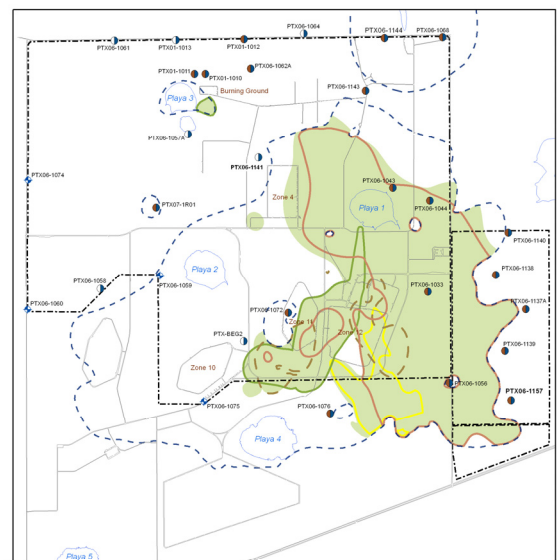
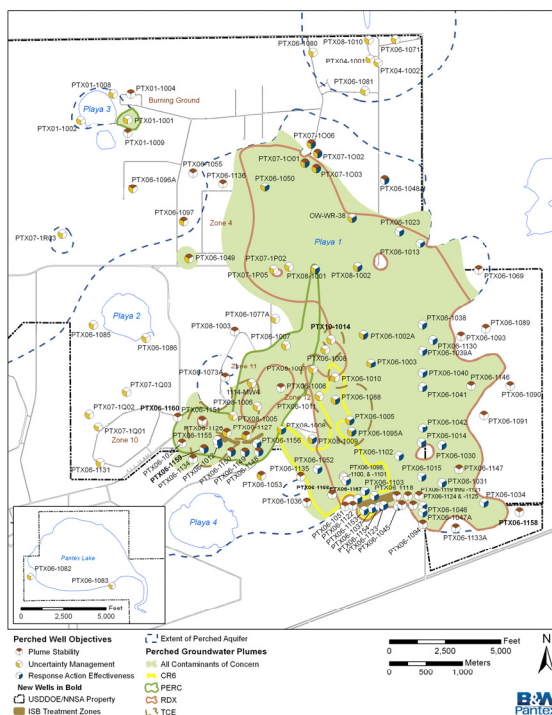
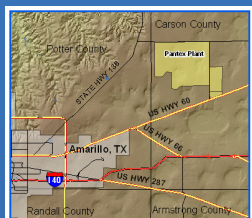
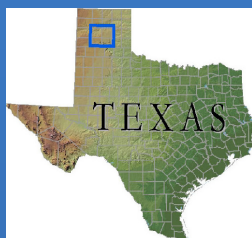


Pantex Plant

Update to the Long-Term Monitoring System Design Report

for the USDOE/NNSA Pantex Plant, Amarillo, TX



January 2014

**Update to the Long-Term Monitoring System Design Report
for the U.S. Department of Energy/
National Nuclear Security Administration
Pantex Plant, Amarillo, Texas**

January 2014

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ACRONYMS

B&W Pantex	Babcock & Wilcox Technical Services Pantex, LLC
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CMS/FS	Corrective Measure Study/Feasibility Study
COC	Constituents of concern
COV	Coefficient of variation
Cr(VI)	Hexavalent chromium
EPA	United States Environmental Protection Agency
GSI	Groundwater Services, Incorporated
GWPS	Groundwater Protection Standard
HE	High explosive
ISB	<i>In-Situ</i> Bioremediation
ISPM	<i>In-Situ</i> Performance Monitoring
LTMO	Long-term monitoring optimization
MAROS	Monitoring and Remediation Optimization System
NNSA	National Nuclear Security Administration
PQL	Practical quantitation limit
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDX	Research Development Explosive (cyclo-trimethylene trinitramine)
ROD	Record of Decision
RRS	Risk Reduction Standard
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TTU	Texas Tech University
USDOE	U.S. Department of Energy

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1. INTRODUCTION

This report presents proposed modifications to the long-term groundwater monitoring (LTM) well network that was developed in 2009 (Appendix A). The original network was developed using statistical methods, fate and transport modeling, and site-specific knowledge for the evaluation of response actions (corrective/remedial actions) for Pantex Plant and monitoring uncertainties near source areas. The proposed modifications are based on an evaluation of the perched aquifer monitoring system and data collected during the first Five-Year Review, as well as updated expected conditions based on changing aquifer conditions. This report also presents the methods for evaluating the effectiveness of the response actions based on the monitoring well network for Pantex Plant. Collected data are evaluated against expected conditions for each well. Contingency actions for unexpected conditions are provided in the *Pantex Plant Ogallala Aquifer and Perched Groundwater Contingency Plan*.

Pantex Plant is located on the plains of the Texas Panhandle, 17 miles northeast of Amarillo as shown in Figure 1-1. The Ogallala Aquifer, part of the High Plains aquifer system, is the principal water-bearing unit and provides a primary source of water for the region. Additionally, bodies of perched groundwater above the Ogallala Aquifer occur beneath much of Pantex Plant. Areas of this perched groundwater zone have been contaminated as a result of past wastewater discharges from legacy operations at the facility. Contaminated sites at the surface are separated from groundwater in either the perched zone or the Ogallala Aquifer by a 200- to 500-ft (61- to 153-m) thick unsaturated zone. In areas where perched groundwater is present, a second vadose zone occurs above the Ogallala Aquifer. A full description of the hydrogeology for Pantex is provided in Appendix A.

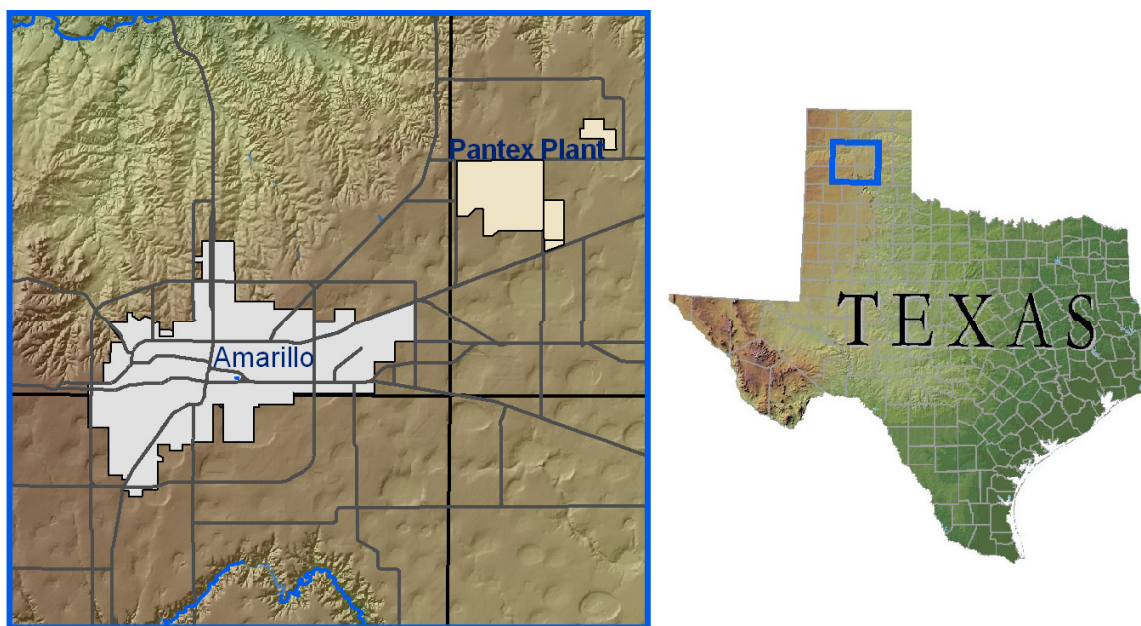


Figure 1-1. Pantex Plant Location Map

The primary purpose of the Long-Term Monitoring (LTM) network is to provide data to determine if Remedial Action Objectives (RAOs) are being achieved. The data collected from the LTM network will be evaluated in annual progress reports with a full evaluation of the effectiveness of the response actions

in a five-year review. The LTM network is also reevaluated during each Five-Year Review to determine if changes are required to the network or the remedies to meet remedial action objectives presented in the Record of Decision (ROD) (B&W Pantex and Sapere Consulting, 2008).

The perched groundwater monitoring network is designed to monitor plume stability, response action effectiveness, and uncertainty management. The many components of the selected remedy for perched groundwater are intended to work together to create conditions that both stabilize and cleanup the contaminants. The pump and treat systems in the southeast perched groundwater and the Playa 1 area focus on affecting the hydraulics of the system, that is groundwater removal as a means of reducing the potential for both vertical and lateral migration of contaminants. With this understanding, the primary metric for success of the pump and treat systems is perched groundwater thickness, as determined through periodic water level measurements. Routine monitoring for this parameter will provide the basis for determining flow direction, gradient, and thickness. These determinations will aid the prediction of plume movement and rate, as well as vertical flux of contaminants. A secondary benefit of the pump and treat systems is contaminant mass removal. Therefore, chemical analysis is also important as it allows the risk posed by the contaminant plumes to be evaluated periodically.

The southeast and Zone 11 *in situ* treatment systems target contaminant mass removal as a means of cleaning up the perched groundwater and protecting the underlying Ogallala Aquifer from future degradation that could affect its use as a drinking water source. These systems are downgradient of the perched groundwater plumes in the areas that pose the greatest potential for vertical migration to the Ogallala Aquifer. Chemical analyses and parameters associated with redox conditions in perched groundwater will provide the most important information for determining the effectiveness of these systems. Evaluation of downgradient wells will provide information regarding the effectiveness of the treatment on the perched groundwater.

1.1. REGULATORY REQUIREMENTS

Long-term monitoring (LTM) is required to confirm expected future conditions within perched groundwater and the Ogallala Aquifer at Pantex Plant. This plan is being provided in accordance with Article 8.5 of the Interagency Agreement, as part of the Remedial Design Submittal Package, Section VIII.F of Compliance Plan No. 50284, as part of the Corrective Measures Implementation Work Plan, and as part of the Compliance Plan Application to modify the Compliance Plan (CP-50284) to include the response (corrective) action provisions.

Uncertainty management objectives are included in the development of the plan to fulfill conditions of approval for the Resource Conservation and Recovery Act (RCRA) Facility Investigation Reports presented by Texas Commission on Environmental Quality (TCEQ) and United States Environmental Protection Agency (EPA). Long-term monitoring of perched groundwater and the Ogallala Aquifer will result in obtaining data to identify any unknown contaminant migration pathways. Should data be acquired that confirms an unexpected condition, the conceptual site model assumptions would be evaluated to determine the cause and mitigation measures would be assessed and implemented, as necessary, to maintain protection of human health and the environment. Contingency actions for unexpected conditions are presented in the *Pantex Plant Ogallala Aquifer and Perched Groundwater Contingency Plan*.

1.2. CURRENT LONG TERM MONITORING NETWORK

In the original LTM Network Design (Appendix A) an approach was developed by the Pantex Core Team to develop monitoring objectives for each water bearing unit, evaluate the existing well networks, and then develop the final proposed monitoring network. As outlined in the final report, monitoring

objectives of plume stability, uncertainty management, and response action effectiveness were developed for the perched aquifer and uncertainty management and early detection were developed for the Ogallala Aquifer. Based on these objectives, a final monitoring network was proposed, approved, and implemented by September 2009.

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2. PERCHED GROUNDWATER

This section summarizes the proposed changes to the LTM network for perched groundwater beneath Pantex Plant. The strategy used to develop the original monitoring network was not changed.

2.1. EVALUATION OF LONG TERM MONITORING NETWORK

The current groundwater monitoring network and groundwater concentration data were evaluated by Dr. Mindy Vanderford of GSI Environmental, Inc. using a formal qualitative approach as well as using statistical tools found in the Monitoring and Remediation Optimization System (MAROS) software. Major contaminant of concern plumes are depicted in Figures 2-1 through 2-4 and the LTM network is depicted in Figure 2-5 and Figure 2-6. MAROS was developed by Groundwater Services, Inc. for the Air Force Center for Engineering and the Environment. Dr. Vanderford made recommendations for perched groundwater sampling frequency and location based on current hydrogeologic conditions and defined LTM goals for the system. The recommendations for the monitoring network are based on a technical review, balancing both the statistical results with goals of the monitoring system and anticipated site management decisions. The summary presented below was taken from the *Groundwater Monitoring Network Optimization 2012* report (GSI, 2012) included in Appendix B.

It should be noted that the perched aquifer monitoring objectives of plume stability and response action effectiveness are affected by this evaluation. The third monitoring objective, uncertainty management, is not addressed by this evaluation. Therefore the wells assigned as uncertainty management to monitor solid waste management units and fulfill conditions of approval for the RCRA Facility Investigation Reports were not changed from the 2009 LTM Design.

