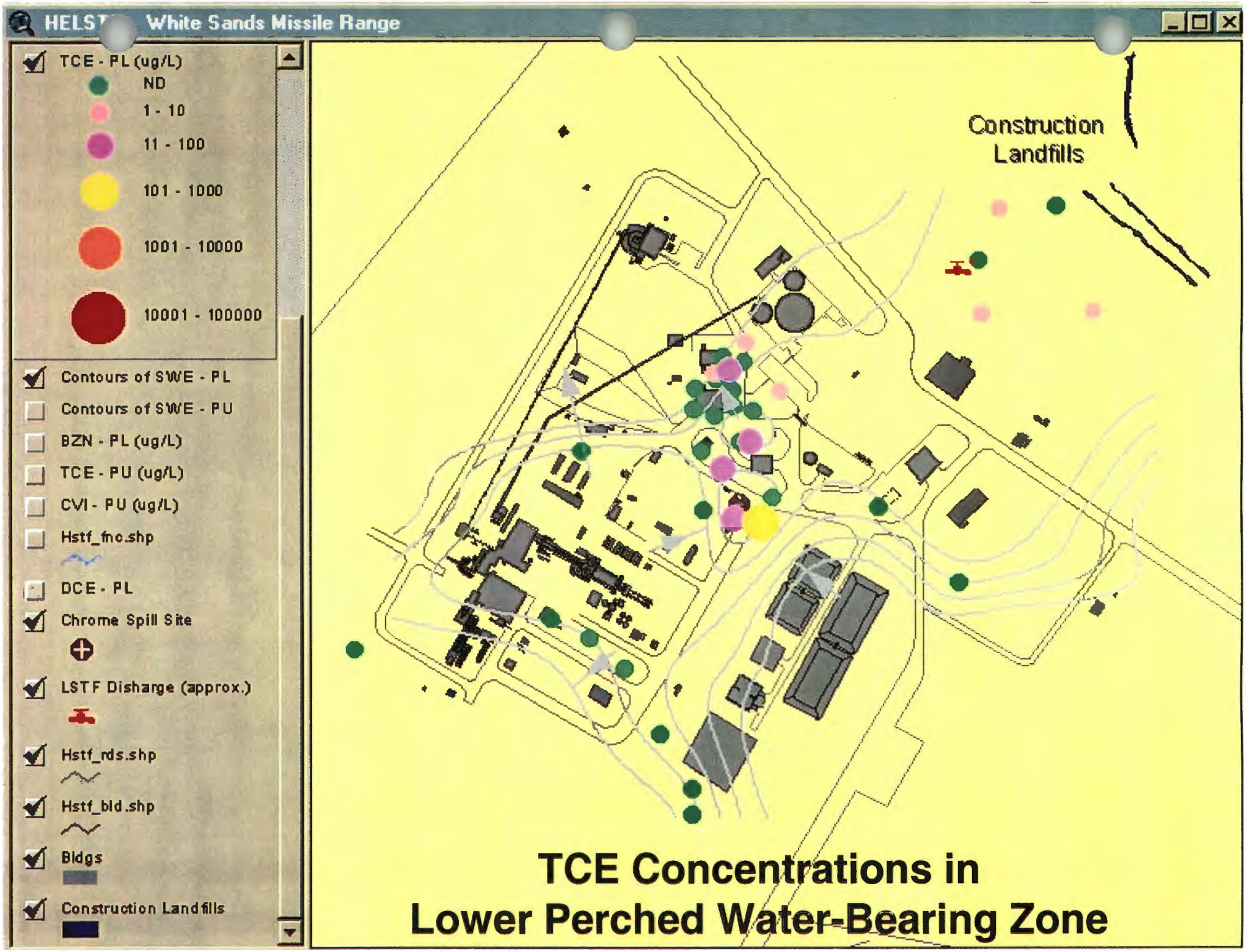

HELS
White Sands Missile Range
CVI - PL (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE - PL
TCE - PU (ug/L)
BZN - PL (ug/L)
CVI - PU (ug/L)
Contours of SWE - PU
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Discharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
Cr+6 Concentrations in
Lower Perched Water-Bearing Zone

