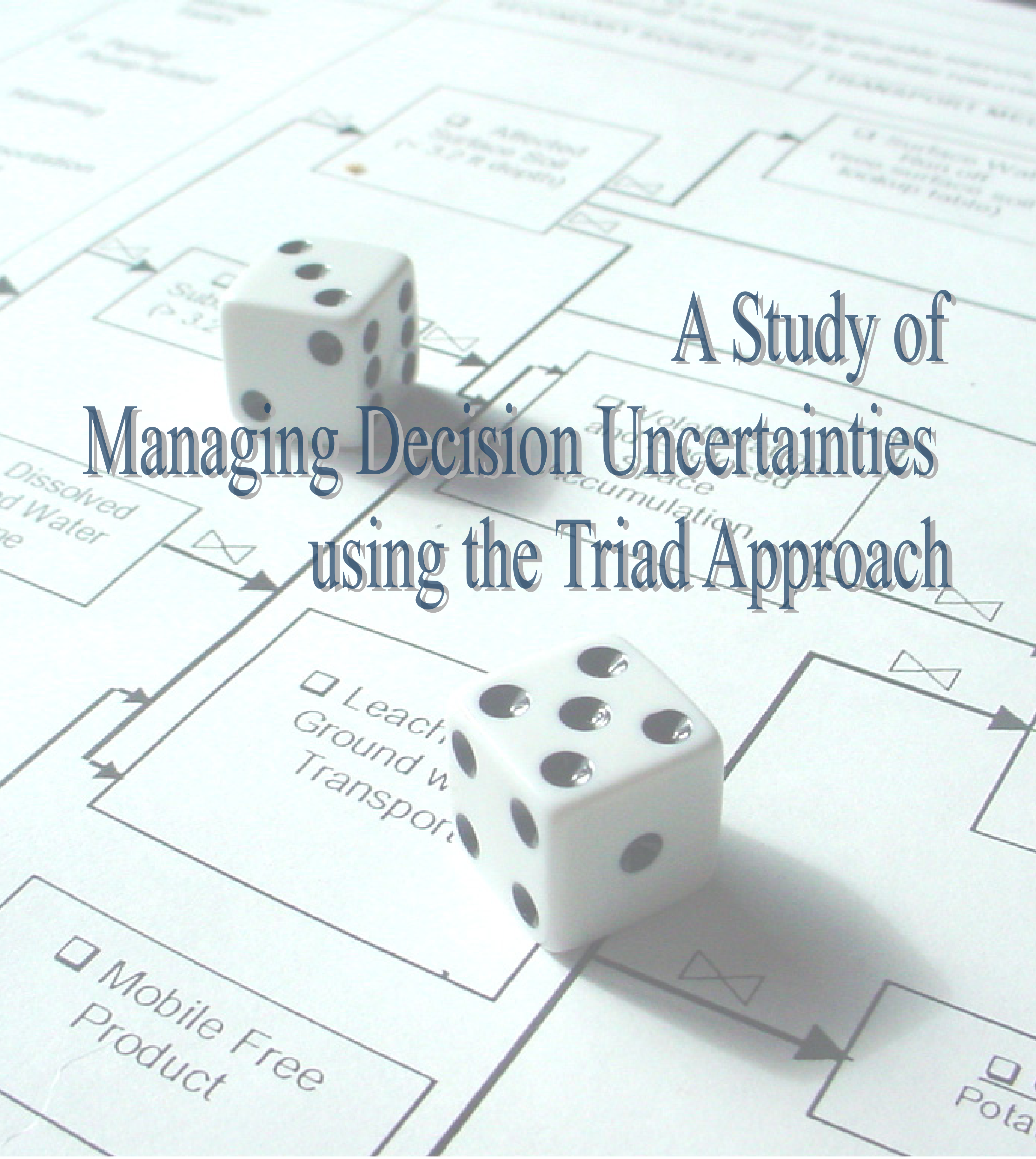

A Study of Managing Decision Uncertainties using the Triad Approach

South Dakota
Petroleum Release Compensation Fund

About the South Dakota Petroleum Release Compensation Fund

The South Dakota Petroleum Release Compensation Fund (PRCF) was established under the Petroleum Inspection and Release Compensation Act in 1988 to financially assist petroleum tank owners with the cleanup costs of petroleum releases and to meet the federal and state environmental financial responsibility requirements for both regulated underground and aboveground tank owners. Both state and federal law require that most owners of petroleum storage tanks be able to demonstrate financial responsibility for pollution cleanup and third-party liability. The United States Environmental Protection Agency (EPA) has approved the PRCF as an acceptable mechanism for tank owners to demonstrate financial responsibility for corrective action and third-party compensation as required by federal law.

The PRCF is a division of the South Dakota Department of Revenue and Regulation. A five-member advisory board appointed by the Governor of South Dakota makes recommendations on program policies and act as a hearing officer in contested case hearings.

The PRCF revenues are generated by a $0.02 per gallon tank inspection fee on petroleum products received in the state. While the fee generates roughly $15 million per year, the PRCF currently only receives 10.65% of the fee, or about $1.6 million per year, with the remainder going to other South Dakota funds.

The PRCF provides reimbursement of cleanup expenses and third-party liability claims up to $990,000 ($1,000,000 less a $10,000 deductible). Only necessary and reasonable cleanup expenses incurred after April 1, 1988 are eligible for PRCF reimbursement. Reimbursement for third-party claims can only be made for certain petroleum releases reported after April 1, 1990. The PRCF also pays for all tank removal and cleanup costs incurred through the Abandoned Tank Removal Program, which is part of the Spruce Up South Dakota Initiative.

Since its enactment in 1988, the PRCF has provided over $77 million for corrective action at approximately 4,000 release sites. The current estimate for future costs on known release sites in approximately $11 million. While much of the past efforts have been to finance corrective action at these old release sites, the PRCF’s mission continues to be that of providing ongoing financial assurance for tank owners so that they can demonstrate financial responsibility as required by federal law. At the same time, the PRCF continues to examine common practices in an effort to help minimize future environmental and economic impacts.

A Study of
Managing Decision Uncertainties
Using the Triad Approach

South Dakota

Petroleum Release Compensation Fund

June 15, 2005

The PRCF would like to thank the following individuals for providing invaluable assistance to the success of this project:

Deana Crumbling – US Environmental Protection Agency, Technology Innovation Program

Lou Martino – Argonne National Laboratory

John Sohl – Columbia Technologies, LLC

Ned Tillman – Columbia Technologies, LLC

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Executive Summary

In the fall of 2004, the South Dakota Petroleum Release Compensation Fund (PRCF) conducted a study to evaluate and report on the effectiveness of using the Triad Approach to manage decision uncertainties as they pertain to petroleum release sites across South Dakota.

Five sites were chosen for the study which included three active gas stations, one closed gas station and a railroad fueling site. Two of the sites remain active fueling stations, where the other 3 are non-operational and have had their tank systems removed. All locations were considered "legacy" sites because the petroleum releases had been discovered some time ago, yet none of the sites were effectively moving toward regulatory closure. Some of the sites had been in the assessment process for over a decade with no remediation to date. The known tanks at one of the closed gas stations had been removed over 10 years ago, but no assessment had been conducted. The goal of the study was to apply the principals of the Triad in order to rapidly characterize the sites, develop accurate conceptual site models, establish clear cleanup goals and move the languishing sites toward regulatory closure as rapidly as possible.

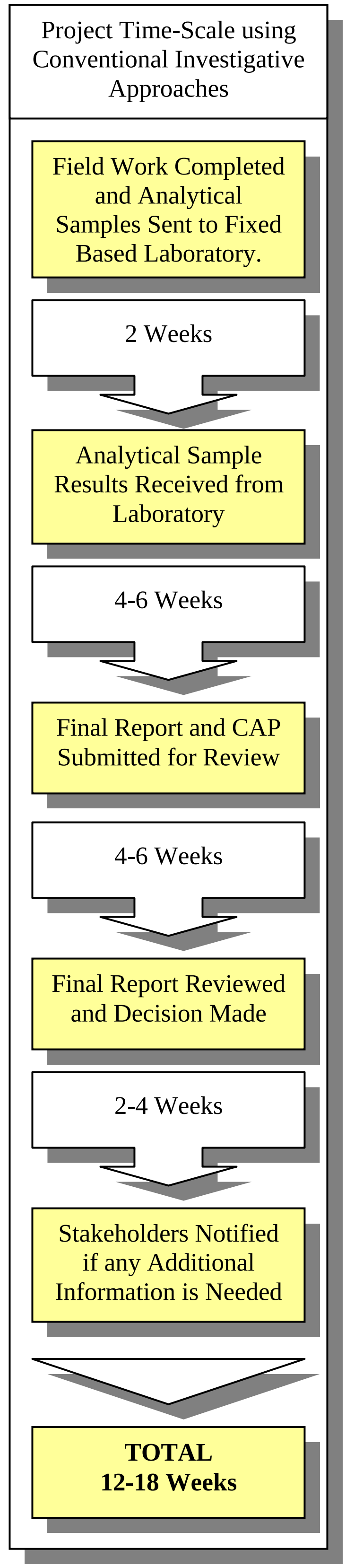
The South Dakota Triad Study was paid for with funds from the PRCF along with a $50,000 grant from the US Environmental Protection Agency. South Dakota Codified Law (SDCL) 34A-13-27 (6) and (7) authorizes the PRCF to conduct special studies designed to develop information and knowledge to aid in the cleanup of petroleum releases.

Results of the study suggest that the Triad Approach reduced the overall data collection costs by increasing the amount of data for every dollar spent. In addition, the Approach expedited work schedules by allowing stakeholders to establish goals and objectives prior to work initiation, and allow for flexible work plans based on the data collected on site. The information gathered in this study is intended to aid in the way site investigations are conducted both from the private and public sector perspectives, determine if this type of approach is technically feasible in South Dakota, and help eliminate backlogs that often occur in cleanup programs.

This report does not detail the process of the Triad Approach, but the rather the results of the study conducted in South Dakota. For more information regarding the Triad Approach, please refer the publications available from other agencies including the US EPA, Interstate Technology and Regulatory Council (ITRC), and many others.