2.1.1 Project Goals and Objectives

The goal of the long-term monitoring optimization (LTMO) process is to review the current groundwater monitoring program and provide recommendations for improving the efficiency and accuracy of the network in supporting monitoring objectives. Specifically, the LTMO process provides information on site characterization, plume stability, sufficiency and redundancy of monitoring locations, and the appropriate frequency of network sampling. The end product of the LTMO process at Pantex Plant is a recommendation for specific sampling locations and frequencies that best address site monitoring goals and objectives while minimizing time and expense associated with collecting and interpreting analytical data.

2.1.2 Results

The monitoring system for perched groundwater was evaluated using analytical and hydrogeologic data from sampling events conducted from 2000 - 2011. Perched groundwater was divided into three sectors for analysis based on the direction of groundwater flow, source areas, and major constituents associated with each sector. Investigation wells were grouped into networks according to the defined sectors. The Southeast Sector monitoring network consists of wells in perched groundwater extending south from Playa 1 to the eastern and southern extent of perched groundwater including Zone 12. The Southwest Sector monitoring network includes and extends west and south of Zone 11. Investigation wells south of Zone 12 were included in both the Southwest and Southeast Sector spatial analyses to account for possible variability in groundwater flow. The North Sector includes groundwater north of Zones 11 and 12 in the vicinity of Playa 1. Pantex Plant perched groundwater analytical data were evaluated using a combination of statistical analyses for priority COCs and consideration of qualitative issues such as

hydrogeology, potential receptors, and monitoring goals to produce general recommendations for monitoring. The recommended changes included:

- Four new wells are recommended to define plumes emanating from Zones 11 and 12. The wells are needed to delineate plumes that come from south/southwest and east of the developed areas of the Plant. These locations will also contribute groundwater elevation data to help refine understanding of the gradients and the extent of saturation in this area.
- Overall, rates of concentration change are low for most locations and annual to biennial (every two years) monitoring is recommended based on the MAROS analysis. However, early warning of changing conditions and collection of a statistically significant dataset are high priorities for the site so semi-annual data collection is recommended for many locations, particularly those monitoring response actions.

As a result of these recommendations, Pantex installed four monitoring wells in the proposed areas. These wells are summarized in Table 2-1 and highlighted in Figure 2-7.

Table 2-1. Summary of LTMO Recommendations

Sector	Recommended Well Additions	
Southeast	2	PTX06-1158, PTX06-1166
Southwest	2	PTX06-1159, PTX06-1160

Additionally, Pantex is recommending the conversion of semi-annual sampling to annual sampling for four wells to help offset the cost of sampling the newly installed monitoring wells. These wells include:

- PTX06-1013
- PTX06-1136
- PTX06-1131
- PTX07-1001

It is important to note that Pantex continues to meet or exceed all sampling frequencies recommended in the MAROS evaluation.

2.2. ADDITIONAL CHANGES TO THE PERCHED AQUIFER MONITORING NETWORK

In Situ Bioremediation Systems

In the original LTM Design Report, quarterly sampling was recommended for ISB treatment zone monitoring. However, as operational experience was gained with these systems, it was determined that potential interference with ISB O&M (well rehabilitation and injection) may affect the representativeness of samples collected after rehabilitation. Therefore a modification to the sampling schedule was proposed in a revised *Sampling and Analysis Plan* (B&W Pantex 2011) and approved in 2012, requesting that treatment zone sampling activities not be conducted during the quarter when well rehabilitation is performed and during the first quarter following injection. Sampling will commence a full quarter after completion of injection to ensure that chase water is not sampled and that samples are not collected immediately following a rehabilitation event. Sampling immediately following injection or rehabilitation can skew treatment zone results as well as trending of those results. Pantex will ensure that the time between sampling events (pre- to post injection) does not exceed six months. It should be noted that the sampled injection wells annotated in Figure 2-10 represent the wells currently sampled for treatment zone

monitoring. These monitoring points may be modified based on changing conditions in individual wells or the ISB system conceptual models. However, these modifications will be reflected by revisions to the Sampling and Analysis Plan rather than this design document.

Three monitoring wells (PTX06-1148, PTX06-1149, and PTX06-1150) installed downgradient of the Zone 11 ISB system have been converted to *in-situ* performance monitoring wells. However, since they are located further away from the injection well field than the original performance monitoring wells, response action objectives are expected to be met 5 -10 years after the initial injection.

Monitoring Wells

Several additional changes were made to the perched aquifer monitoring network since the original LTM design was approved in 2009, primarily due to changing hydrogeologic conditions in the perched aquifer or individual wells. These changes are reflected in Table 2-2 and Figure 2-7. Monitoring objectives, reporting metrics, and expected conditions have been modified where needed. Major changes include:

- Several historically dry wells located along the fringe of the perched groundwater extent, including PTX06-1133A, PTX06-1073A, PTX06-1120, and PTX06-1121, were dry when the LTM Design was published in 2009 but now have consistent measured water levels in their screened intervals. These slight fluctuations at the perched groundwater fringes are not unexpected as the perched aquifer continues to slowly spread. The objectives, metrics, and expected conditions in Table 2-2 have been modified to reflect these changes in conditions.
- PTX10-1013 was plugged and replaced with PTX10-1014 (previously parked well located approximately 175 feet southeast) in August 2010 due to potential storm water intrusion into the well casing.
- PTX06-1167 was installed approximately 200 feet north of the west side of the Southeast ISB system in August 2013. This well, which was dry when installed, was needed to continue to evaluate groundwater flow patterns and plume characteristics in the area.

Due to continued plume movement downgradient from source areas, the monitoring frequencies for PTX06-1035 (southwest of Zone 11) and PTX06-1049 (west of Playa 1) have been increased from annual to semi-annual to more effectively monitor COC concentrations moving into these areas.

These proposed changes to the LTM network are reflected in Table 2-2 and Figures 2-7 through 2-10.

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Table 2-2. Proposed Long-Term Monitoring Network for Perched Groundwater

Indicator Area ¹	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List ² Monitoring Frequency	Appendix IX Monitoring List ³	Appendix IX Monitoring Frequency
Zone 11	1114-MW4	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
North	OW-WR-38	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	Y	5 Yrs
Burning Ground	PTX01-1001	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	Y	5 Yrs
Burning Ground	PTX01-1002	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Burning Ground	PTX01-1004	Plume Stability	Dry	Remain dry	NA	N	NA
Burning Ground	PTX01-1008	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	Y	5 Yrs
Burning Ground	PTX01-1009	Plume Stability	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX04-1001	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX04-1002	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Southeast	PTX06-1002A	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1003	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	Y	5 Yrs
Southeast	PTX06-1005	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Zone 11	PTX06-1006	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Annual	N	NA
Zone 11	PTX06-1007	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Southeast, Zone 11	PTX06-1008	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Southeast	PTX06-1010	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Southeast, Zone 11	PTX06-1011	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Zone 11	PTX06-1012	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1013	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1014	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1015	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1023	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1030	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1031	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1034	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Zone 11	PTX06-1035	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	N	NA
Southeast	PTX06-1036	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Southeast	PTX06-1037	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1038	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1039A	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1040	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA

Indicator Area ¹	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List ² Monitoring Frequency	Appendix IX Monitoring List ³	Appendix IX Monitoring Frequency
Southeast	PTX06-1041	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1042	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1045	Response Action Effectiveness	Water level, Trend/Compare to GWPS	Limited water, Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1046	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1047A	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
North	PTX06-1048A	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Miscellaneous	PTX06-1049	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
North	PTX06-1050	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1051	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1052	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast, Zone 11	PTX06-1053	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	N	NA
Miscellaneous	PTX06-1055	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1069	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Miscellaneous	PTX06-1071	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	Y	5 Yrs
Zone 11	PTX06-1073A	Plume Stability	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	NA	N	NA
Zone 11	PTX06-1077A	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX06-1080	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	N	NA
Miscellaneous	PTX06-1081	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Miscellaneous	PTX06-1082	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX06-1083	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX06-1085	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX06-1086	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Southeast	PTX06-1088	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1089	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1090	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1091	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1093	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1094	Plume Stability	Water Level	Limited water	NA	N	NA
Southeast	PTX06-1095A	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Miscellaneous	PTX06-1096A	Plume Stability, Uncertainty Management	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX06-1097	Plume Stability, Uncertainty Management	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1098	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA

Indicator Area ¹	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List ² Monitoring Frequency	Appendix IX Monitoring List ³	Appendix IX Monitoring Frequency
Southeast	PTX06-1100	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1101	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1102	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1103	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1118	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1119	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1120	Plume Stability	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1121	Plume Stability	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1122	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1123	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1124	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1125	Plume Stability	Dry	Remain dry	NA	N	NA
Zone 11	PTX06-1126	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Zone 11	PTX06-1127	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1130	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Miscellaneous	PTX06-1131	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1133A	Plume Stability	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	Semi-Annual	N	NA
Zone 11	PTX06-1134	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1135	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
North	PTX06-1136	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1146	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1147	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Zone 11	PTX06-1148	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 5 -10 years	Quarterly	N	NA
Zone 11	PTX06-1149	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 5 -10 years	Quarterly	N	NA
Zone 11	PTX06-1150	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 5 -10 years	Quarterly	N	NA
Zone 11	PTX06-1151	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1153	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Quarterly	N	NA
Southeast	PTX06-1154	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Quarterly	N	NA
Zone 11	PTX06-1155	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Quarterly	N	NA
Zone 11	PTX06-1156	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Quarterly	N	NA
Southeast	PTX06-1158	Plume Stability	Water Level, Trend/Compare to GWPS	Limited water, Long-term stabilization of concentrations	NA	N	NA
Zone 11	PTX06-1159	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA

Indicator Area ¹	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List ² Monitoring Frequency	Appendix IX Monitoring List ³	Appendix IX Monitoring Frequency
Zone 11	PTX06-1160	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1166	Plume Stability	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1167	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
North	PTX07-1O01	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
North	PTX07-1O02	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
North	PTX07-1O03	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
North	PTX07-1O06	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Zone 11	PTX07-1P02	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	Y	5 Yrs
Zone 11	PTX07-1P05	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1Q01	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1Q02	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1Q03	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1R03	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	Y	5 Yrs
Zone 11	PTX08-1001	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	Y	5 Yrs
Southeast	PTX08-1002	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Zone 11	PTX08-1003	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Zone 11	PTX08-1005	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Zone 11	PTX08-1006	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Southeast, Zone 11	PTX08-1007	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Southeast, Zone 11	PTX08-1008	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast	PTX08-1009	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Miscellaneous	PTX08-1010	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	Y	5 Yrs
Southeast, Zone 11	PTX10-1014	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs

1 The indicator monitoring lists are set according to the monitoring areas. The indicator monitoring lists can be found in the *Sampling and Analysis Plan*, Table IIIA of the Corrective Action Compliance Plan, and are shown on Figure 2-6.

2 Refer to the latest approved Pantex Sampling and Analysis Plan or the Corrective Action Compliance Plan Table IIIA for the indicator monitoring lists.

3 A full list of constituents to be monitored is required for uncertainty management. A modified Appendix IX has been recommended for the Corrective Action Compliance Plan Application (Table III) and in the *Sampling and Analysis Plan*.