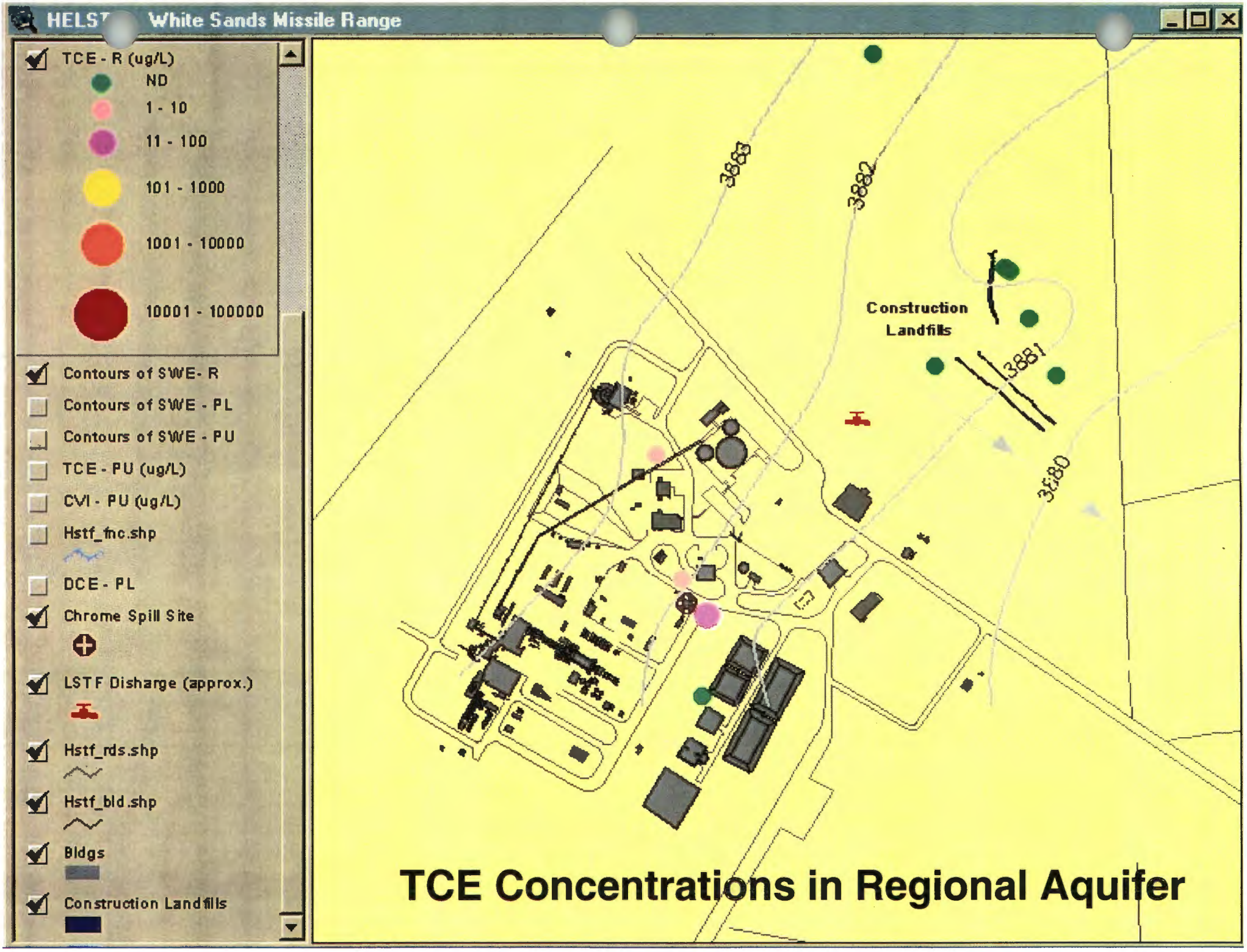

HELST White Sands Missile Range
CVI - R (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE- R
TCE - PU (ug/L)
BZN - PL (ug/L)
CVI - PU (ug/L)
Contours of SWE - PU
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
3883
3882
3881
3880
Construction Landfills
Cr+6 Concentrations in Regional Aquifer

# *TCE*

- No significant levels in upper perched water-bearing zone
- Focused in lower perched water-bearing zone
- Highest levels located near groundwater sink
  - Hits in regional aquifer below location of sink
- MCL = 5 μg/L