Purpose

Since the 1995 implementation of Risk-Based Cleanup Actions (RBCA) in South Dakota, there have been 327 cases that have required active cleanup, with costs totaling $9.85 million and additional future costs estimated at $1.2 million. Many of these cleanups have been criticized for their high costs, duration, lack of efficacy, and often times the level of uncertainty that most often dictate whether or not No Further Action status or Closure was an option. The way site assessment data has historically been collected and analyzed at petroleum release sites and other environmental cleanup sites is partially to blame.



Traditional assessment programs rely on work plans that dictate how many boring and monitoring wells will be installed and where, how many soil and groundwater samples will be collected and for what parameters, and other risk based evaluations. Most often, a lengthy amount of time passes from the time the investigation occurs to the time a decision is made as to whether or not a level of uncertainty remains warranting additional assessment. As a result, multiple site visits are typically needed to gather relatively small, but important information as it relates to the overall risk of a contaminate plume. This inefficient and costly approach to site investigations has prolonged many cases due to changing site conditions and continued lack of certainty, not to mention the inability to develop an accurate Conceptual Site Model (CSM). Most often corrective actions are based on these inaccurate CSMs, which often leads to inappropriately designed remediation systems that are unable to reach the site's cleanup goals.

Therefore, in the fall of 2004, the South Dakota Petroleum Release Compensation Fund (PRCF) conducted a study to evaluate and report on the effectiveness of using the Triad Approach to manage decision uncertainties as they pertain to petroleum release sites across South Dakota.

This study incorporated the three major components of the Triad Approach:

1. Systematic planning prior to field work activities,
2. Dynamic work plans, and
3. Real-time measurement technologies.

The study consisted of 5 individual release sites located in eastern and central South Dakota that had previously been assessed, or were known release sites that had not had prior assessment activities preformed. Of the five sites selected for the study, the

PRCF had reimbursed costs associated with corrective action at 3 of these sites. The eligible costs incurred prior to the Triad Study are summarized in Table 1.

The stakeholders associated with this Study included the consultants, the PRCF, Department of Environment and Natural Resources (DENR), and Columbia Technologies, LLC. Because cooperation and commitment by all stakeholders is crucial to implementing the Triad Approach for any project, the “stakeholders” were often referred to as “team members”. In addition, all team members were issued a ballcap with a South Dakota Triad logo. Although this may appear as a marketing scheme, the implication that all team members had an integral part of this study was extremely important.

Table 1 – Eligible Costs Incurred Prior to Study

Site	Spill Discovered	Previous Site Assessment Costs	Other Corrective Action Costs	Total Costs
Steve’s Amoco	2003	$0.00	$0.00	$0.00
T&T Standard	1991	$62,837.06	$87,508.54	$150,345.60
Severson’s Service	1991	$103,044.38[1]	$53,508.21	$156,552.59
DM&E Railroad	1990	$34,763.29	$61,380.58	$96,143.87
Former Husky’s	1995	$0.00	$0.00	$0.00

[1] Includes costs incurred under Leaking Underground Storage Tank (LUST) program

Discussion

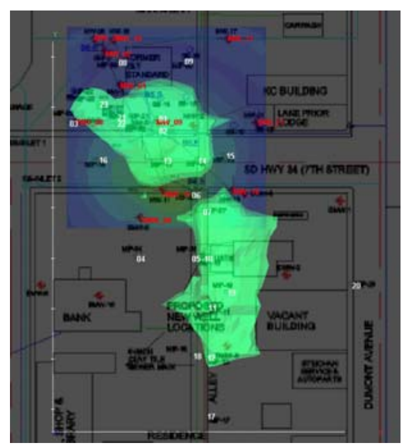
Systematic Planning Meeting

The PRCF met with all team members for an informational and systematic planning meeting. It was during this time that team members could discuss the purpose of the Triad Approach and the general purpose of the study, and address any questions or concerns that exist. Although it appeared the general concept of the Triad Approach was accepted, there were concerns regarding the collection of quantitative data sets, or the number of soil and groundwater samples that would be collected and analyzed using a fixed based laboratory. In most subsurface assessments conducted in South Dakota, at least one soil sample is collected from a boring and sent to a fixed laboratory for analysis. However, because "in situ" field analysis was to be performed using MIP technology during this study, the need for multiple soil samples was not necessary. Therefore, it was decided that personnel in the field would determine the number of necessary samples to be sent to a fixed laboratory in an effort to collaborate the results from the field analyses.

During the initial planning meeting, team members were also given a summary of the previous work performed at each site, and the data gaps that have been identified. Once a basic understanding of each site had been reached, a cleanup goal was established and a list of objectives were developed that would help pave the way towards the cleanup goal.

Real Time Measurements

The Membrane Interface Probe (MIP) technology was chosen to gather real-time data measurements that enabled team members to make decisions in the field, and allowed the CSM to mature and evolve as the data was collected. Technical information regarding this technology is included in Appendix A of this report.



Columbia Technologies of Columbia, Maryland was chosen to provide the equipment and data management associated with using this type of technology. The MIP in conjunction with Columbia's "SmartData Solutions" software enabled all stakeholders to review the results of the field analysis in real-time, and determine what specific information is needed in order to eliminate existing or future data gaps.

Matrix Technologies of Osseo, MN was subcontracted through Colombia Technologies to provide the drilling services for this study. Drilling was completed using a Geoprobe® 6600 truck mounted rig.

The field work associated with each site consisted of advancing at least two MIP borings in the location of known areas of high soil contamination, which most often was the source area. These two borings provided information as to the expected vertical extent of the contaminate plume, but also as a response standard that would provide comparison with respect to contamination found at other boring locations. Following the advancement of the first two borings, background information was gathered from the surrounding areas to “box in” or horizontally delineate the contaminate plume. This allowed team members to focus on potential pathways and receptors in the immediate area of the contaminate plume, and determine the level of risk to those receptors.

Dynamic Work Strategies

Through the course of the study, a planning meeting was held each day with each sites respective team members. This meeting included a review of the site objectives along with a review of the previous day’s assessment results to determine if any new data gaps had been created from the previous day’s assessment activities. If uncertainties were identified with respect to the available data, the necessary information was gathered to eliminate those uncertainties. However, there were instances that changed the focus of the assessment activities and the overall goals of the site. For instance, the contaminate plume associated with a particular site was believed to have extended within a source water protection zone as delineated by the local water resource board. However, information gathered using the MIP technology confirmed that this contamination was not the result of a release from the suspected site location. In addition, the soil conductivity results indicated that the general lithology in the area of the site was not consistent with that of aquifer materials, and the groundwater beneath this site was not hydraulically connected to the aquifer which is currently utilized for drinking water purposes. Based on this new information, the CSM evolved and the cleanup goal associated with this site was changed from meeting groundwater quality standards to ensuring that the contaminate plume was stable, and eliminating the risk to any other potential receptors.

Site Results

Through the course of the study, 133 MIP borings were advanced, resulting in a total of 349,500 data points collected. This high data density provided the ability to generate a CSM that depicted both the horizontal and vertical extents of the contaminate plumes. The following are the results of each individual project location, along with the associated CSM generated for each site.

Steve's Amoco
Watertown, SD

Summary: The release was first discovered in March 1998 during upgrading of the underground piping for the UST system (DENR #98.045, PRCF #3385). Assessment was performed in 1999, and groundwater monitoring was performed from 1999 through August of 2003. Due to elevated concentrations of gasoline constituents in MW-2 and MW-6 in late 2002 and early 2003, DENR inspected the facility and required line tightness testing. One of the dispenser lines failed the line test, and the line was excavated in early August 2003. The leak was determined to have been at an elbow of the fiberglass piping near the west edge of the tank basin. Free phase product was measured at a thickness of 0.03 feet in MW-2 on August 19, 2003. Additional assessment was required to determine potential risk to receptors in the area.

Potential Source(s): Former UST piping

Potential Pathways: Groundwater

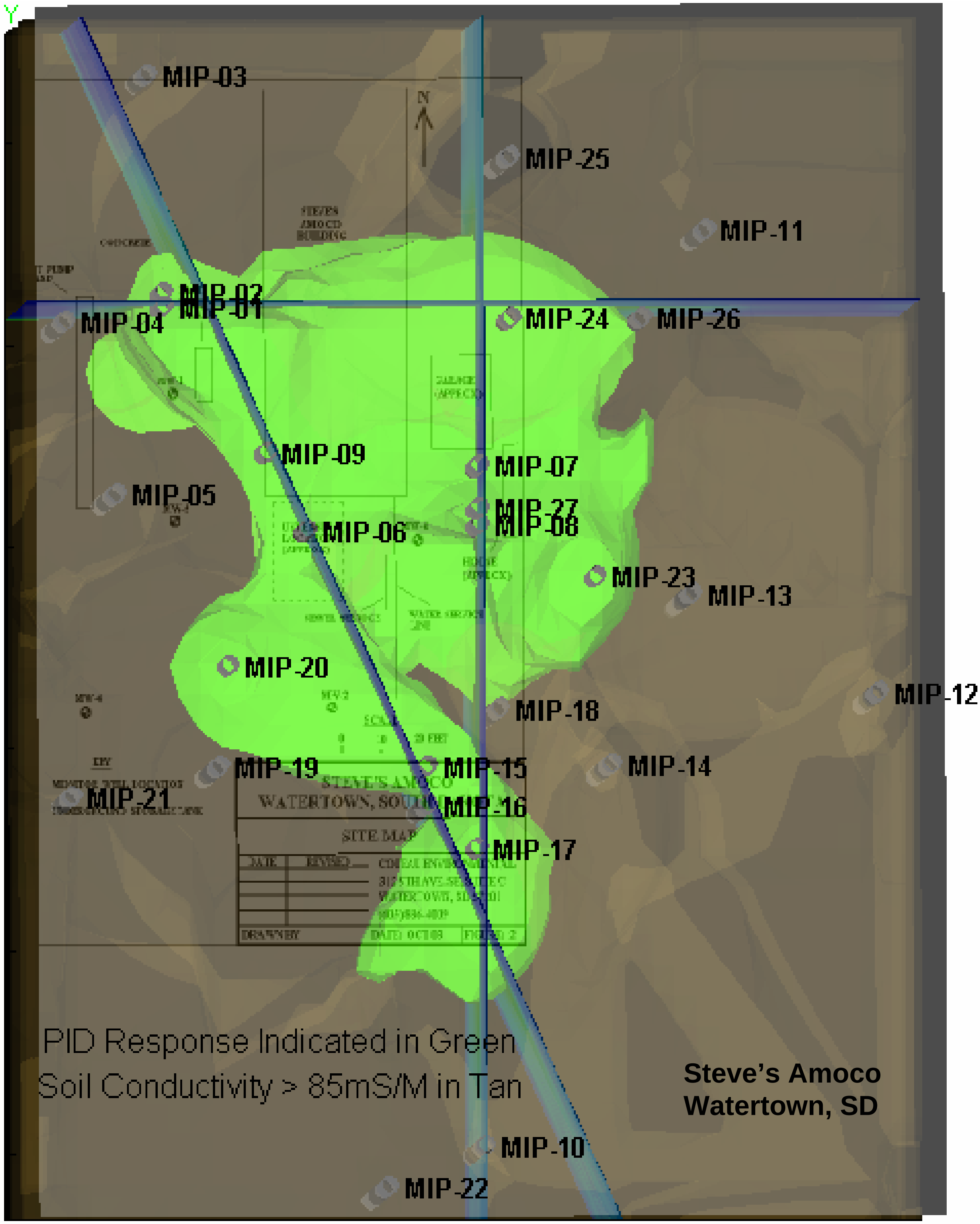
Potential Receptors: Home directly east of the site.