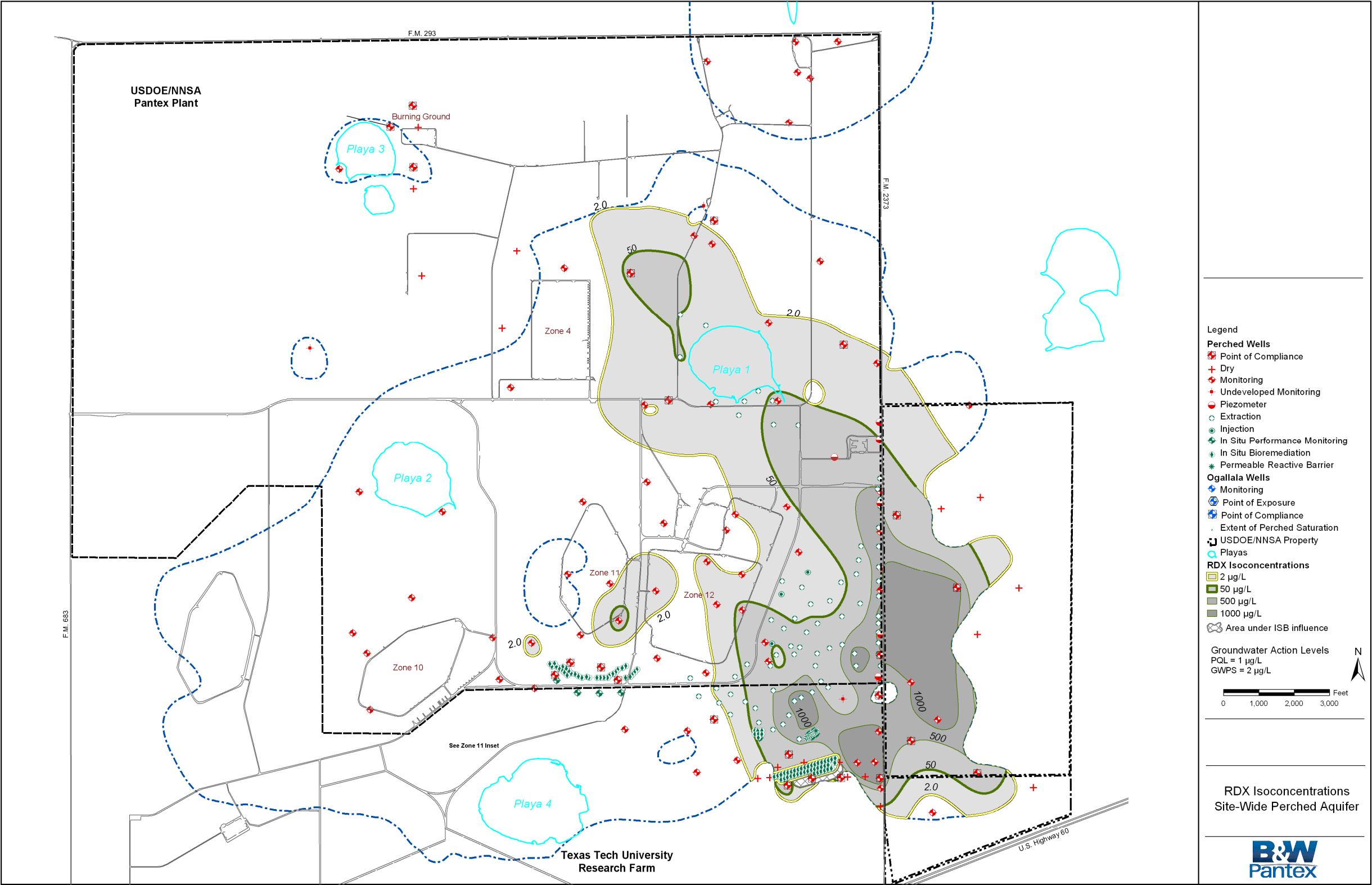


Figure 2-1. Perched Groundwater RDX Isoconcentrations

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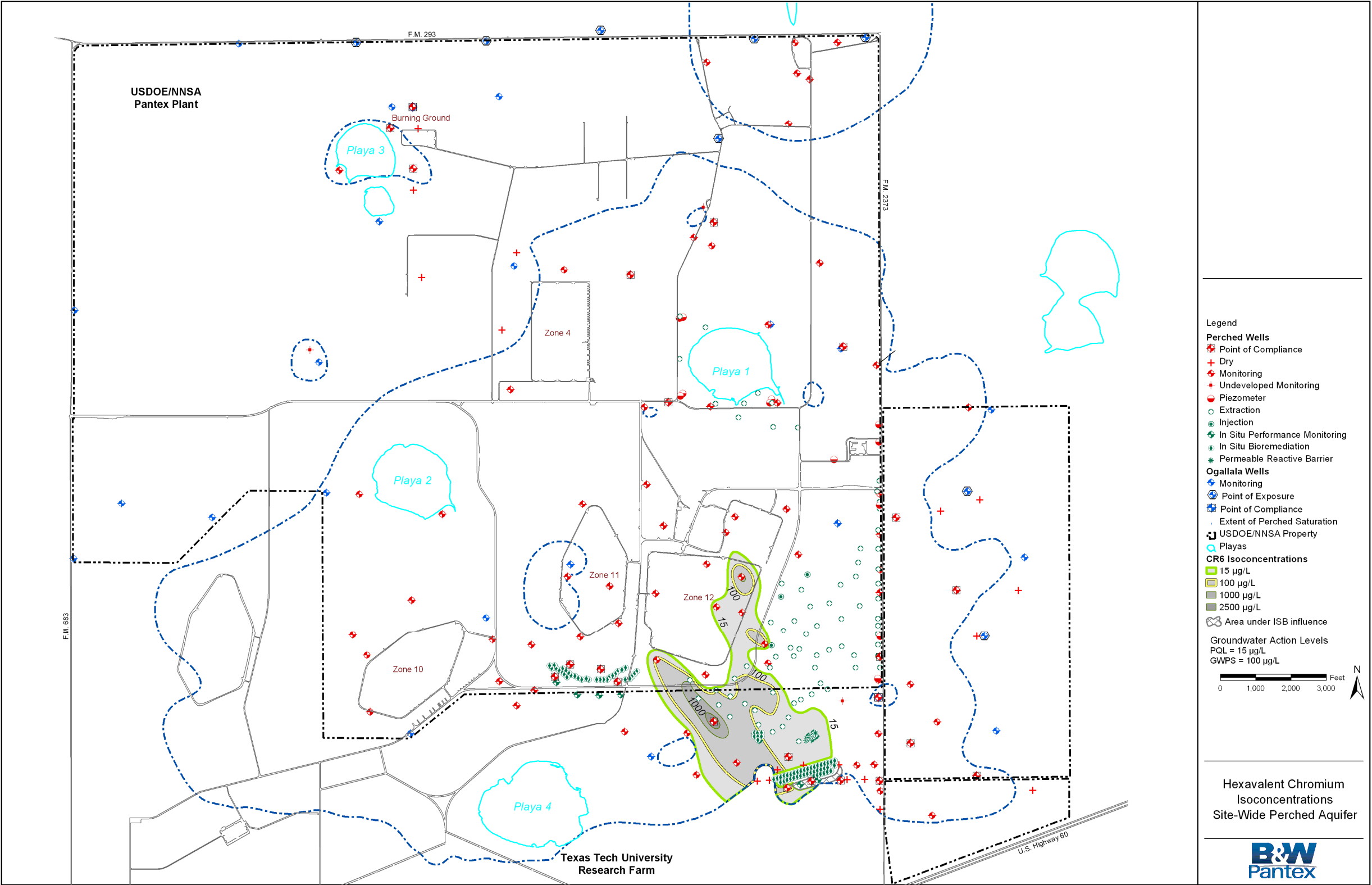


Figure 2-2. Perched Groundwater Hexavalent Chromium Isoconcentrations

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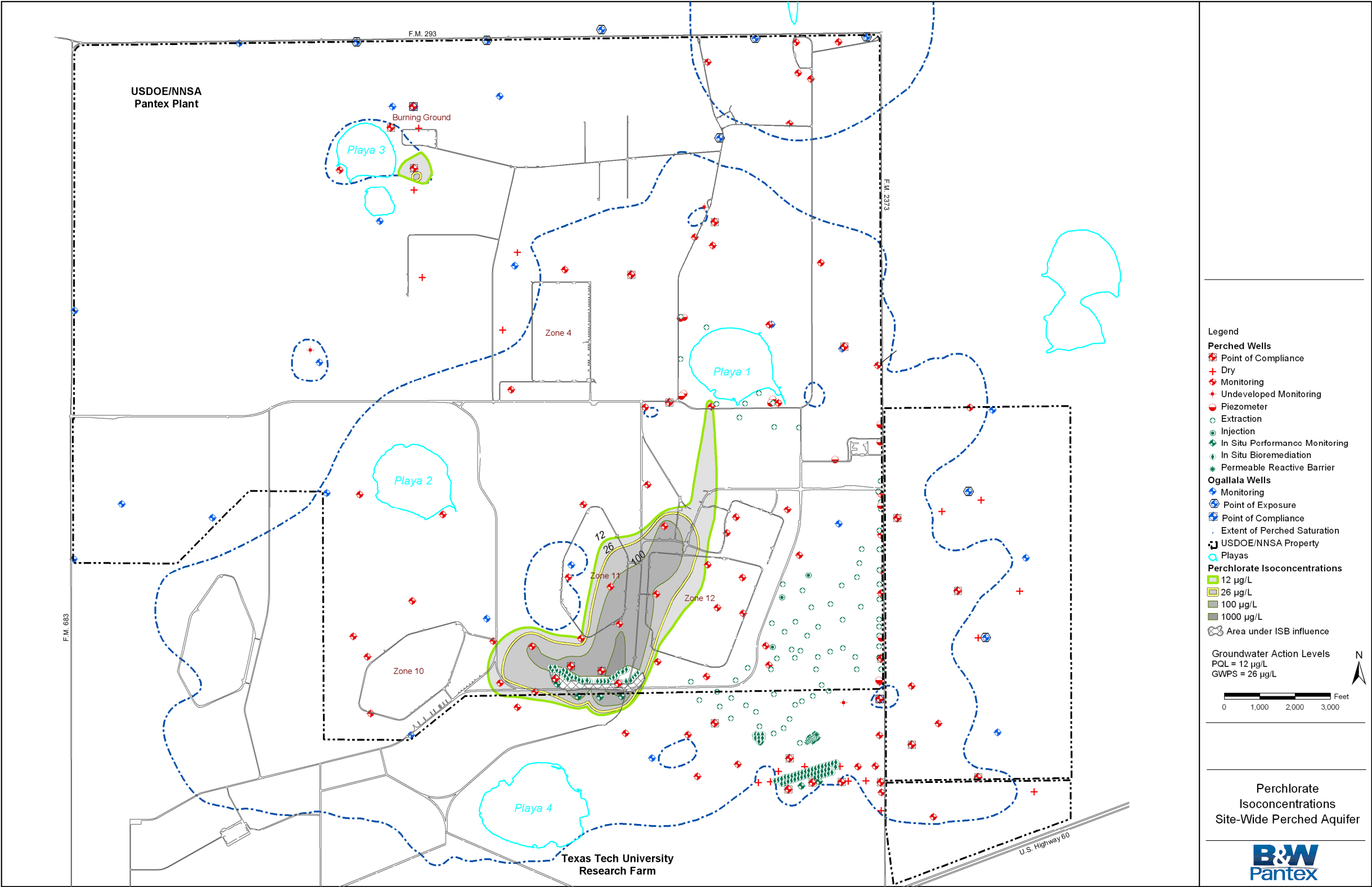


Figure 2-3. Perched Groundwater Perchlorate Isoconcentrations

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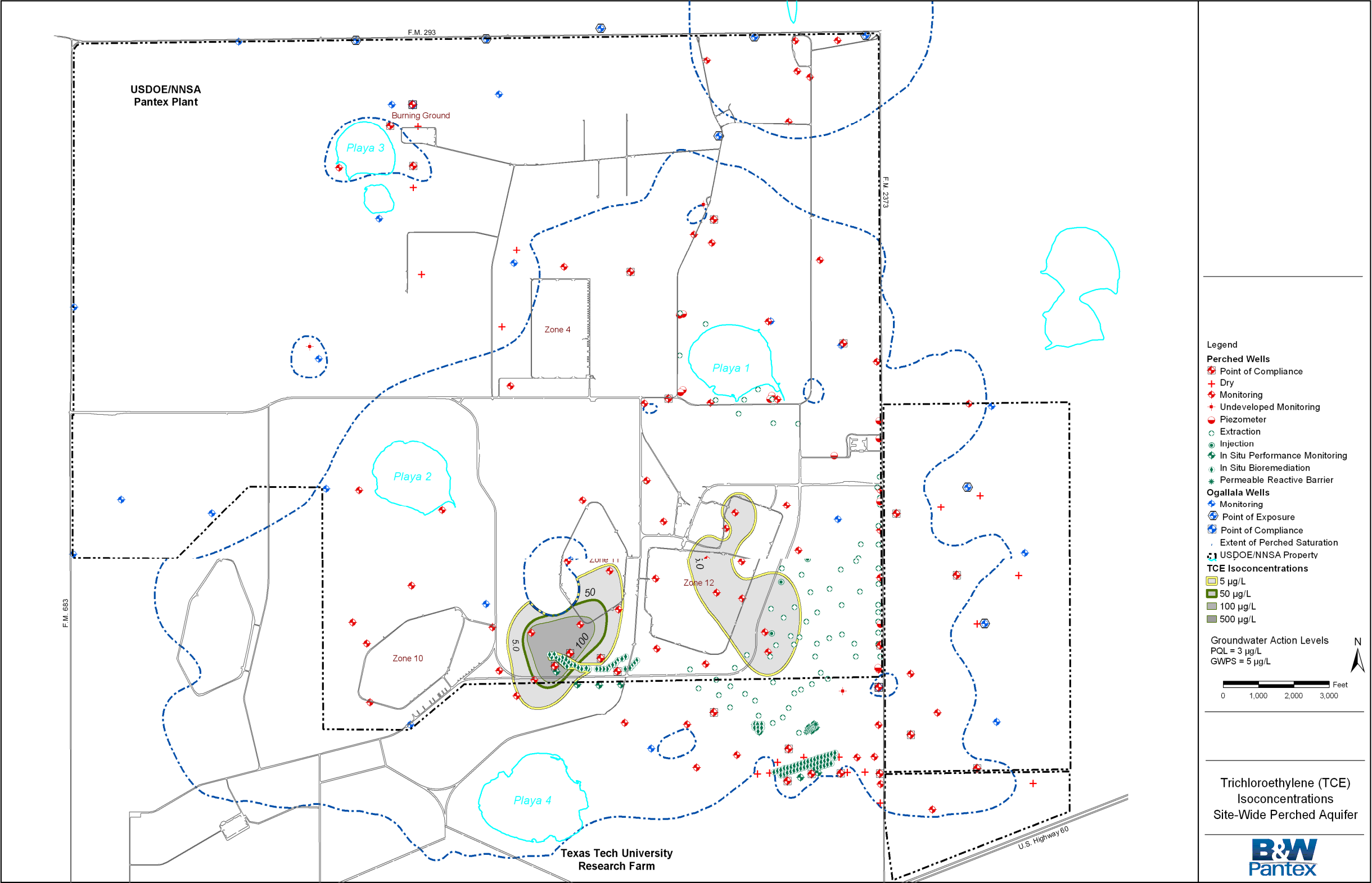