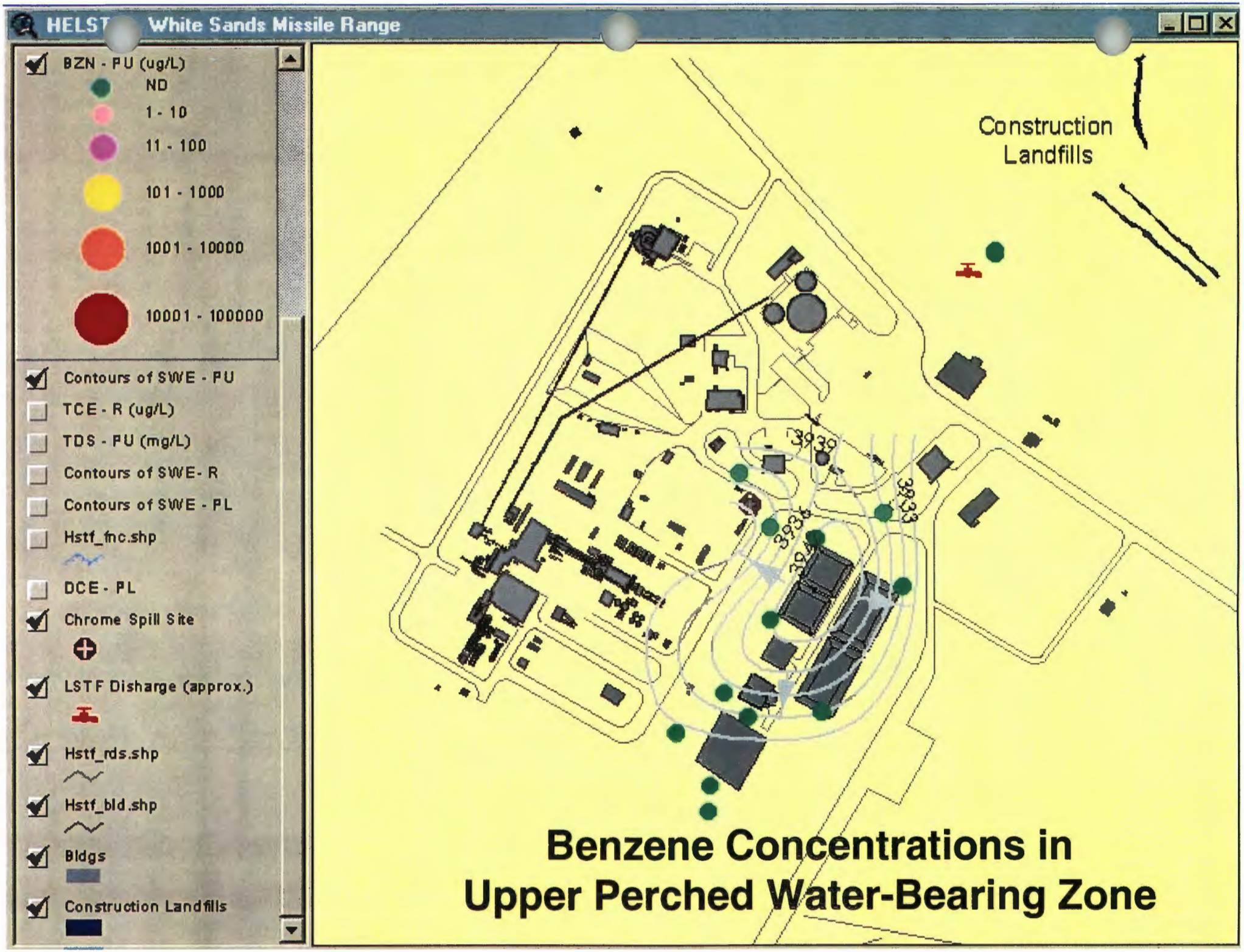

HELS White Sands Missile Range
TCE - PU (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE - PU
CVI - R (ug/L)
Contours of SWE- R
BZN - PL (ug/L)
CVI - PU (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
3939
3936
3933
TCE Concentrations in
Upper Perched Water-Bearing Zone