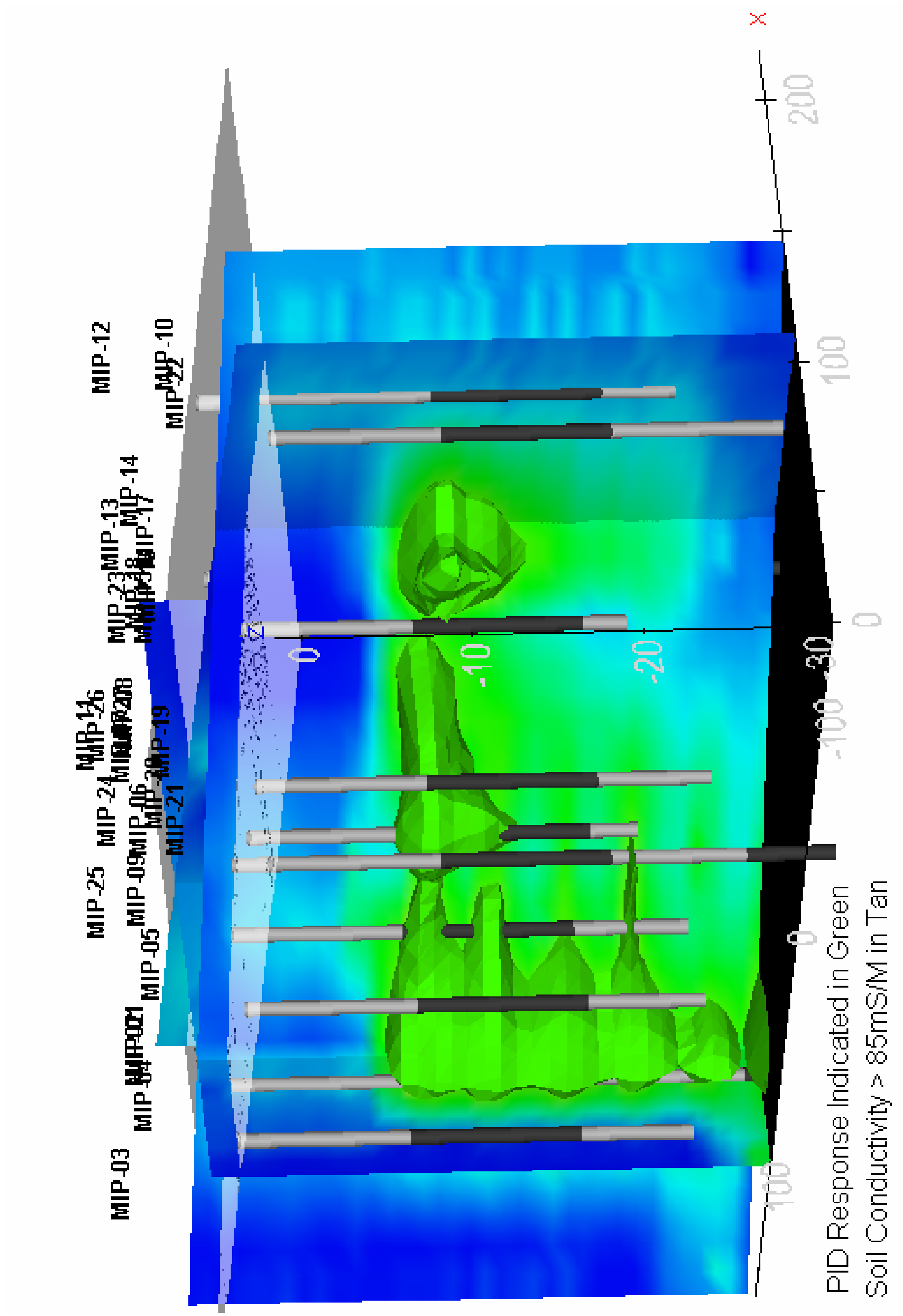
Goals
1) Remove free phase product (if present)
2) Eliminate risks to potential receptors
3) Because this site is located within a source water protection area, MCL's must be met.
Major Objectives
1) Determine if source areas are separate or co-mingled.
2) Identify pathways and receptors.
3) Identify location, depth, and construction of utilities and determine any impacts.
5) Determine if contamination has impacted residential basement to the east.
6) Characterize free product plumes around pump islands and tank basin. (vert. & horiz.)
7) Delineate dissolved phase contaminate plume(s) (vert. & horiz.)
8) Confirm soil & groundwater samples.
9) Analyze soil and groundwater samples for TPH-G, BTEX, MTBE, EDB, TPA
10) Determine need for additional compliance monitoring wells.
11) Confirm background data using perimeter test holes.
12) Develop corrective action plan

Triad Study Results

There were a total of 27 MIP borings advanced at this location; resulting in 72,600 data points. From those borings, 7 soil samples and 2 groundwater samples were collected to collaborate the results from the MIP.

The 13 objectives were completed, and corrective action plan has been established for this case. The corrective action includes replacing a nearby PVC watermain with a petroleum resistant material, and conducting compliance groundwater monitoring.


MIP-03
MIP-25
MIP-11
MIP-02
MIP-01
MIP-04
MIP-24
MIP-26
MIP-09
MIP-07
MIP-05
MIP-27
MIP-08
MIP-06
MIP-23
MIP-13
MIP-20
MIP-12
MIP-18
MIP-19
MIP-15
MIP-14
MIP-21
MIP-16
MIP-17
STEVE'S AMOCO
WATERTOWN, SOUTH
SITE MAP
PID Response Indicated in Green
Soil Conductivity > 85mS/M in Tan
Steve's Amoco
Watertown, SD
MIP-10
MIP-22


MIP-03
MIP-05
MIP-25
MIP-24
MIP-09
MIP-19
MIP-21
MIP-14
MIP-13
MIP-12
MIP-10
0
-10
-20
-30
-100
100
200
PID Response Indicated in Green
Soil Conductivity > 85mS/M in Tan

Former T&T Standard
Platte, SD

Summary: The release was discovered in December 1991, with assessments performed in 1992, 1993, 1994 and 1999. Three USTs (1-10K gallon gasoline, 1-8K gallon gasoline, and 1-3K gallon diesel) and about 900 cubic yards of PCS from the source area were removed in 1992. Two waste oil USTs (1-270 gallon and 1-100 gallon) and about 10 cubic yards of PCS were removed in 1994. Groundwater monitoring was performed between 1992 and 2003. Additional assessment has been required to define the extent and evaluate potential for risk to underground structures (utilities) and city water supply wells.

Potential Source(s): Former on-site tank system and tank systems from adjacent properties.

Potential Pathways: Utilities and groundwater.

Potential Receptors: Utilities and City water supply wells.

Goals

1) Remove free phase product (if present)
2) Eliminate risks to potential receptors
3) MCL's must be met. However, if it could be determined that the geology below the area is inconsistent with aquifer materials, this goal may not apply.