Figure 2-4. Perched Groundwater TCE Isoconcentrations

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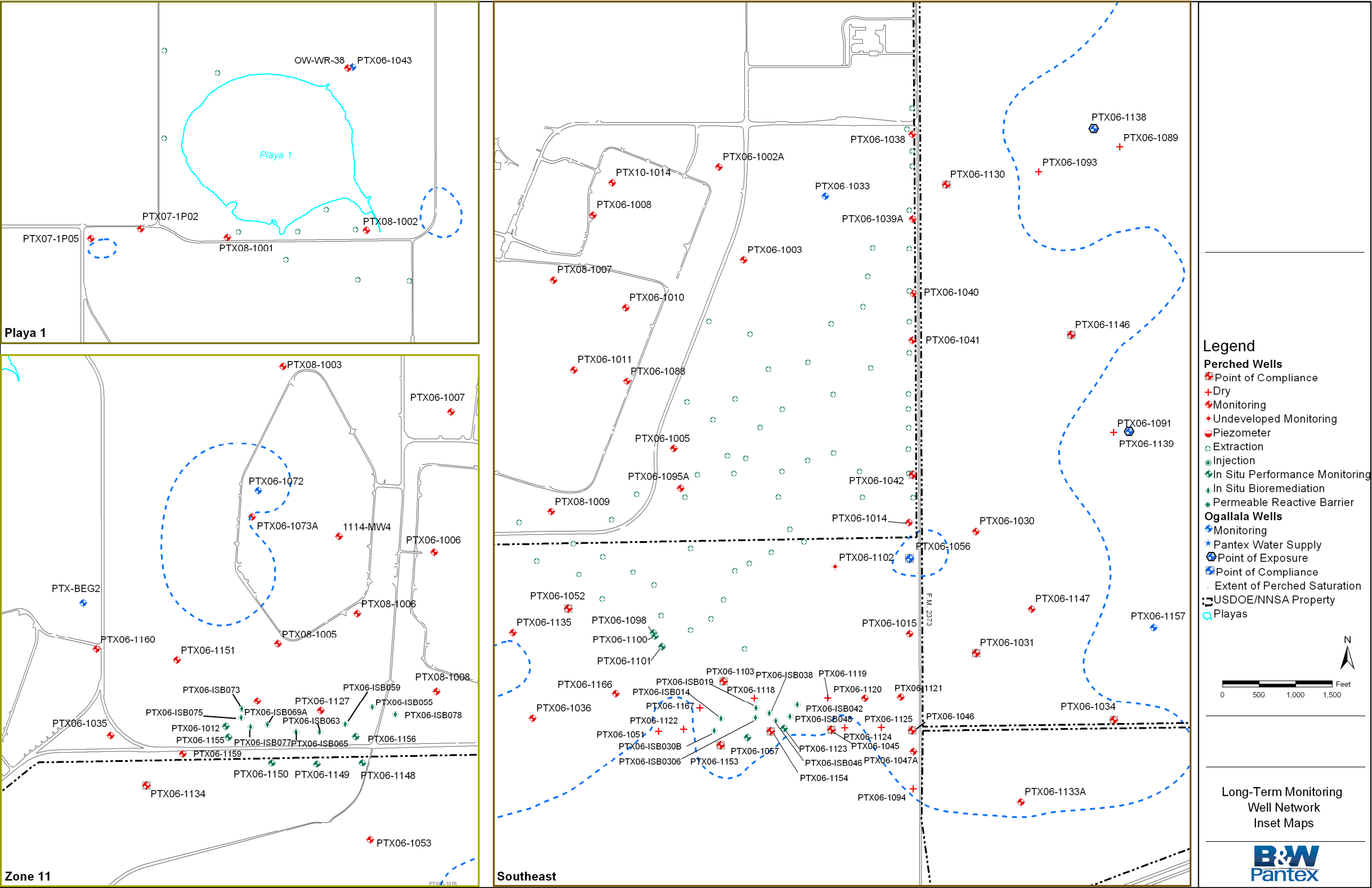


Figure 2-6. Inset LTM Well Location Maps

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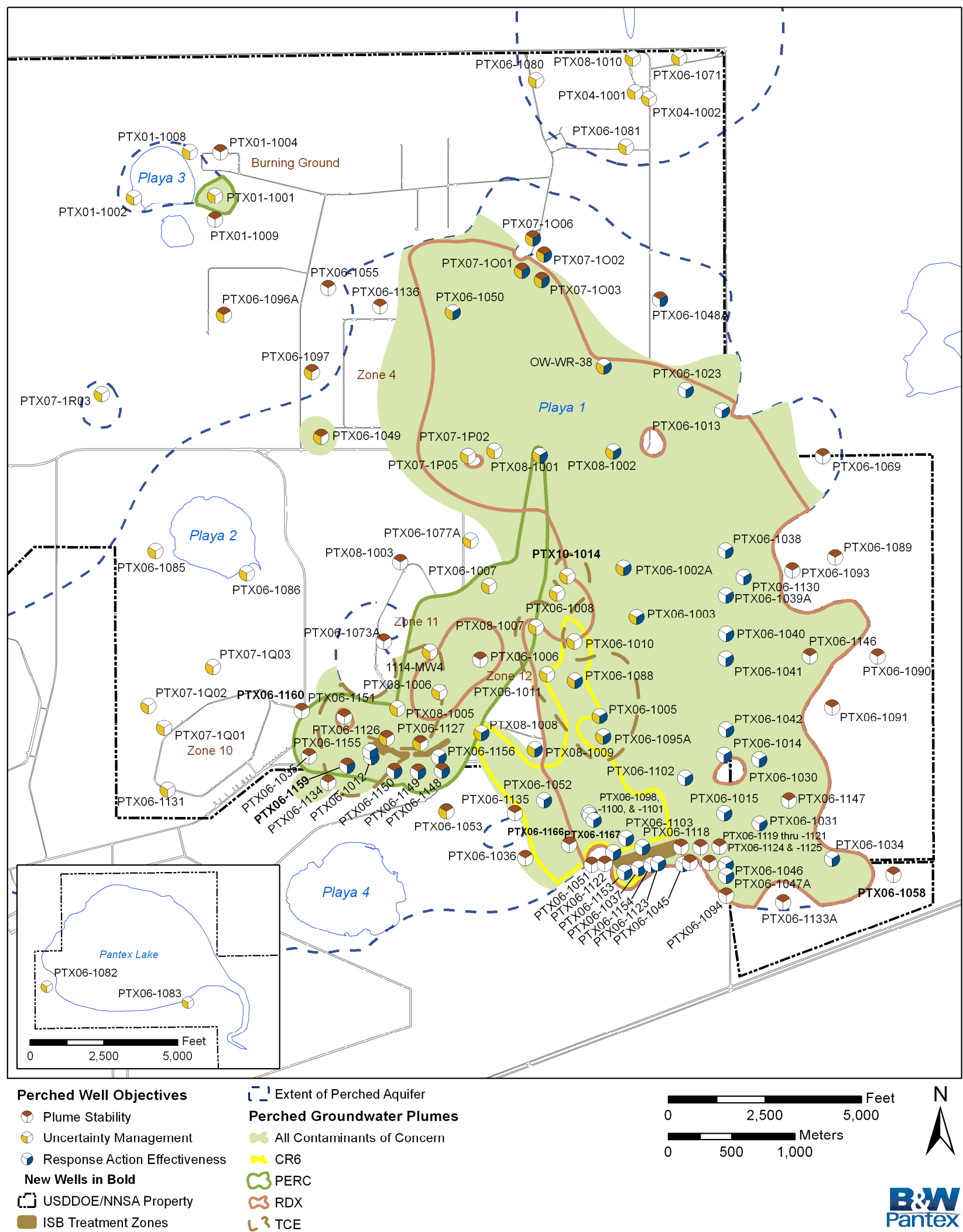
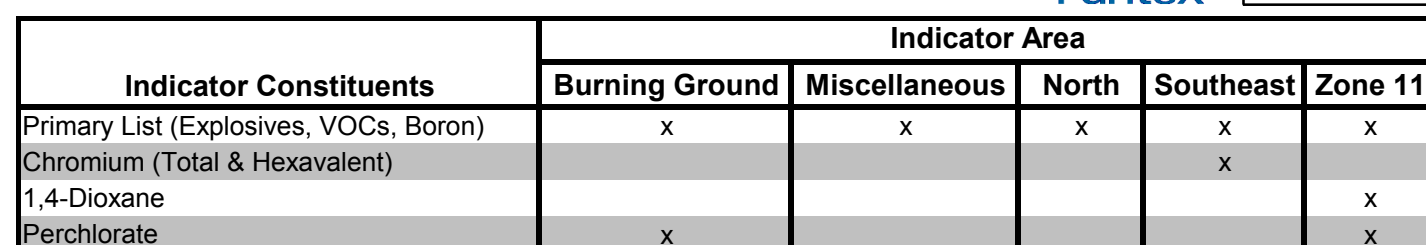


Figure 2-7. Perched Groundwater Long-Term Monitoring Network

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High Explosives (12)

VOCs (7)

Metals (1)

Boron

Figure 2-8. Indicator Constituent Areas for Perched Groundwater

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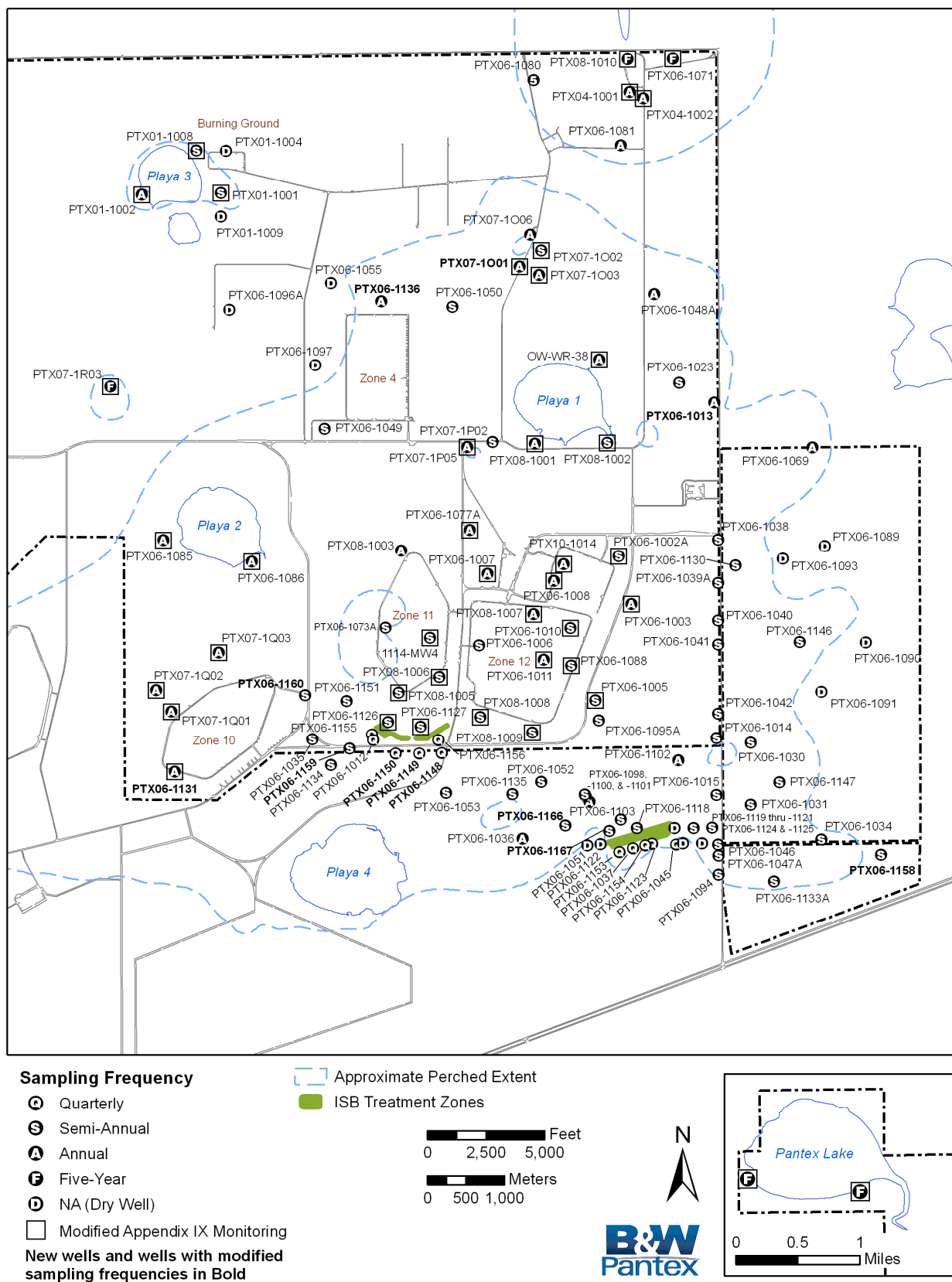