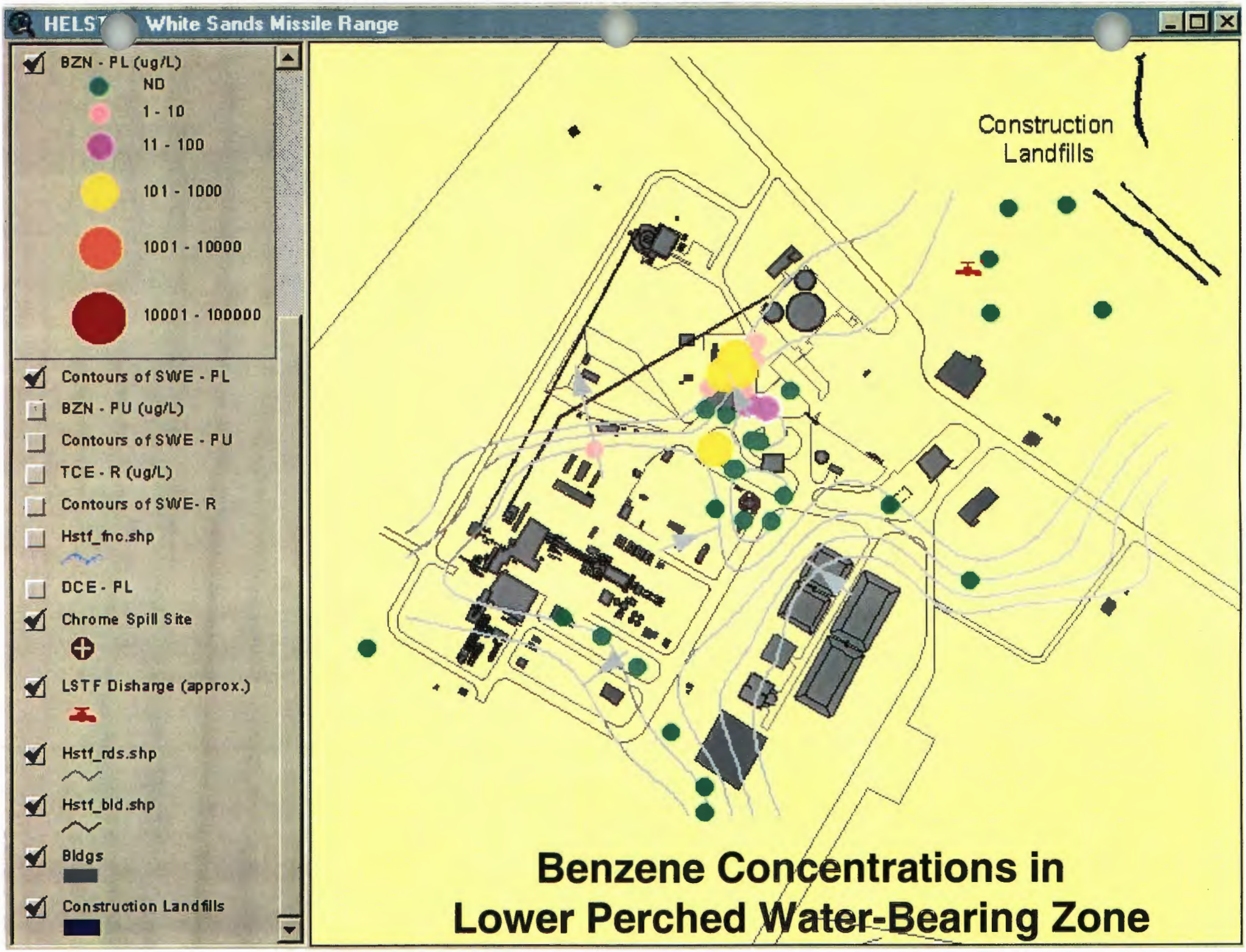

HELST White Sands Missile Range
TCE - PL (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE - PL
Contours of SWE - PU
BZN - PL (ug/L)
TCE - PU (ug/L)
CVI - PU (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction Landfills
TCE Concentrations in
Lower Perched Water-Bearing Zone