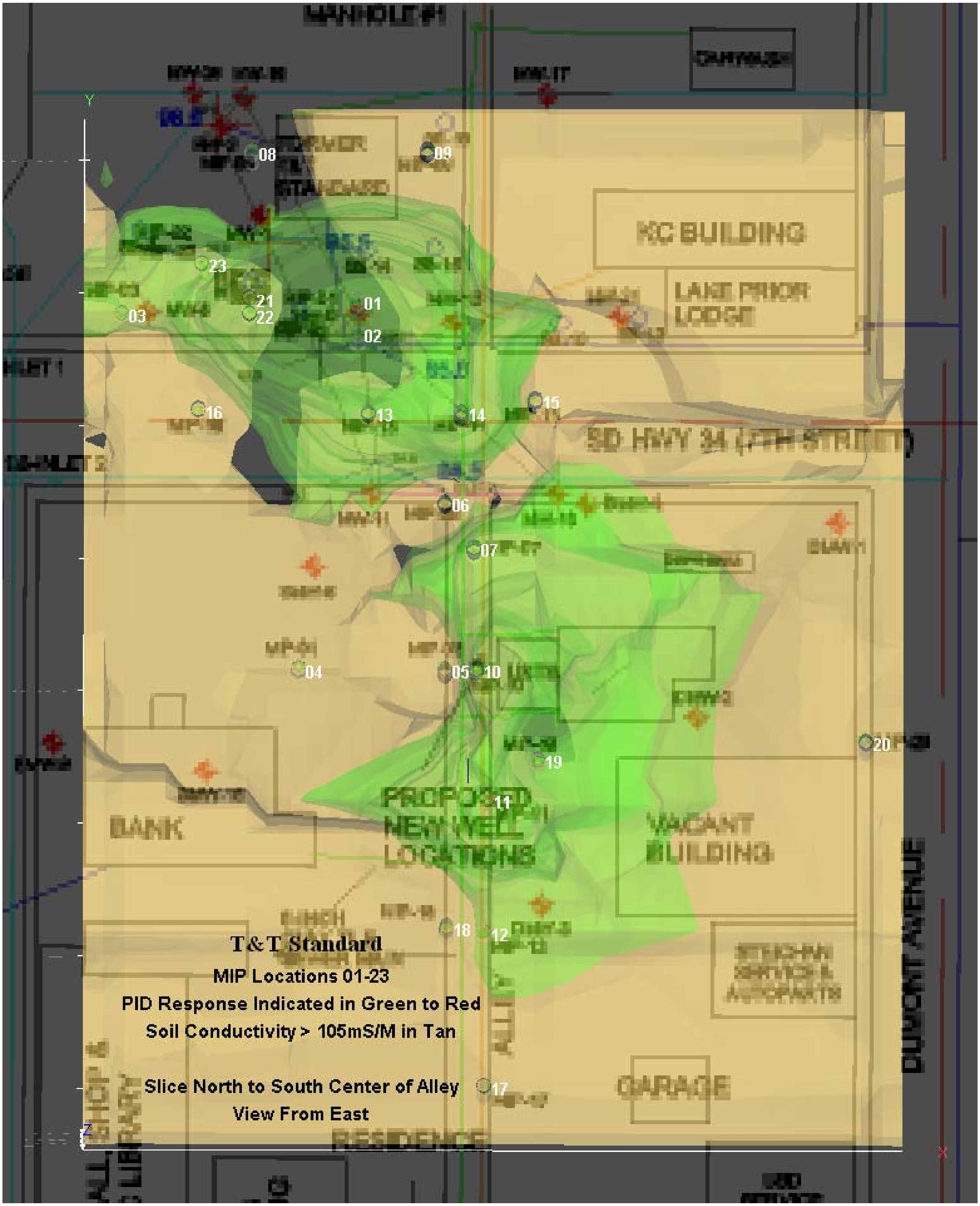
Major Objectives

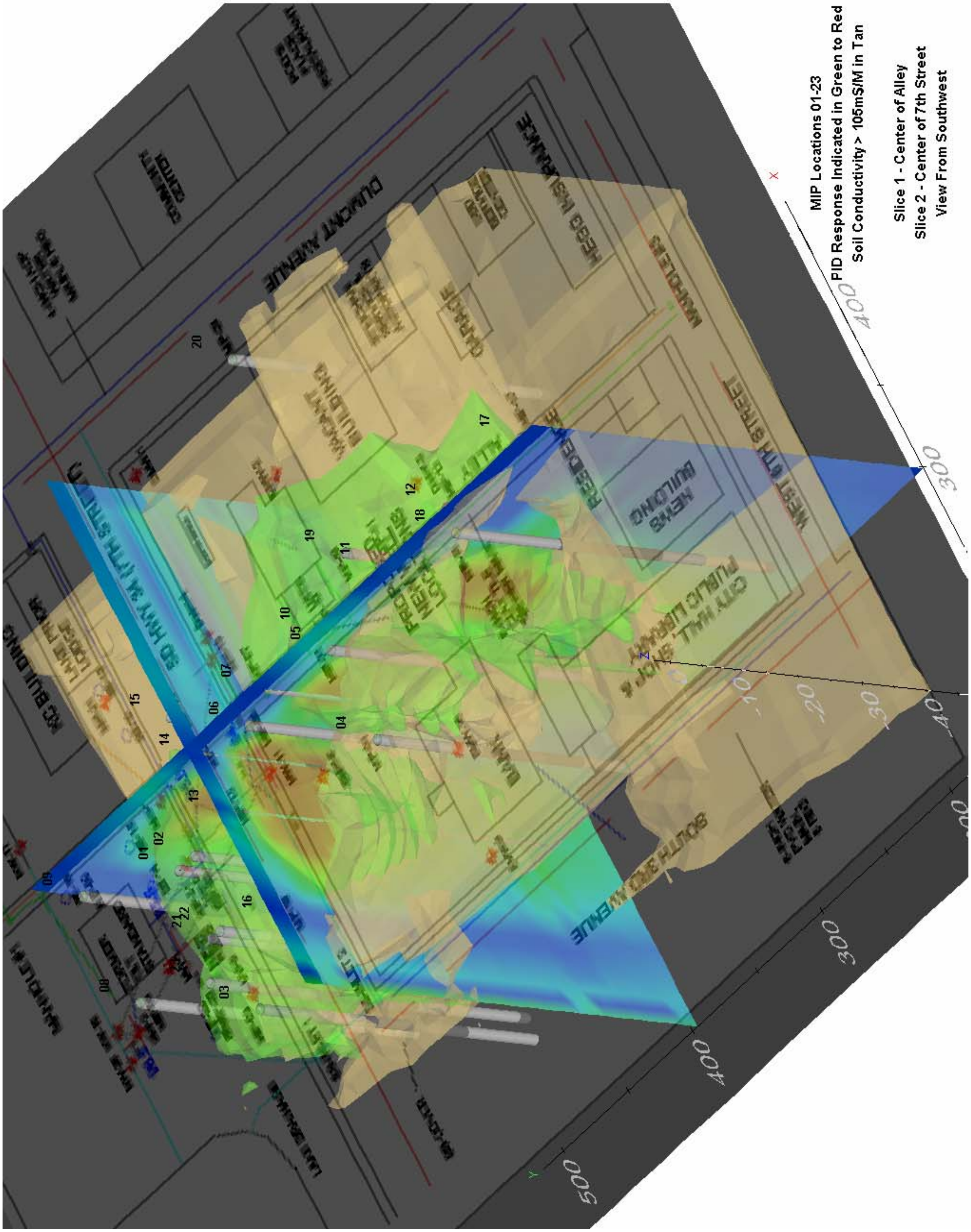
1) Confirm background data using perimeter test holes.
2) Identify all potential sources and determine if source areas are separate or co-mingled.
3) Resolve potential sources between on-site and off-site properties.
4) Determine extent of dissolved plume relative to Source Water Protection Area.
5) Determine if deeper lithology is consistent with aquifer material.
6) Evaluate potential of excluding site from Source Water Protection Area.
7) Identify all downgradient pathways and receptors
8) Identify location, depth, and construction of utilities and determine any impacts.
9) Confirm soil & groundwater samples.
10) Analyze soil and groundwater samples for TPH-G, BTEX, MTBE, EDB, TPA
11) Determine need for additional compliance monitoring wells.
12) Develop corrective action plan

Triad Study Results

There were a total of 23 MIP borings advanced at this location; resulting in 64,100 data points. From those borings, 2 soil samples and 4 groundwater samples were collected to collaborate the results from the MIP.

The 13 objectives were completed, and corrective action plan has been established for this case. It was determined that the groundwater beneath this site is not hydraulically contacted with the drinking source water; therefore MCL's are not required. Therefore, once a series of vapor screening from the utilities has been conducted, it is expected that this case will receive NFA status.


T&T Standard
MIP Locations 01-23
PID Response Indicated in Green to Red
Soil Conductivity > 105mS/M in Tan
Slice North to South Center of Alley
View From East
KC BUILDING
LAKE PRIOR LODGE
SD HWY 34 (7TH STREET)
BANK
PROPOSED NEW WELL LOCATIONS
VACANT BUILDING
GARAGE
DUMONT AVENUE
RESIDENCE


MIP Locations 01-23
PID Response Indicated in Green to Red
Soil Conductivity > 105mS/M in Tan
Slice 1 - Center of Alley
Slice 2 - Center of 7th Street
View From Southwest

Severson's Service
Platte, SD

Summary: Release was first discovered in 1983 when a LUST investigation was performed for the State in response to petroleum vapors in a nearby sanitary sewer. Additional assessment was performed in 1990 for the State in response to petroleum contamination discovered during installation of a new water main in the street north of the site. A drain tile and sump were installed along the new water main north of the site at that time. The tank owner did not comply with DENR directives in 1991 and 1993 to complete an assessment. Additional assessment was performed in 1998 and 1999 in response to vapors in a nearby business located about one-half block north of the site. Three USTs and about 700 cubic yards of contaminated soil were removed from the site in the summer of 1998. The sump in the nearby business was also sealed in spring of 1998 to minimize vapors from entering the building. Petroleum contaminated soil was encountered in the fall of 2001 during replacement of the nearby sanitary sewer. Additional assessment was performed in December 2001 to better define the extent of contamination. Groundwater monitoring was performed periodically between 1998 and the present time, and contaminated groundwater was being removed from the drain tile on a quarterly basis.

Potential Source(s): The previous tank system, and possibly the current tank system (?).