Figure 2-9. Sampling Frequency for Perched Groundwater

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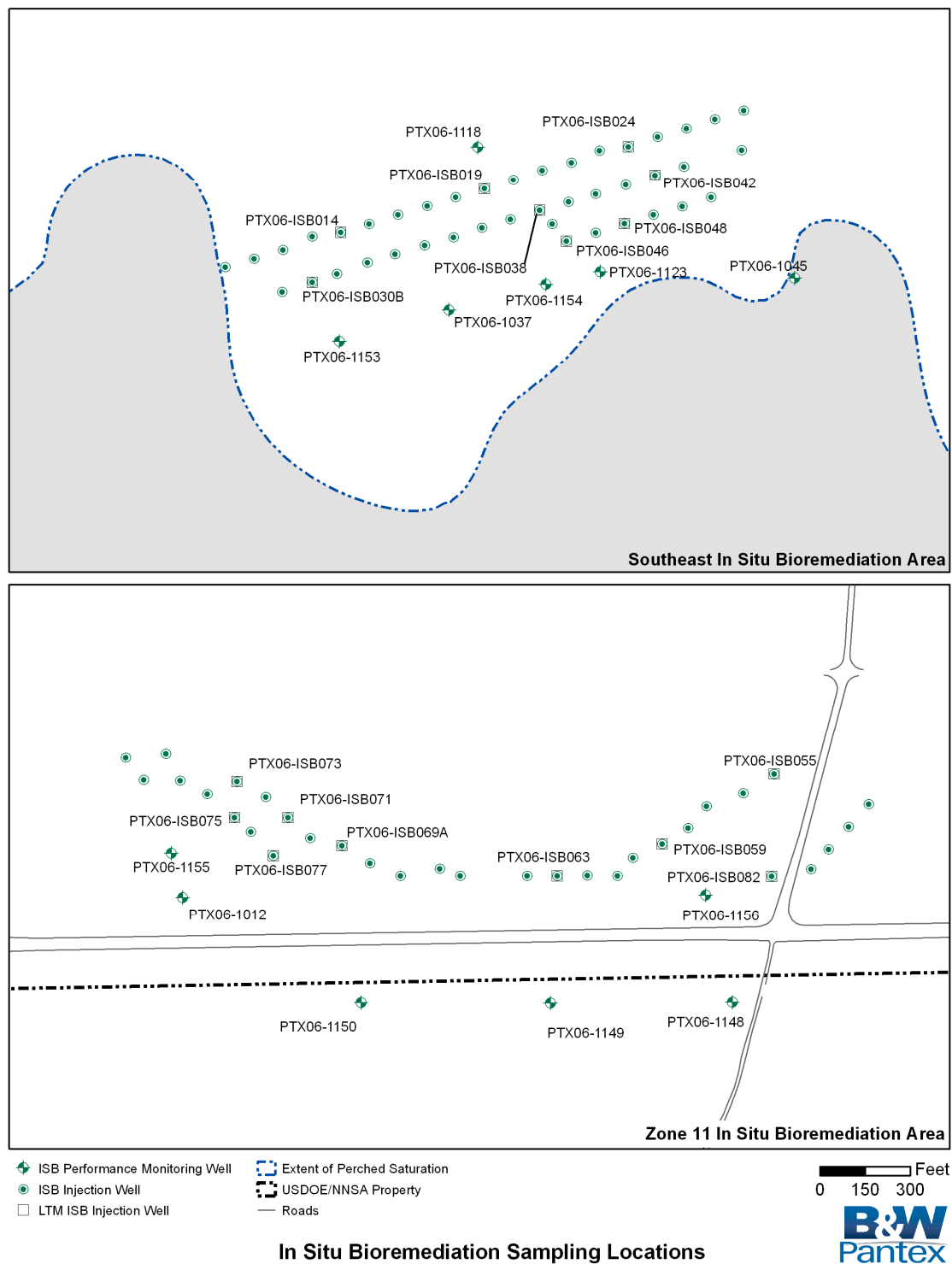


Figure 2-10. ISB Performance Monitoring Sampling Locations

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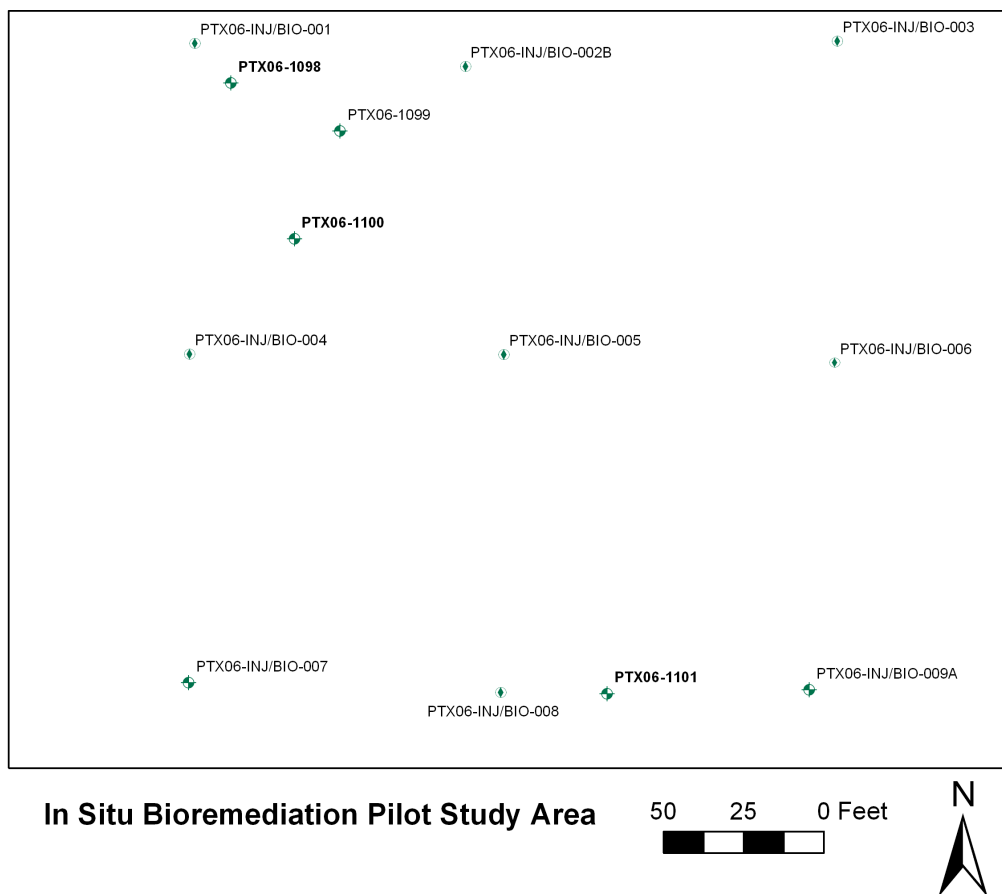


Figure 2-11. Wells sampled in ISB Pilot Study Area

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3. OGALLALA AQUIFER

The Ogallala Aquifer Monitoring Network was evaluated as part of the first Five-Year Review and no changes to the monitoring network were recommended. However, an evaluation of Ogallala aquifer monitoring well construction and sampling methods was also conducted as part of the Five-Year Review process and several recommendations regarding sampling and well construction were made. As a result, an Ogallala Aquifer Sampling Improvement Plan was developed and submitted as an Appendix to the 2012 Annual Progress Report (Appendix D). While no changes to the physical monitoring network were recommended in these evaluations, several other changes to sampling methods and materials were recommended and discussed in Section 4.

The only change to the Ogallala Aquifer Monitoring Network is the replacement of PTX06-1032 with PTX06-1157. Low-level high explosives were detected and confirmed in PTX06-1032 in 2009. A subsequent investigation indicated that an improper annular seal at the fine-grained zone was likely the cause of the HE detections. Therefore, Pantex requested that PTX06-1032 be plugged, abandoned, and replaced in the monitoring network in January 2010. The well was plugged and abandoned after TCEQ and EPA approval in February 2010. PTX06-1157 was installed approximately 1,500 feet northeast of the original location in April 2010 to avoid encountering affected perched groundwater. The Ogallala Aquifer monitoring network is depicted in Figure 3-1 and summarized in Table 3-1. Ogallala Aquifer indicator areas and sampling frequencies are depicted in Figure 3-2 and Figure 3-3 respectively.

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Table 3-1. Proposed Long-Term Monitoring Network for the Ogallala Aquifer

Indicator Area ¹	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List ² Monitoring Frequency	Multiple Sampling Depth Frequency ³	Appendix IX Monitoring List ⁴	Appendix IX Monitoring Frequency ⁵
Northwest	PTX01-1010	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX01-1011	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX01-1012	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Northwest	PTX01-1013	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Northwest	PTX06-1057A	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	NA	Y	5 Yrs
Northwest	PTX06-1058	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	NA	Y	5 Yrs
Northwest	PTX06-1061	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	NA	N	NA
Northwest	PTX06-1062A	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX06-1064	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX06-1068	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX06-1072	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX06-1141	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	5-Yr	Y	5 Yrs
Northwest	PTX06-1143	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	Y	5 Yrs
Northwest	PTX06-1144	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	N	NA
Northwest	PTX07-1R01	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX-BEG-2	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1157	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	N	NA
Southeast	PTX06-1056	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1137A	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	N	NA
Southeast	PTX06-1138	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	N	NA
Southeast	PTX06-1139	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	N	NA
Southeast	PTX06-1140	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	5-Yr	N	NA
Southeast/Northwest	PTX06-1033	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast/Northwest	PTX06-1043	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast/Northwest	PTX06-1044	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast/Northwest	PTX06-1076	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA

1

The indicator monitoring lists are set according to the monitoring areas.

2

Refer to the current Pantex Sampling and Analysis Plan or the Compliance Plan Table IIIA for the indicator monitoring lists.

3

The wells that were completed with blanks between the screened intervals were selected for this sampling because the intervals could be isolated during sampling. Dedicated pumps used for standard sampling will be removed and sampling will be conducted to correspond to the 5-year sampling event for the Five-Year Review under CERCLA and the Compliance Plan. These samples will be analyzed for the indicator list of constituents.

4

A full list of constituents to be monitored is required for uncertainty management. A modified Appendix IX has been included in Corrective Action Compliance Plan 50284 Table III and in the current Pantex Sampling and Analysis Plan.

5

The Appendix IX monitoring list and 5-year frequency are applied to wells near source areas where the uppermost aquifer may be affected (outside the perched groundwater).