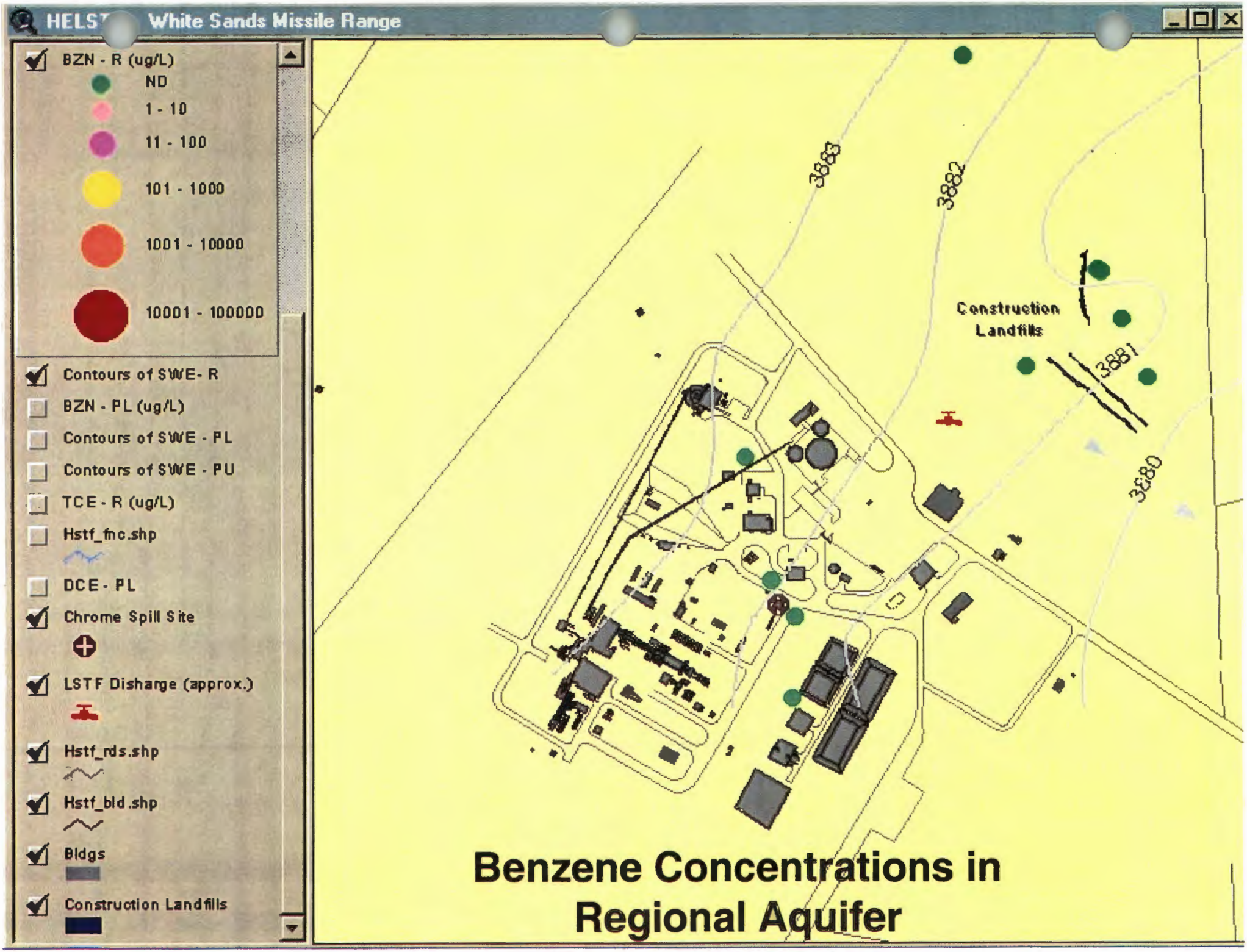

HELST
White Sands Missile Range
TCE - R (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE- R
Contours of SWE - PL
Contours of SWE - PU
TCE - PU (ug/L)
CVI - PU (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
3883
3882
3881
3880
Construction
Landfills
TCE Concentrations in Regional Aquifer

# *Benzene*

- Benzene is indicative of diesel and is the risk driver in diesel
- MCL = 5 μg/L
- Centered around SWMU 154
- Only present in Lower Perched Unit
- Highest levels occur under Cleaning Facility (200 μg/L)


HELST
White Sands Missile Range
BZN - PU (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE - PU
TCE - R (ug/L)
TDS - PU (mg/L)
Contours of SWE- R
Contours of SWE - PL
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction
Landfills
3939
3933
3936
3934
Benzene Concentrations in
Upper Perched Water-Bearing Zone