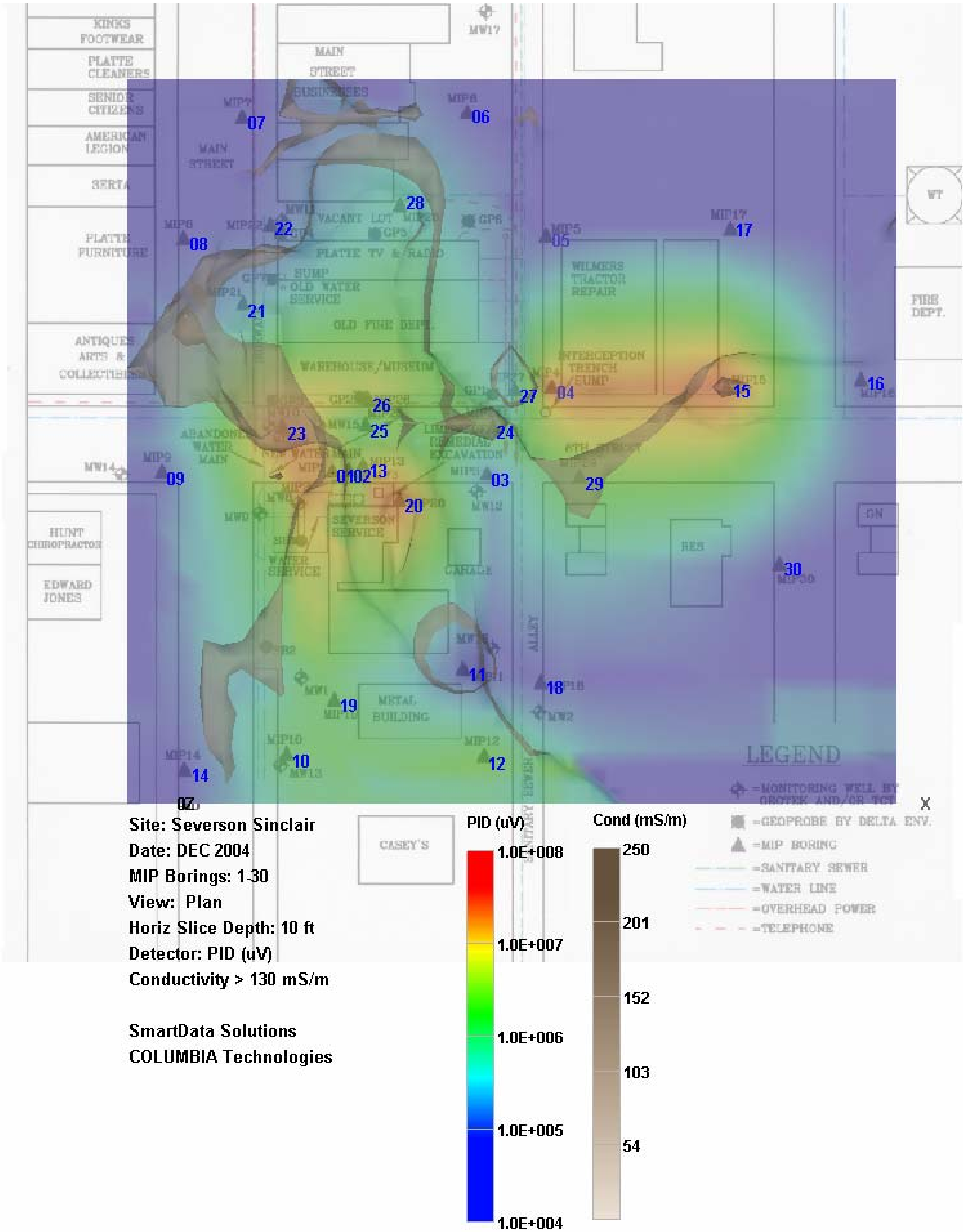
Potential Pathways: Groundwater, utilities.

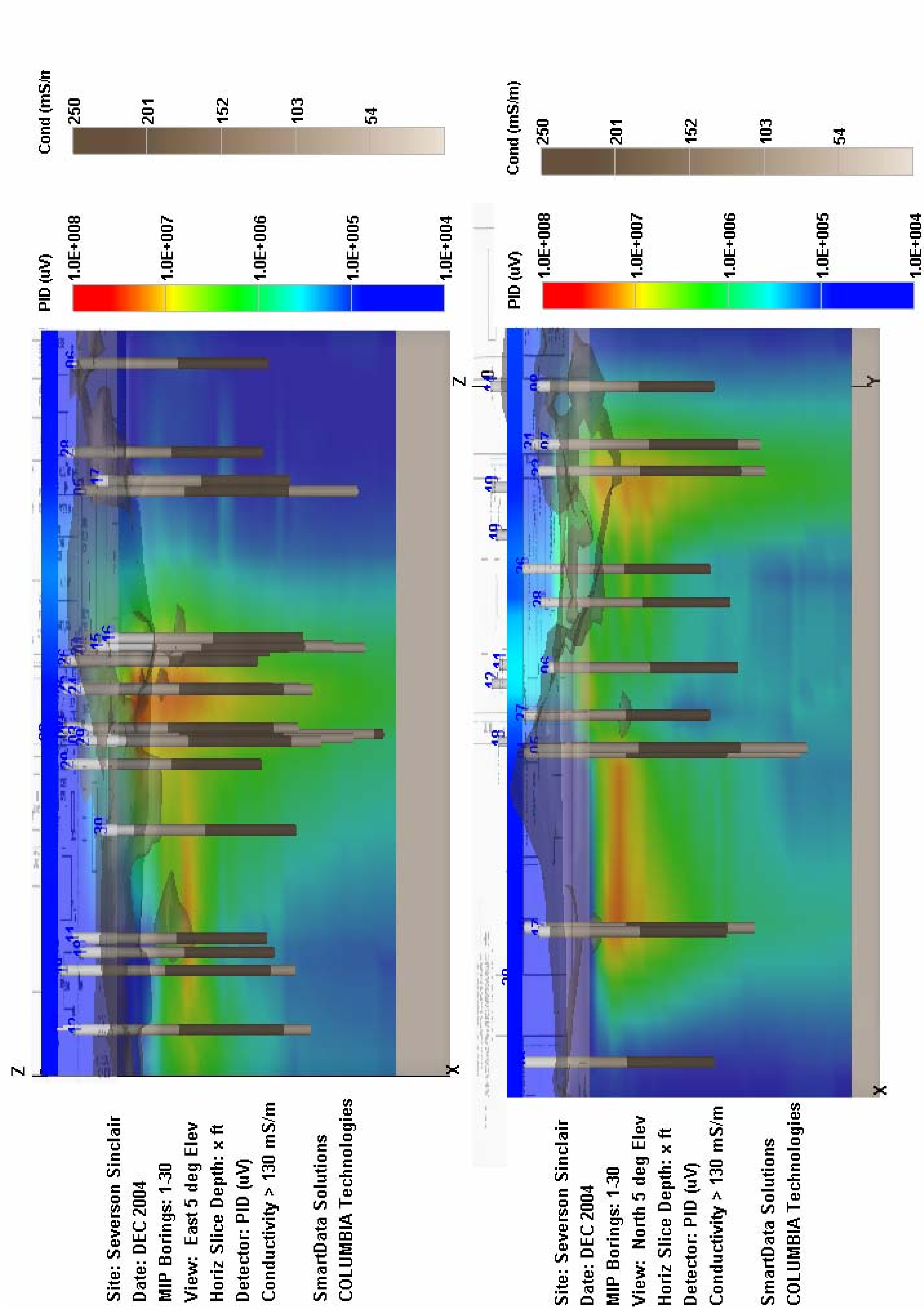
Potential Receptors: Utilities and other sub-grade structures.

Goals
1) Remove free phase product (if present) 2) Eliminate risks to potential receptors 3) Ensure dissolved contaminate plume is stable and attenuating.
Major Objectives
1) Determine if current fuel system is tight and that no on-going releases are occurring. 2) Identify all potential sources, including area adjacent to old Fire Station building 3) Delineate dissolved contaminate plume. 4) Confirm background data using perimeter test holes. 5) Identify pathways and receptors downgradient of MW-11. 6) Identify location, depth, and construction of utilities and determine any impacts. 7) Evaluate effectiveness of current groundwater interceptor trench. 9) Confirm soil & groundwater samples. 10) Analyze soil and groundwater samples for TPH-G, BTEX, MTBE, EDB, TPA 11) Determine need for additional compliance monitoring wells. 12) Develop corrective action plan

There were a total of 30 MIP borings advanced at this location; resulting in 64,400 data points. From those borings, 7 soil samples and 4 groundwater samples were collected to collaborate the results from the MIP.

The 13 objectives were completed, and corrective action plan has been established for this case which includes mitigating vapor potentials to the basement and utility impacts.


Site: Severson Sinclair
Date: DEC 2004
MIP Borings: 1-30
View: Plan
Horiz Slice Depth: 10 ft
Detector: PID (uV)
Conductivity > 130 mS/m
SmartData Solutions
COLUMBIA Technologies
PID (uV)
1.0E+008
1.0E+007
1.0E+006
1.0E+005
1.0E+004
Cond (mS/m)
250
201
152
103
54
LEGEND
=MONITORING WELL BY GROTEK AND/OR TGT
=GEOPROBE BY DELTA ENV.
=MIP BORING
=SANITARY SEWER
=WATER LINE
=OVERHEAD POWER
=TELEPHONE


Site: Severson Sinclair
Date: DEC 2004
MIP Borings: 1-30
View: East 5 deg Elev
Horiz Slice Depth: x ft
Detector: PID (uV)
Conductivity > 130 mS/m
SmartData Solutions
COLUMBIA Technologies
PID (uV)
1.0E+008
1.0E+007
1.0E+006
1.0E+005
1.0E+004
Cond (mS/m)
250
201
152
103
54
Site: Severson Sinclair
Date: DEC 2004
MIP Borings: 1-30
View: North 5 deg Elev
Horiz Slice Depth: x ft
Detector: PID (uV)
Conductivity > 130 mS/m
SmartData Solutions
COLUMBIA Technologies
PID (uV)
1.0E+008
1.0E+007
1.0E+006
1.0E+005
1.0E+004
Cond (mS/m)
250
201
152
103
54

DM&E Railroad
Pierre, SD

Summary: A spill report was filed in November 1990 based on a report of staining and fuel odors in the fueling area of the railroad property. Assessment performed in 1991 found contamination in the soils and groundwater, and free phase product in on-site and off-site monitoring wells. Additional assessment performed in 1998 further defined the extent of the contamination. Four recovery wells were installed in 1991, and approximately 2,100 gallons of product recovery has been reported between late 1991 and early 2003. The majority of the product was recovered from one recovery well between 1991 and 1994. Additional assessment was necessary to identify the source(s) and extent of the free phase product, and, if necessary, develop a corrective action plan to remediate the remaining free phase product.

Potential Source(s): Former on-site AST and loading devices, likely historical surface spills near railroad track, and off-site ASTs.