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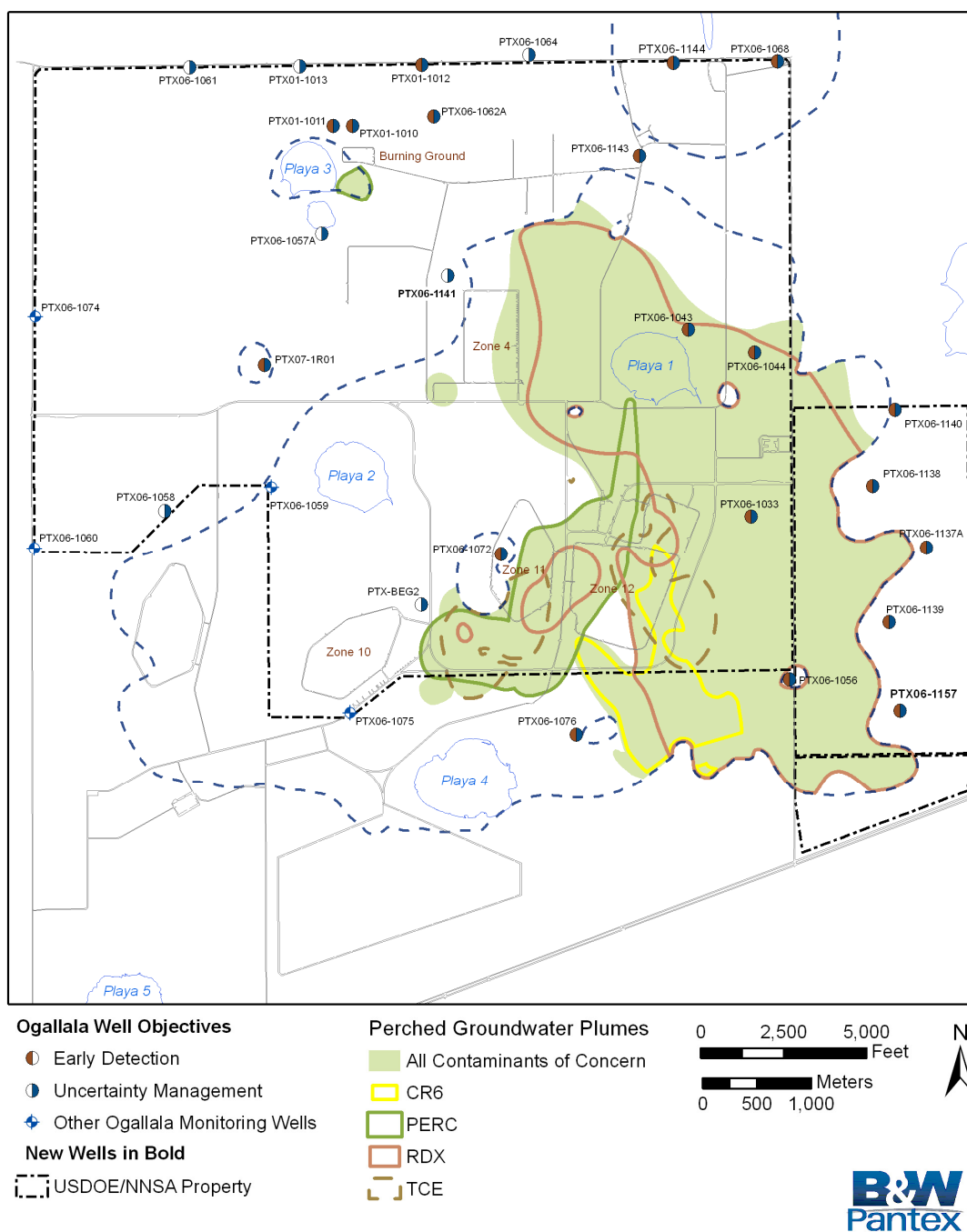
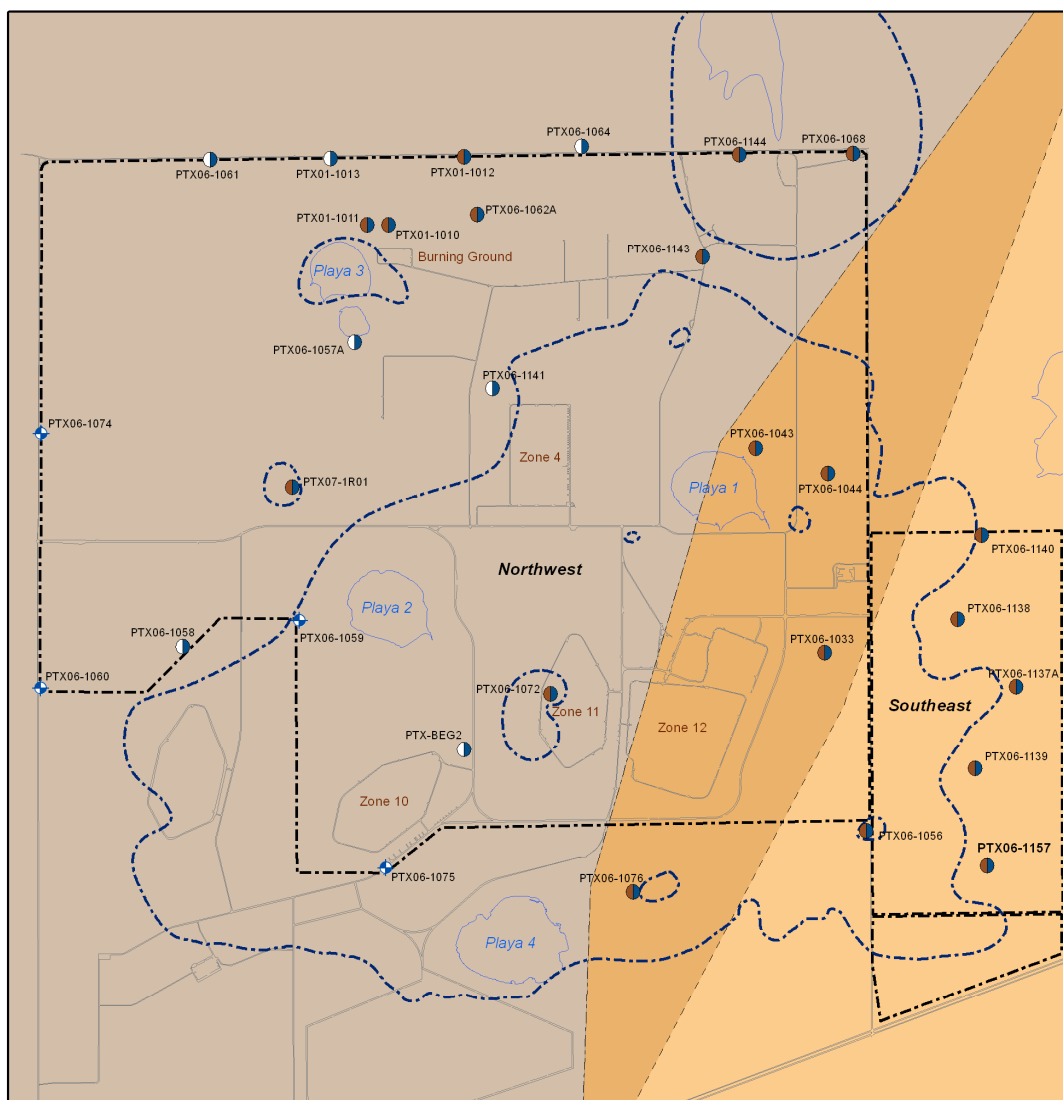


Figure 3-1. Ogallala Aquifer Long-Term Monitoring Network

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**Ogallala Well Objectives**

- Early Detection
- Uncertainty Management
- ◆ Other Ogallala Monitoring Wells

New Wells in Bold

USDOE/NNSA Property

Indicator Areas

- Northwest
- Southeast

--- Approximate Perched Extent

0 2,500 5,000 Feet
0 500 1,000 Meters



Indicator Constituents	Indicator Area	
	Southeast	Northwest
Primary List (Explosives, VOCs, Boron)	x	x
1,4-Dioxane		x
Chromium (Total & Hexavalent)	x	
Perchlorate		x
Treatment Zone Metals (Arsenic, Barium, and Manganese)	x	x

B&W
Pantex

Figure 3-2. Indicator Constituent Areas for the Ogallala Aquifer

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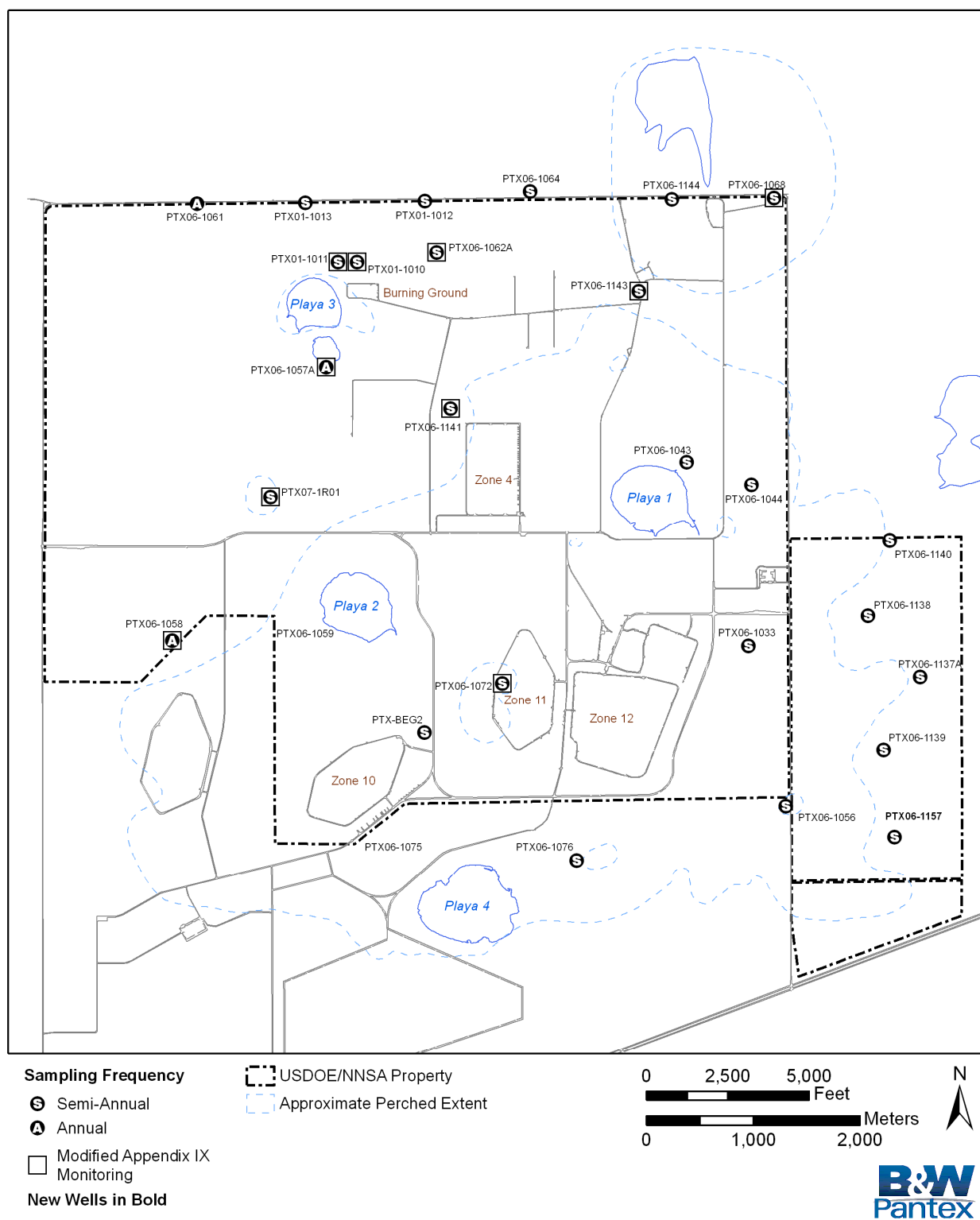


Figure 3-3. Ogallala LTM Network Sampling Frequency

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4. MONITORING WELL CONSTRUCTION

This section describes the screened intervals and the sample intake placement for each LTM Network well. The well construction information is presented for perched and Ogallala wells that will be part of the LTM Network.

4.1. PERCHED WELL CONSTRUCTION AND SCREENED INTERVALS

New perched monitoring wells will be constructed in accordance with the standard Compliance Plan Attachment B Well Specifications with one exception. In cases where the perched aquifer saturated thickness exceeds 10 feet and the well is to be constructed in an area under the influence of a groundwater pump and treat system, the wells will be screened across the entire perched saturated interval, thus exceeding the design specification. This construction extends the effective well lifetime and allows for continued monitoring of declining perched groundwater in these areas. Any deviations from the Attachment B Specifications other than that described above will be requested via electronic mail from the TCEQ and EPA Project Managers prior to installation.

4.2. PERCHED WELL SAMPLE INTAKE PLACEMENT

Table 4-1 provides the current sample intake placement for perched monitoring wells. Because many sample intakes were installed in the upper saturated thickness of the groundwater, as water levels decline, the sample intake levels will require adjustment to maintain the ability to sample from the upper 5-10 feet of saturated thickness.