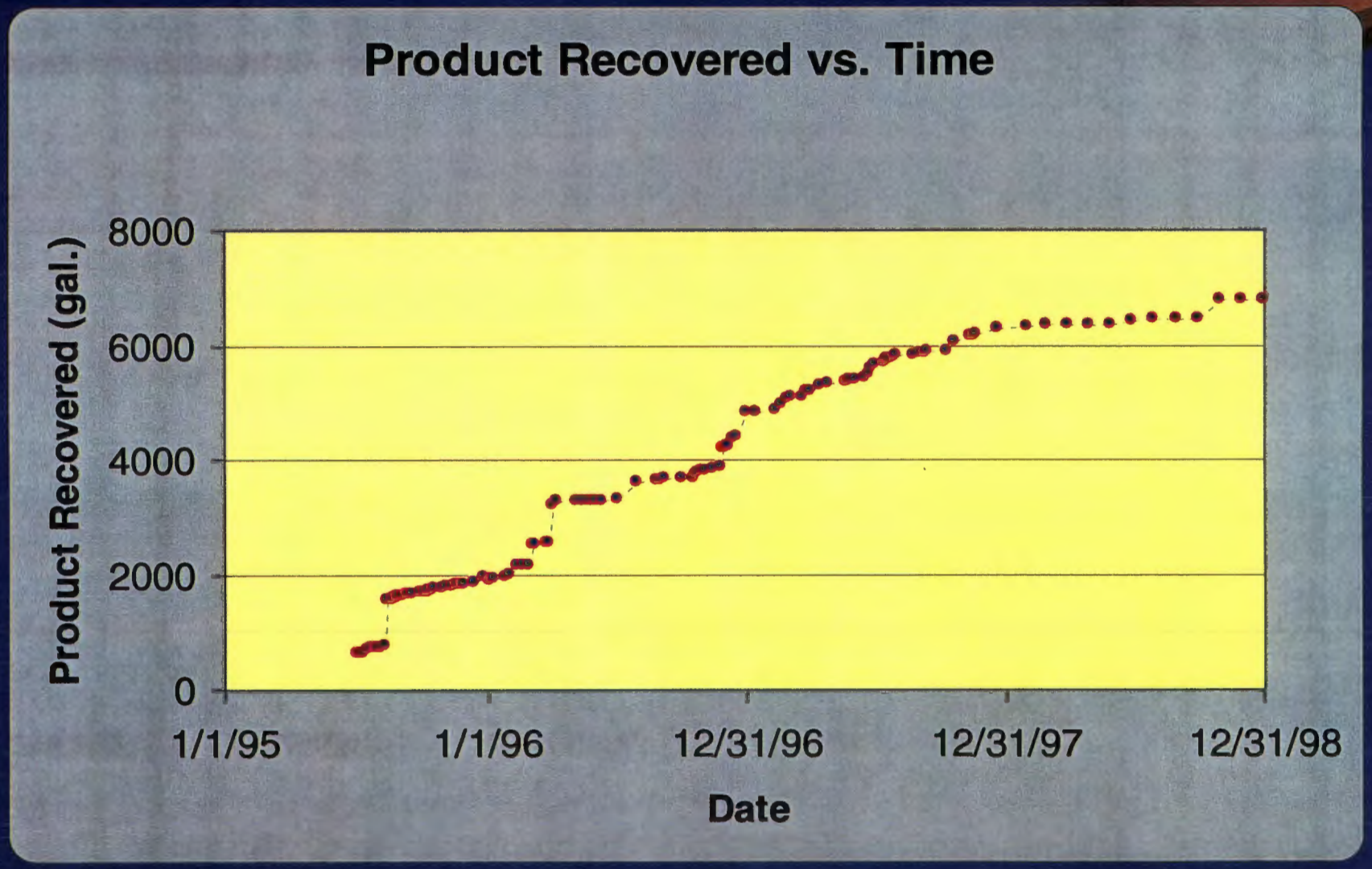

HELST
White Sands Missile Range
BZN - PL (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE - PL
BZN - PU (ug/L)
Contours of SWE - PU
TCE - R (ug/L)
Contours of SWE- R
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
Construction
Landfills
Benzene Concentrations in
Lower Perched Water-Bearing Zone


HELST White Sands Missile Range
BZN - R (ug/L)
ND
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Contours of SWE- R
BZN - PL (ug/L)
Contours of SWE - PL
Contours of SWE - PU
TCE - R (ug/L)
Hstf_fnc.shp
DCE - PL
Chrome Spill Site
LSTF Disharge (approx.)
Hstf_rds.shp
Hstf_bld.shp
Bldgs
Construction Landfills
3883
3882
3881
3880
Construction Landfills
Benzene Concentrations in Regional Aquifer