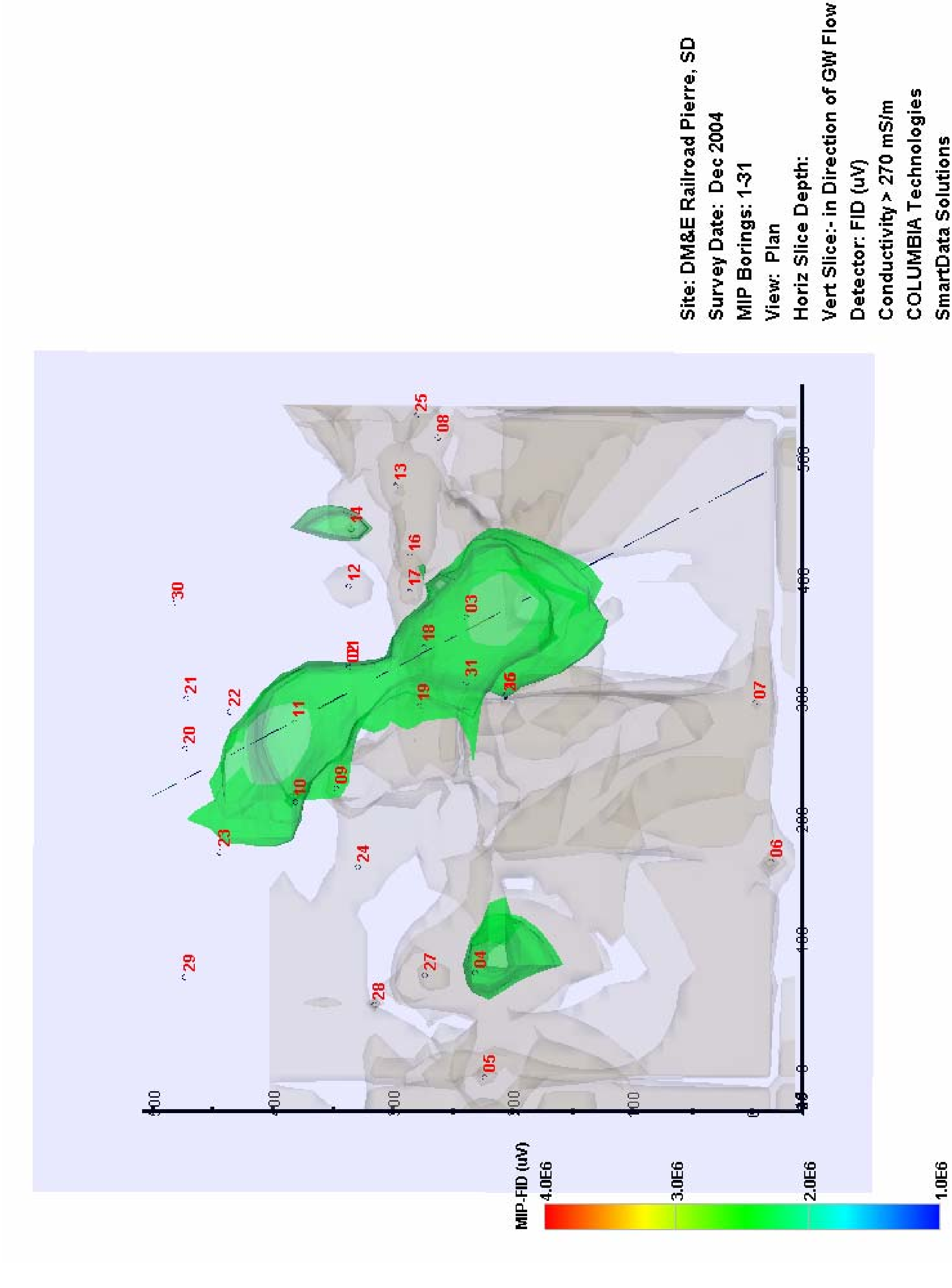
Potential Pathways: Groundwater

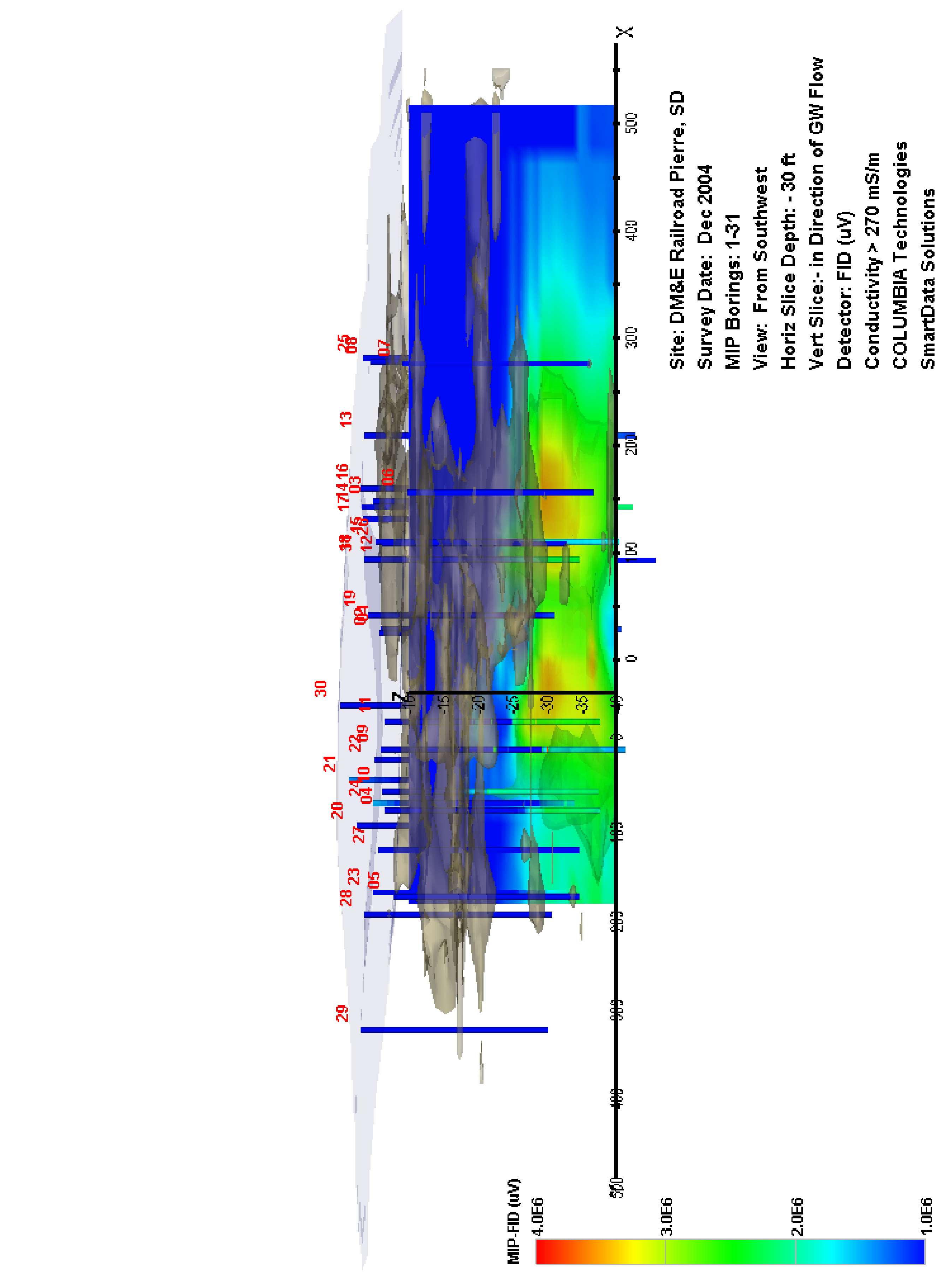
Potential Receptors: None identified to date.

Goals
1) Remove free phase product 2) Eliminate risks to potential receptors 3) Because this site is located w/in a source water protection area, MCL's must be met.
Major Objectives
1) Define source areas. 2) Identify pathways and receptors 3) Identify location, depth, and construction of utilities and determine any impacts. 4) Further characterize LNAPL and conduct product identification analysis. 5) Determine if lithology is consisted with aquifer materials. 6) Confirm soil & groundwater samples. 7) Analyze soil and groundwater samples for TPH-D, Napth, MTBE, EDB, TBA 8) Determine need for additional compliance monitoring wells. 9) Confirm background data using perimeter test holes. 10) Develop corrective action plan

There were a total of 31 MIP borings advanced at this location; resulting in 88,300 data points. From those borings, 2 soil samples, 1 groundwater sample were collected to collaborate the results from the MIP. In addition, 1 product sample was collected for Identification Analysis.

Due to the properties of the heavier fuel, the MIP had a difficult time “clearing” the trunkline from one boring to the next. In addition, the responses were much more subtle than that of lighter gasoline. As a result, only one potential source area was identified, and it is not yet clear if this area is the source of free phase product. However, the areal extent of the contaminate plume was delineated, and due to the lack of immediate receptors in the area, the corrective action plan is limited to monitors the effects of natural attenuation.


Site: DM&E Railroad Pierre, SD
Survey Date: Dec 2004
MIP Borings: 1-31
View: Plan
Horiz Slice Depth:
Vert Slice:- in Direction of GW Flow
Detector: FID (uV)
Conductivity > 270 mS/m
COLUMBIA Technologies
SmartData Solutions
MIP-FID (uV)
4.0E6
3.0E6
2.0E6
1.0E6


Site: DM&E Railroad Pierre, SD
Survey Date: Dec 2004
MIP Borings: 1-31
View: From Southwest
Horiz Slice Depth: - 30 ft
Vert Slice:- in Direction of GW Flow
Detector: FID (uV)
Conductivity > 270 mS/m
COLUMBIA Technologies
SmartData Solutions
MIP-FID (uV)
4.0E6
3.0E6
2.0E6
1.0E6

Former Husky Oil
Pierre, SD

Summary: This site was an operating gas station as early as 1973 and up until 1986. The USTs were reportedly removed around that time, but there is no record of an assessment or spill at that time. Petroleum constituents (gasoline and diesel fuel) were discovered in borings and wells on the west property boundary during the assessment of a release site west of this property in 1995. Free phase product has been measured in one of the wells. DENR directed former owner/operators of the property to perform an assessment in 1995 and 1997. The former owners have disputed being named the responsible party, and no assessment has been performed to date.