Table 4-1. Perched Aquifer Well Pump Intake Placement

Well ID	Status	Groundwater Elevation ¹ (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness ² (ft)	Bottom of Screen Elevation (ft amsl)
1114-MW4	Active	3277.53	3264.4	13.13	17.21	3260.32
OW-WR-38	Active	3298.76	3294.9	3.86	2.90	3295.86
PTX01-1001	Active	3280.12	3270.3	9.82	10.02	3270.1
PTX01-1002	Active	3298.09	3286.2	11.89	26.10	3271.99
PTX01-1008	Undeveloped	3294.65	3289.8	4.85	4.89	3289.75
PTX04-1001	Active	3306.65	3295.4	11.25	17.58	3289.07
PTX04-1002	Active	3306.53	3300.1	6.43	17.70	3288.83
PTX06-1002A	Active	3281.93	3276.1	5.83	11.27	3270.67
PTX06-1003	Active	3275.87	3275.1	0.77	1.08	3274.78
PTX06-1005	Active	3261.21	3251.9	9.31	16.41	3244.81
PTX06-1006	Active	3276.59	3258.6	17.99	24.05	3252.54
PTX06-1007	Active	3278.39	3275.7	2.69	21.86	3256.53
PTX06-1008	Active	3280.22	3276.2	4.02	7.61	3272.61

Well ID	Status	Groundwater Elevation ¹ (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness ² (ft)	Bottom of Screen Elevation (ft amsl)
PTX06-1010	Active	3286.63	3272.2	14.43	22.60	3264.04
PTX06-1011	Active	3271.29	3262.9	8.39	18.70	3252.59
PTX06-1012	Active	3271.28	3257.4	13.88	15.09	3256.19
PTX06-1013	Active	3295.76	3290.2	5.56	9.51	3286.25
PTX06-1014	Active	3260.04	3253.5	6.54	8.44	3251.60
PTX06-1015	Active	3247.26	3242.1	5.16	4.31	3242.95
PTX06-1023	Active	3298.63	3296.1	2.53	6.69	3291.94
PTX06-1030	Active	3251.35	3245.3	6.05	4.20	3247.15
PTX06-1031	Active	3247.73	3240.1	7.63	5.86	3241.87
PTX06-1034	Active	3242.89	3238.1	4.79	6.76	3236.14
PTX06-1035	Active	3270.29	3259.3	10.99	14.11	3256.18
PTX06-1036	Active	3252.21	3250.6	1.61	0.09	3252.12
PTX06-1037	Undeveloped	3249.56	3246.3	3.26	1.69	3247.87
PTX06-1038	Active	3277.63	3269.3	8.33	16.90	3260.73
PTX06-1039A	Active	3269.81	3262.7	7.11	7.75	3262.06
PTX06-1040	Active	3264.96	3258.7	6.26	10.44	3254.52
PTX06-1041	Active	3263.34	3252.8	10.53	23.73	3239.61
PTX06-1042	Active	3259.62	3250.4	9.22	7.52	3252.10
PTX06-1045	Undeveloped	Dry	No Dedicated Pump	NA		3244.84
PTX06-1046	Active	3246.44	3236.7	9.74	13.39	3233.04
PTX06-1047A	Active	3246.59	3243	3.59	6.92	3239.67
PTX06-1048A	Active	3303.85	3301	2.85	6.84	3297.02
PTX06-1049	Active	3282.34	3259.3	23.04	38.95	3243.38
PTX06-1050	Active	3295.67	3282.2	13.47	30.71	3264.96
PTX06-1052	Active	3260.48	3254.6	5.88	14.02	3246.45
PTX06-1053	Active	3270.39	3267.8	2.59	8.18	3262.21
PTX06-1069	Active	3279.75	3275.4	4.35	4.72	3275.02
PTX06-1071	Active	3307.10	3302.22	4.88	37.97	3269.13
PTX06-1073A	Active	3277.50	No Dedicated Pump ³	NA	3.77	3273.73
PTX06-1077A	Active	3280.80	No data available	NA	8.36	3272.45
PTX06-1080	Active	3266.14	3264	2.14	16.02	3250.12
PTX06-1081	Active	3304.00	3301.2	2.80	17.50	3286.50
PTX06-1082	Active	3291.11	3289.3	1.81	4.17	3286.94

Well ID	Status	Groundwater Elevation ¹ (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness ² (ft)	Bottom of Screen Elevation (ft amsl)
PTX06-1083	Active	3289.08	3277.9	11.18	19.18	3269.91
PTX06-1085	Active	3271.43	3253.3	18.13	24.91	3246.52
PTX06-1086	Active	3273.10	3232.5	40.60	47.38	3225.72
PTX06-1088	Active	3269.73	3259.1	10.63	22.19	3247.54
PTX06-1095A	Active	3261.03	3251.39	9.64	14.81	3246.23
PTX06-1098	Active	3257.14	3251.39	5.75	15.40	3241.74
PTX06-1100	Active	3257.51	No Dedicated Pump ³	NA	12.80	3244.70
PTX06-1101	Active	3256.32	No Dedicated Pump ³	NA	12.52	3243.80
PTX06-1102	Undeveloped	3248.11	3249.7	-1.49	-0.19	3248.30
PTX06-1103	Active	Dry	No Dedicated Pump	NA		3249.74
PTX06-1118	Undeveloped	3249.07	No Dedicated Pump ³	NA	-1.32	3250.39
PTX06-1120	Undeveloped	3249.13	3245.58	NA	4.60	3244.53
PTX06-1121	Undeveloped	3248.01	No Dedicated Pump ³	NA	1.52	3246.49
PTX06-1123	Undeveloped	3250.80	3249.03	1.77	1.97	3248.84
PTX06-1126	Active	3273.05	3265.45	7.60	20.50	3252.55
PTX06-1127	Active	3273.72	3266.6	7.11	25.14	3248.57
PTX07-1O01	Active	3296.25	3294.45	1.80	1.57	3294.68
PTX07-1O02	Active	3299.23	3295.33	3.90	5.97	3293.26
PTX07-1O03	Active	3298.38	3293.51	4.87	5.16	3293.22
PTX07-1O06	Undeveloped	3288.21	3288.21	0.00	0.03	3288.18
PTX07-1P02	Active	3293.49	3283.90	9.59	10.04	3283.46
PTX07-1P05	Active	3295.05	3294.60	0.45	0.27	3294.77
PTX07-1Q01	Active	3268.63	3262.55	6.08	18.77	3249.86
PTX07-1Q02	Active	3268.47	3248.70	19.77	30.53	3237.94
PTX07-1Q03	Active	3270.51	3260.50	10.01	42.22	3228.29
PTX07-1R03	Undeveloped	3318.16	3316.00	2.16	3.26	3314.90
PTX08-1001	Active	3289.22	3278.86	10.36	47.59	3241.63
PTX08-1002	Active	3283.01	3279.01	4.00	28.30	3254.71
PTX08-1003	Active	3277.93	3273.49	4.44	23.55	3254.39
PTX08-1005	Active	3273.69	3263.72	9.97	14.07	3259.61
PTX08-1006	Active	3274.50	3269.76	4.74	33.54	3240.96

Well ID	Status	Groundwater Elevation ¹ (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness ² (ft)	Bottom of Screen Elevation (ft amsl)
PTX08-1007	Active	3278.44	3274.81	3.63	32.89	3245.55
PTX08-1008	Active	3270.65	3263.6	7.05	23.61	3247.04
PTX08-1009	Active	3266.00	3262.2	3.80	15.91	3250.09
PTX08-1010	Active	3307.02	3304.6	2.42	20.80	3286.22
PTX10-1013	Active	3289.85	3276	13.85	16.00	3273.85
PTX06-1130	Active	3271.05	3266.79	4.26	12.31	3258.74
PTX06-1131	Active	3267.57	3260.37	7.20	8.77	3258.81
PTX06-1133A	Active	3243.28	3241.65	1.63	1.66	3241.61
PTX06-1134	Active	3270.82	3264.19	6.63	9.75	3261.07
PTX06-1135	Active	3263.18	3261.03	2.15	1.79	3261.39
PTX06-1136	Active	3286.21	3277.42	8.79	8.99	3277.22
PTX06-1146	Active	3263.09	3253.09	10.00	19.13	3243.96
PTX06-1147	Active	3247.87	3242.75	5.12	16.25	3231.62
PTX06-1148	Active	3271.92	3267.12	4.80	15.86	3256.06
PTX06-1149*	Active	3272.05	3267.45	4.60	12.77	3259.28
PTX06-1150	Active	3272.39	3266.99	5.40	11.49	3260.90
PTX06-1151	Active	3272.08	3265.68	6.40	17.53	3254.55
PTX06-1153	Active	3249.88	3245.29	4.59	5.50	3244.38
PTX06-1154	Active	3250.26	3248.14	2.12	2.72	3247.54
PTX06-1155	Active	3270.70	3261.83	8.86	15.69	3255.01
PTX06-1156	Active	3271.20	3259.54	11.66	22.80	3248.40
PTX06-1158	Dry	Dry	No Dedicated Pump	NA		3235.25
PTX06-1159	Active	3271.32	3265.87	5.45	17.39	3253.93
PTX06-1160	Active	3271.59	3266.59	5.00	25.08	3246.51
PTX06-1166	Active	3253.26	3248.46	4.80	8.90	3244.36
PTX06-1167	Dry	Dry	No Dedicated Pump	NA		3258.22
PTX01-1004	Dry	Dry	No Dedicated Pump	NA		3300.24
PTX01-1009	Dry	Dry	No Dedicated Pump	NA		3280.69
PTX06-1051	Dry	Dry	No Dedicated Pump	NA		3239.85
PTX06-1055	Dry	Dry	No Dedicated Pump	NA		3273.88

Well ID	Status	Groundwater Elevation ¹ (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness ² (ft)	Bottom of Screen Elevation (ft amsl)
PTX06-1089	Dry	Dry	No Dedicated Pump	NA		3263.28
PTX06-1090	Dry	Dry	No Dedicated Pump	NA		3254.83
PTX06-1091	Dry	Dry	No Dedicated Pump	NA		3261.29
PTX06-1093	Dry	Dry	No Dedicated Pump	NA		3274.60
PTX06-1094	Dry	Dry	No Dedicated Pump	NA		3243.62
PTX06-1096A	Dry	Dry	No Dedicated Pump	NA		3302.99
PTX06-1097	Dry	Dry	No Dedicated Pump	NA		3268.73
PTX06-1119	Dry	Dry	No Dedicated Pump	NA		3251.31
PTX06-1122	Dry	Dry	No Dedicated Pump	NA		3251.50
PTX06-1124	Dry	Dry	No Dedicated Pump	NA		3245.58
PTX06-1125	Dry	Dry	No Dedicated Pump	NA		3245.35

¹ Based on June 2013 water level measurements

² Saturated thickness above the bottom of the well screen, negative numbers likely due to water measured in the sump

³ No dedicated pumps have been installed in these wells because the wells have low yield or limited saturated thickness.

*PTX06-1149 was plugged and replaced in September 2013 due to a casing separation so the water level included was collected in November 2013

4.3. OGALLALA WELL CONSTRUCTION, SCREENED INTERVALS, AND DIVERTERS

As presented in the 2009 LTM Network Design Report (Appendix A) and recommended in the *Sampling Evaluation for High Plains Aquifer Monitoring Wells* (Appendix C), all new Ogallala Aquifer monitoring wells will continue to be installed with screens that provide flexibility to sample from both the uppermost part of the aquifer and the deeper part of the aquifer. The wells will intercept the upper 30 to 100 feet of saturation using multiple screened intervals (no greater than 40 ft each) separated by blank casing. The decision of the upper screen intervals for each well is based on the anticipated decline of the water table. The blank casing separating the screen segments will be 15 ft long. The blank casing sections will enable placement of diverters to isolate the upper screened interval. The diverters and dedicated pumps will be adjusted as necessary to account for the declining Ogallala Aquifer water table.

Additionally, several older wells were identified in the *Ogallala Aquifer Sampling Improvement Plan* (Appendix D) that are not currently sampled as multi-level wells, yet have multiple screen segments. Of these wells, three were identified that have relatively short saturated screen intervals (i.e. < 100 ft) that could potentially yield more representative samples with diverters installed. Table 4-2 summarizes the proposed diverter placement.