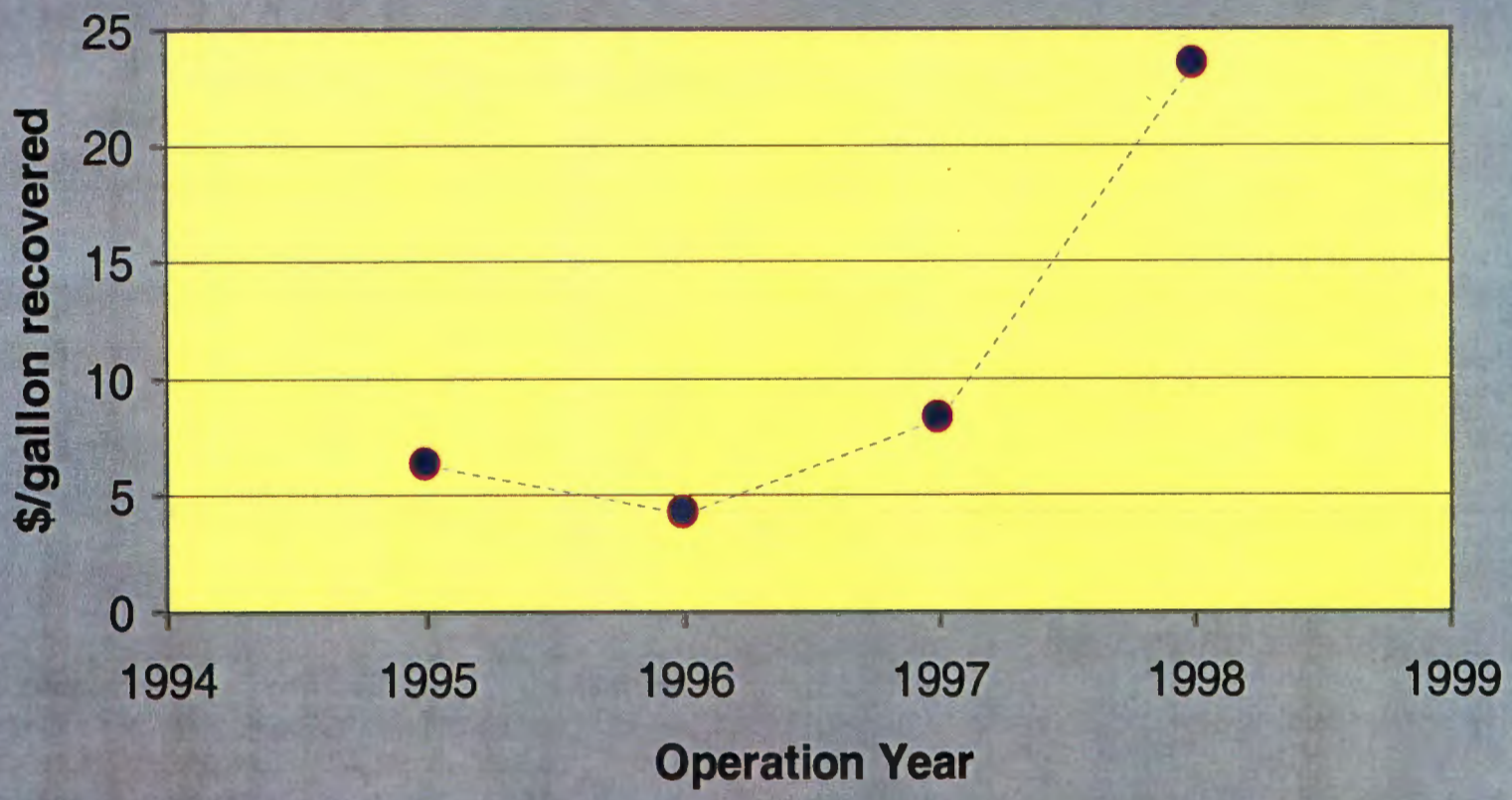
# *Diesel Recovery System*

- Recovered approximately 6800 gal. to date (1/1/99)
- Removal efficiency significantly decreasing
- Cost per gal. removed increasing significantly

# *Product Removed*



# *Efficiency of Diesel Recovery System*



# *Recommended Actions*

- Voluntary Corrective Actions (VCAs)
  - Abandon Wells HMW 42 and HMW 47
  - Re-grade over construction landfills to minimize infiltration potential
- Monitored Natural Attenuation
  - Locate monitoring wells outside and down-gradient of contaminant plumes