Potential Source(s): Former on-site UST system, possible surface spill from transport, possible fueling line found in Henry Street (?), and release site to the west.

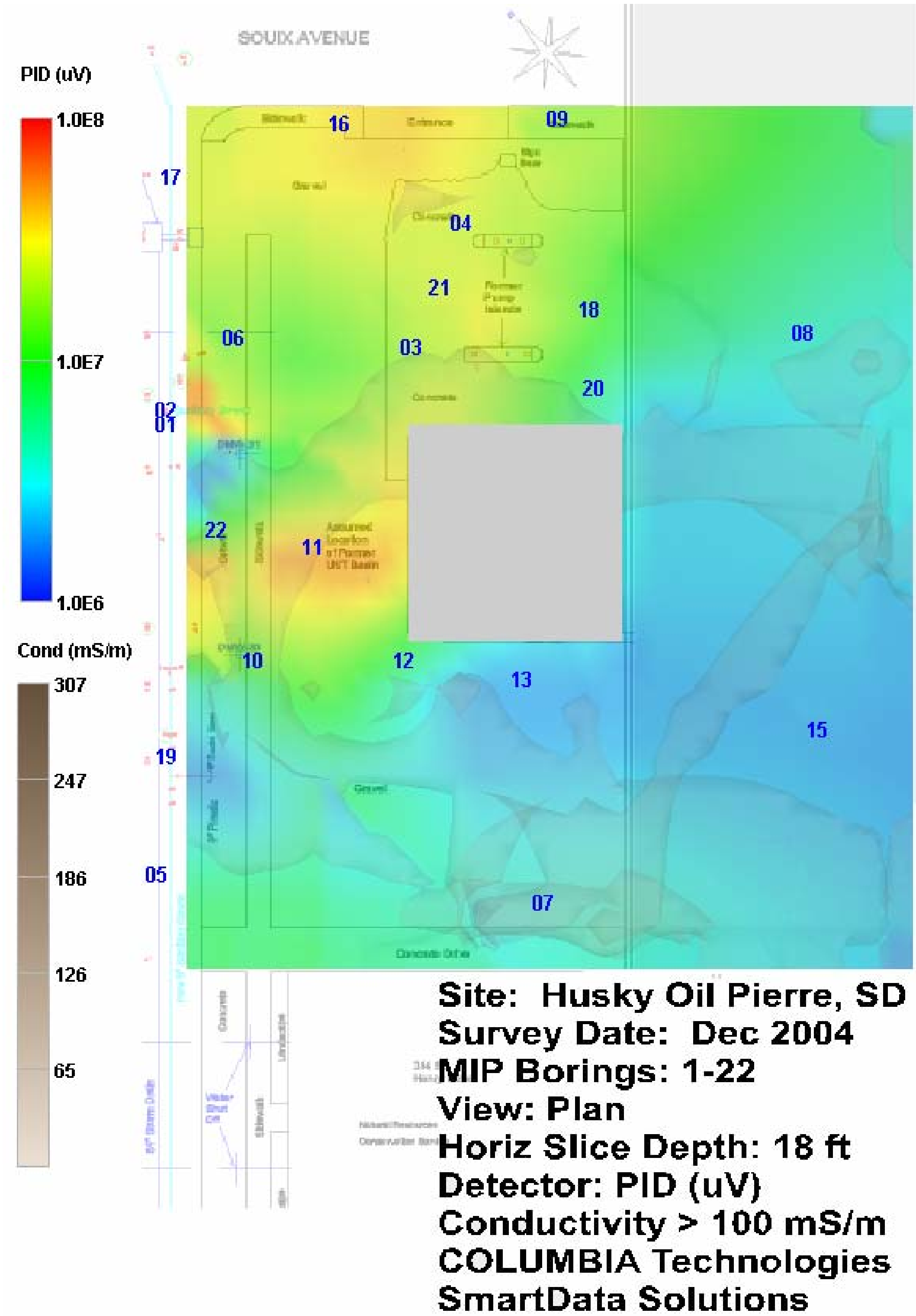
Potential Pathways: Soil, utilities and groundwater.

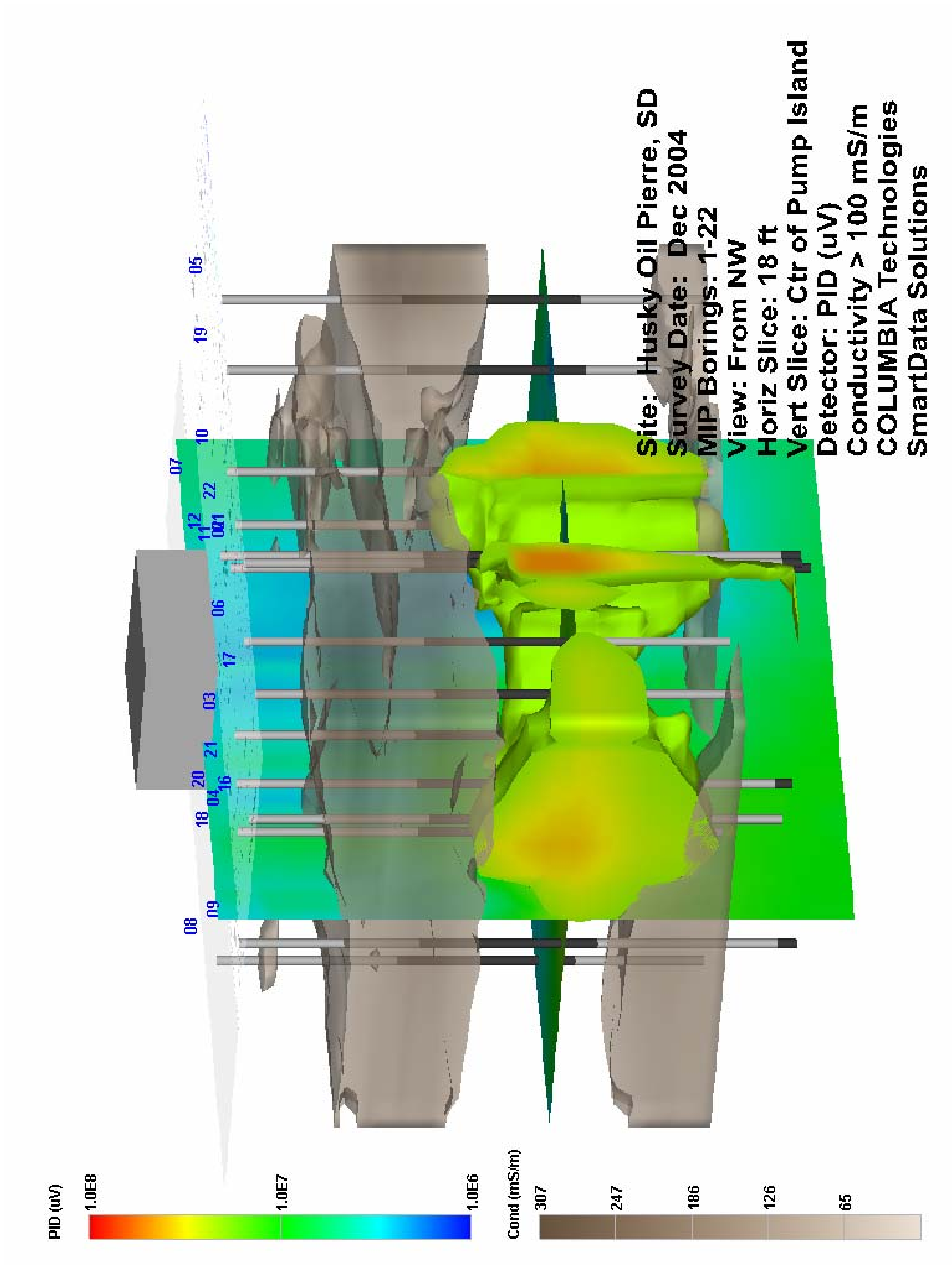
Potential Receptors: Utilities and city water supply.

Goals
1) Remove free phase product (if present) 2) Eliminate risks to potential receptors 3) Because this site is located within a source water protection area, MCL's must be met.
Major Objectives
1) Collect free product from MW-20 & MW-21 and submit it for Identification Analysis. 2) Determine source areas. 3) Identify pathways and receptors. 4) Identify location, depth, and construction of utilities and determine any impacts. 5) If present, characterize free product plume. 6) Delineate dissolved phase contaminate plume. 7) Confirm soil & groundwater samples. 8) Analyze soil and groundwater samples for TPH-G, BTEX, MTBE, TPA, TPH-D, Napth. 9) Determine need for additional compliance monitoring wells. 10) Confirm background data using perimeter test holes. 11) Develop corrective action plan

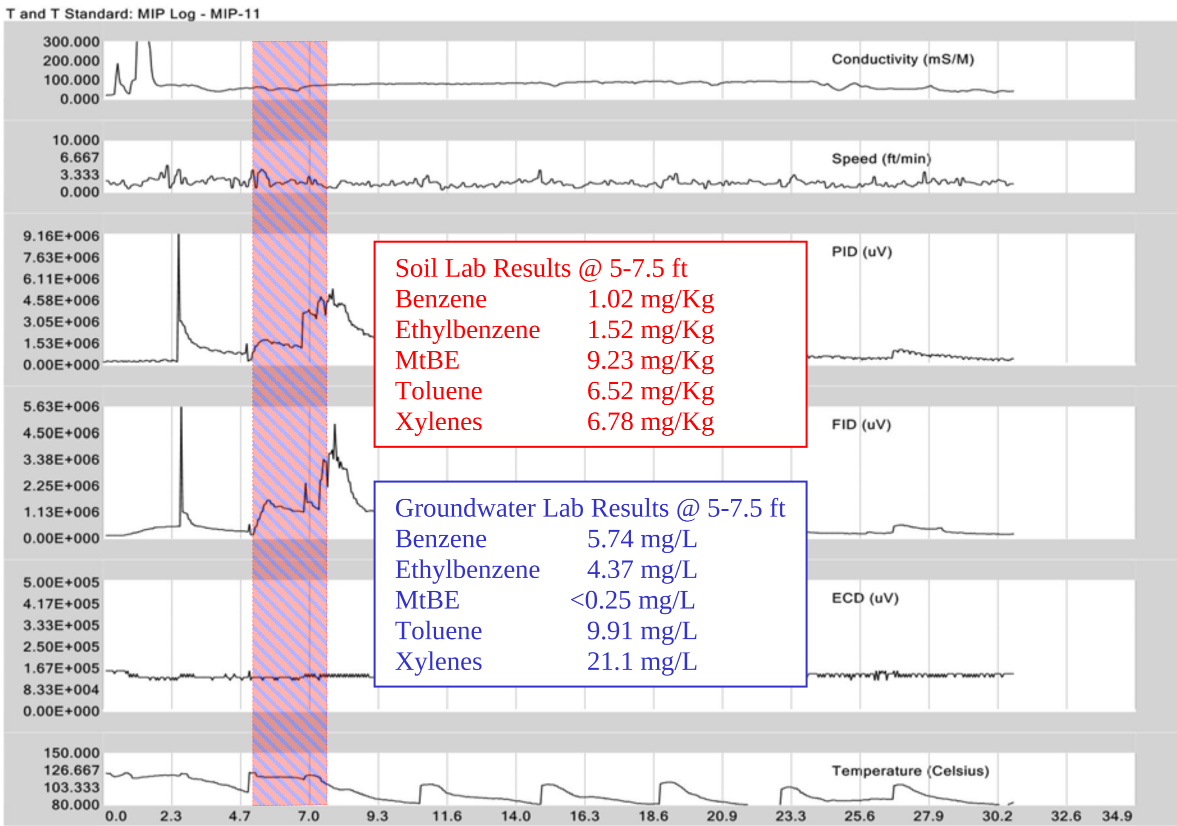
There were a total of 22 MIP borings advanced at this location; resulting in 66,100 data points. From these borings, 7 soil samples and 2 groundwater samples were collected to collaborate the results from the MIP.

The 13 objectives were completed, and corrective action plan has been established for this case. The discovered abandoned UST is scheduled for removal in the summer of 2005, at which time a remedial excavation of the source area will be conducted. Once completed, the groundwater beneath the site will be monitored for natural attenuation.


SOUIX AVENUE
PID (uV)
1.0E8
1.0E7
1.0E6
Cond (mS/m)
307
247
186
126
65
16
09
17
04
21
18
06
03
08
20
02
01
22
11
10
12
13
15
19
05
07
Site: Husky Oil Pierre, SD
Survey Date: Dec 2004
MIP Borings: 1-22
View: Plan
Horiz Slice Depth: 18 ft
Detector: PID (uV)
Conductivity > 100 mS/m
COLUMBIA Technologies
SmartData Solutions


Site: Husky Oil Pierre, SD
Survey Date: Dec 2004
MIP Borings: 1-22
View: From NW
Horiz Slice: 18 ft
Vert Slice: Ctr of Pump Island
Detector: PID (uV)
Conductivity > 100 mS/m
COLUMBIA Technologies
SmartData Solutions
PID (uV)
1.0E8
1.0E7
1.0E6
Cond (mS/m)
307
247
186
126
65

Through the course of the study, 133 borings were advanced, resulting in a total of 349,500 data points. In order to assure the quality of the data collected, quantitative soil and groundwater samples were collected from discrete locations to collaborate the results of the MIP. Based on these analytical samples, the team members agreed the results of the MIP closely matched actual site conditions.



Future Work

Following the assessment activities, the team members reconvened to determine the next course of action at each site. It was determined that additional corrective action was needed at two of the sites to eliminate the potential risk to receptors, and monitoring natural attenuation and/or plume stability was agreed as the corrective action plan for two others. Following additional vapor monitoring at the final site, it is expected that the case will be eligible for NFA.

In addition, three underground storage tanks were discovered during the course of the study. These tanks were found primarily do to the vast number of borings installed, and the ability to obtain continuous soil information has the probe was advanced. It is likely that these UST's contributed to the respective contaminate plumes. Two of these tanks have already been removed, and the final tank is scheduled to be removed sometime in the summer of 2005.

Findings

Once a corrective action plan had been established for each of the 5 sites, the team members again reconvened as a whole to review the Triad Approach and offer comments or concerns regarding this approach to decision making.

There was overwhelming support for this type of approach for numerous reasons. First, the communication between the State and environmental consultants provided for a certain level of trust that usually does not exist during conventional site investigations. The fact that all team members had input in the developing the dynamic work plan made for a defensible course of direction.

Using real-time measurements provided the team members with instant and precise results, and decisions were not based on assumptions and incomplete data sets. This technology also provided the team members with direct sensing and data density that cannot be obtained using conventional drilling methods. This allowed for an accurate and precise CSM that was refined with each data point.

Through the course of the study, 133 borings were advanced, resulting in a total of 349,500 data points collected. In contrast, using conventional drilling methods which a PID reading is taken every 2-1/2 foot, and a sample collected from each boring, the total data points collected would have totaled 1,403. Because the data density was far greater using real-time measurements compared to traditional sampling, an obvious cost savings was realized. Table 2 summarizes the comparison between traditional sampling and the use of real time measurements.

In addition, the availability of real-time data allowed for the flexibility of augmenting the project work plan during the same mobilization, minimizing the need for future site visits to collect additional data. As a result, this eliminates redundant mobilization and demobilization costs, along with the associated expenses of generating interim reports, revised work plans, and additional contract amendments to complete the necessary work.

The cost associated with utilizing the Triad Approach in comparison to conventional site investigations was astonishing. Of the 3 sites which payments had been made in the past for previous assessment work, the costs associated with the additional assessment under the Triad Approach were as far less expensive than conventional assessments. In one case, the assessment activities under the Triad Approach were 70% less expensive than the previous assessment work. In addition, the information gathered during the Triad Approach did not contain data gaps and uncertainties as the conventional assessment did. Based on this information, substantial cost savings can be expected both in the short term and long term.

One of the challenges that were discussed was the availability of the real-time technologies in South Dakota. At the time of this report, there are no known vendors of this type of equipment in the State of South Dakota, resulting in a large expenditure not only to the PRCF, but also indirectly to the consultant who has a conventional drill-rig parked at their office or shop. Based on this, it could be expected that the costs associated with the Triad Approach could be inflated; resulting in the possibility of even larger cost savings.

One of the main challenges to implementing this type of approach is the availability of not only the technology, but the human aspects. At times, other commitments prohibited a team member(s) from visiting the site and taking part in the decision making processes, resulting in a lack of assurance by the other team members that the decisions made would be acceptable to the missing team member(s).

Table 2 – Traditional Screening/Sampling vs. Real-Time Measurements

Traditional Screening/Sampling (Hypothetical)

Site	No. of Conventional Borings	Total No. of Feet	Total No.of Data Points[1]
Steve's Amoco	27	726	291
T&T Standard	23	641	257
Severson's Service	30	644	259
DM&E Railroad	31	883	354
Former Husky Oil	22	601	241
TOTAL	**133**	**3,495**	**1,403**

[1] Consists of 1 data point per 2.5 foot interval using a PID, and one data point for 1 soil sample analyzed in a fixed laboratory.

VS.

Real-Time Measurements (Actual)

Site	No. of MIP Borings	Total No. of Feet of Data	Total No.of Data Points
Steve's Amoco	27	726	72,600
T&T Standard	23	641	64,100
Severson's Service	30	644	64,400
DM&E Railroad	31	883	88,300
Former Husky Oil	22	601	60,100
TOTAL	**133**	**3,495**	**349,500**

[1] Consists of 20 data points/instrument/ per foot. Instruments include Conductivity, PID, FID, ECD, and Temp.

Table 3 – Cost Reduction Using Triad Study

Site	Previous Assessments	Triad Assessment	% Reduction
Steve's Amoco	$0.00	$32,220.63	0.00%
T&T Standard	$62,837.06	$30,574.07	51.34%
Severson's Service	$103,044.38	$30,997.17[1]	69.92%
DM&E Railroad	$34,763.29	$29,937.93	13.88%
Former Husky's	$0.00	$25,312.17[1]	0.00%

[1] Invoices for work have not yet been received, therefore, costs are estimated.

Conclusions

Using the Triad Approach provided team members with a clear understanding of what the goals were, the steps that would be taken to reach the goals, and the flexibility to augment the work plans based on field analyses. In addition, a clear cost savings was realized, determined to be the result of up front project planning and the density of data collected from each boring location.

One of the main objectives of the systematic planning meeting was to generate a CSM based on the available information, and to identify uncertainties and data gaps in the CSM that must be addressed before the project goals could be attained. When stakeholders disagree with a certain corrective action plan, it is most often the result of inadequate information or a misinterpretation of the existing data. The systematic planning meeting enables all the available information to be gathered, including observations from field personnel and historical information gathered from previous stakeholders. This ensures all parties are basing their decisions on the same set of data.

Once all stakeholders had a clear understanding of what has been done and what is needed in order to move forward, a concurrence was made in regards to the proposed work strategy. This concurrence was three-fold: it provided a road-map for the future work; improved the communications between stakeholders; and heightened level of confidence each stakeholder had in one another.

The use of MIP technology for sample analyses had a significantly lower per-analysis cost than samples collecting during conventional drilling and analyzed in a fixed laboratory. Since samples collected and analyzed in a fixed laboratory are more accurate and consequently more expensive, most often very few soil samples (~1 per boring) can be analyzed compared to the number needed to accurately characterize contaminant distributions. This higher degree of analytical quality is seldom needed to develop or refine the CSM. However, the use of the MIP defined the CSM and allowed stakeholders to determine the best locations to collect soil samples to collaborate the results of the MIP.