Table 4-2. Proposed Diverter Placement

Well ID	Year Installed	Thickness of Upper Screened Interval (ft)	Diverter Depth (ft bgs)
PTX01-1010	2000	~70	565-570
PTX01-1013	2000	~85	584-590
PTX06-1072	2001	~85	498-506

4.4 OGALLALA INTAKE PLACEMENT

Table 4-3 provides the current sample intake placement for Ogallala Aquifer monitoring wells. Figure 4-1 presents the Ogallala Aquifer wells and their sample intake placements and approximate saturated thickness (some wells are not completed to the base of the aquifer, so only the in-well saturated thickness can be calculated). As discussed in the 2009 LTM Network Design Report, initial sampling in newly installed Ogallala Aquifer wells will be conducted at multiple depths using procedures described in the *Sampling and Analysis Plan*.

Dedicated sample pumps are installed in the wells at the proposed sample intake depth. As illustrated in Table 4-3, sample pump intake depths are typically set in the upper 15-feet of the uppermost screened interval. Routine samples at the proposed frequency for indicator constituents will be obtained from this depth.

At the five-year sampling event, the dedicated sample pumps will be removed after collecting the sample. Samples at the remaining screened intervals will be collected using the equipment described in the 2009 LTM Design Report. As summarized in Table 4-4, the sampling equipment is currently designed for the intake to be set 10-feet below the bottom of the upper blank in every screened interval where the dedicated pump is not installed. However, this length may need to be re-evaluated as water levels continue to drop in the Ogallala Aquifer.

Table 4-3. Dedicated Sample Intake Information for Ogallala Aquifer Wells

Well ID	Status	Groundwater Elevation¹ (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness² (ft)	Bottom of Screen Elevation (ft amsl)
PTX01-1010	Active	3072.5	3058.1	14.40	343.49	2729.01
PTX01-1011	Active	3090.1	3019.1	71.00	307.29	2782.81
PTX01-1012	Active	3056.1	3053.8	2.30	378.62	2677.48
PTX01-1013	Active	3089.17	3011.4	77.77	372.00	2717.17
PTX06-1033	Active	3097.41	3084.3	13.11	103.37	2994.04
PTX06-1043	Active	3081.77	2910.1	171.67	185.68	2896.09
PTX06-1044	Active	3059.93	3044.5	15.43	131.24	2928.69
PTX06-1056	Active	3137.48	3125	12.48	76.71	3060.77
PTX06-1057A	Active	3105.99	3095.1	10.89	294.47	2811.52
PTX06-1058	Active	3168.25	3157.6	10.65	129.80	3038.45
PTX06-1061	Active	3091.34	3081.5	9.84	361.69	2729.65
PTX06-1062A	Active	3068.73	3054	14.73	384.84	2683.89
PTX06-1064	Active	3059.57	3053.2	6.37	287.58	2771.99
PTX06-1068	Active	3020.07	3004.7	15.37	283.52	2736.55
PTX06-1072	Active	3137.26	3127.2	10.06	130.96	3006.31
PTX06-1076	Active	3179.95	3170.3	9.65	12.31	3167.64
PTX07-1R01	Active	3125.31	3110.47	14.84	150.84	2974.47
PTX-BEG2	Active	3156.99	3148.70	8.29	31.42	3125.57
PTX06-1137A	Active	3061.71	3042.61	19.10	109.21	2952.50
PTX06-1138	Active	3076.94	3066.70	10.24	127.47	2949.47
PTX06-1139	Active	3095.29	3091.73	3.56	115.88	2979.42
PTX06-1140	Active	3047.39	3035.39	12.00	200.06	2847.33
PTX06-1141	Active	3087.23	3070.73	16.50	201.66	2885.57
PTX06-1143	Active	3056.08	3033.94	22.14	290.09	2766.00
PTX06-1144	Active	3037.94	2886.58	151.36	311.61	2726.34
PTX06-1157	Active	3128.38	3112.95	15.43	129.79	2998.59

¹ Based on June 2013 measurements for most wells.

² Saturated thickness above the bottom of the well screen.

Table 4-4. Pump Intake depths for Multi-level Wells

Well ID	Approximate pump intake depths - ft bgs					Comments
	Screened Interval					
	1	2	3	4	5	
PTX06-1137A	--	DP	--	--	--	no water in first interval
PTX06-1138	DP	505	--	--	--	
PTX06-1139	DP	465	--	--	--	
PTX06-1140	DP	525	625	--	--	
PTX06-1141	DP	530	585	--	--	
PTX06-1143	DP	540	595	695	770	
PTX06-1144	495	550	DP	670	790	pump set in third screened interval
PTX06-1157	DP	465	505	--	--	

-- No water in/well not constructed with this interval

DP – dedicated pump

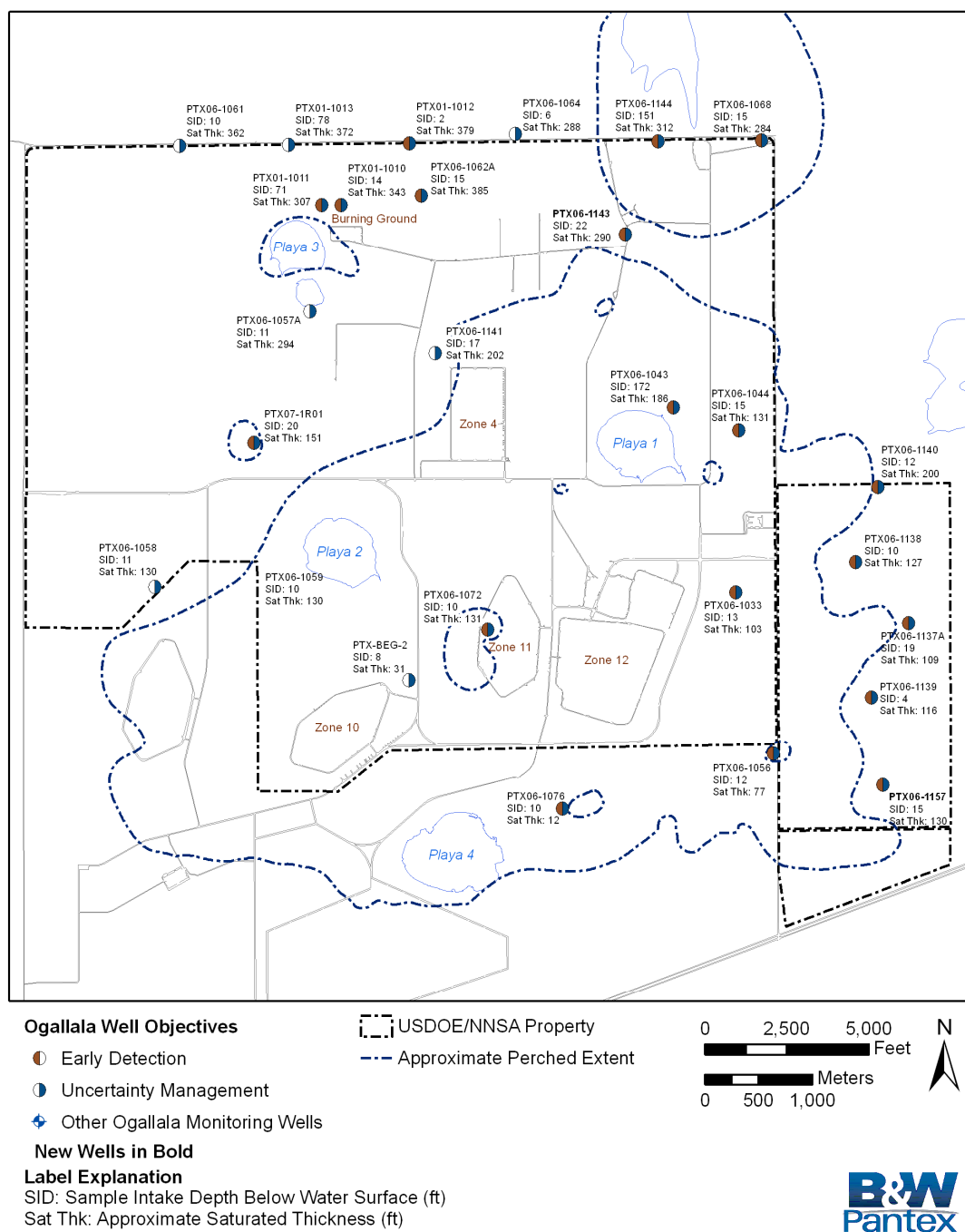


Figure 4-1. Sample Intake Depths for Ogallala Aquifer Wells

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5. EVALUATION OF MONITORING DATA

This section discusses methods that will be used to evaluate monitoring data with respect to the various objectives identified in this report. Monitoring data are collected at various frequencies including quarterly, annually, and every 5 years. All data are reviewed as received from the laboratories as part of the data validation process. The data also undergoes an automated review process as it is received to identify anomalies such as first time detections, all-time high detections, or off-trend values. Monitoring data are further reviewed at various frequencies according to the purpose for collection of the data. For example, quarterly data collected from ISB treatment zones are reviewed after validation to evaluate redox conditions within the barrier and determine the need for amendment injection. A comprehensive review and evaluation is conducted annually with findings documented in an annual progress report. Quarterly progress reports will supplement the annual reports by providing snapshots of monitoring data, evaluation of redox conditions, charts of pump and treat system performance, and evaluation of key uncertainty management well data. The data will also support the Five-Year Review required under the Inter-Agency Agreement (IAG) and Compliance Plan.

5.1. ANNUAL PROGRESS REPORT EVALUATION

For the annual progress report, data will be compared to the GWPS and evaluated with respect to the remedial action objectives in the ROD and the response actions installed for Pantex. The following will be evaluated:

- Plume stability
- Response Action Effectiveness: performance of individual response actions and the combination of response actions as a total remedy, achievement of cleanup standards
- Uncertainty Management: evaluation of soil stabilization measures
- Early Detection: COC concentrations in the perched groundwater and Ogallala Aquifer
- Natural attenuation of COCs

The expected conditions identified for each well in Tables 2-2 and 3-1 will be used in data evaluations.

5.1.1 Plume Stability

Plume stability will be evaluated through examination of water level and concentration data. Water levels will be used to generate hydrographs and trends for individual wells, maps of water elevations and contours, water level trends, and saturated thickness. Data from dry wells (e.g., continuing dry conditions or influx of water) will support this analysis.

Concentration data will be used to perform concentration trend analysis. Concentration trend data will be mapped for each COC to identify trends in the spatial distribution of COCs. The concentration data will also be combined with the water level data to generate plume maps for each COC. The maps and trends together will form the basis for an evaluation of overall plume stability.

5.1.2 Response Action Effectiveness

In Situ Bioremediation Systems

Data collected at wells within and downgradient of the *in situ* bioremediation systems will be used to evaluate system performance and to determine when subsequent injections of bioremediation amendment are needed as described in the bioremediation system O&M plans. Within the treatment zone, data will be evaluated to demonstrate that appropriate reducing conditions have been achieved and are being maintained, that amendment degradation products are available to support microbial growth, and that concentrations of primary COCs and degradation products are decreasing. Separate from the evaluation for the annual report, these data will also be used to determine when additional injections of bioremediation amendment are needed to ensure that reducing conditions are maintained and that amendment availability is not a limiting factor in overall ISB treatment performance. Downgradient of the treatment zone, the data evaluation must demonstrate that objectives of the response action have been achieved; specifically, concentrations of COCs and degradation products must be below GWPS within 3 to 5 years after initial injection. Additionally, three monitoring wells (PTX06-1148, PTX06-1149, and PTX06-1150) installed downgradient of the Zone 11 ISB system have been converted to *in-situ* performance monitoring wells. However, since they are located further away from the injection well field than the original performance monitoring wells, response action objectives are expected to be met 5 -10 years after the initial injection.

Data collected from ISB performance monitoring wells will be used in trend analyses of concentrations of COCs and degradation products, geochemical parameters, and amendment performance indicators to support evaluation of ISB effectiveness. Estimates of groundwater velocities and plume migration rates will also support determination of amendment injection frequency.

Pump and Treat Systems

Because the primary metric for success of the pump and treat systems is decreasing perched groundwater thickness, well hydrographs and water level trends will be used to demonstrate pump and treat system effectiveness. The water level data will also be used to determine the effects of the extraction systems on flow direction, hydraulic gradient, and saturated thickness. Although hydraulic containment is not a primary objective of either system, extraction well capture zones will be determined through available data and modeling. Concentration data collected at extraction wells will also benefit the plume stability analysis.

Comparison of process monitoring data to GWPS will demonstrate that the treatment processes are achieving cleanup standards.

Overall Response Action Effectiveness

The derived data outputs described previously, including plume maps, concentration and water level trends, potentiometric surface maps, and capture zone analysis, will together provide the basis for analysis of overall response action effectiveness. Over time, these data evaluations must demonstrate overall declines in perched saturated thickness, decreases in perched hydraulic gradients and rates of COC plume migration, and effective treatment of COC plumes downgradient of the *in situ* bioremediation systems.

5.1.3 Uncertainty Management

Uncertainty management monitoring is designed to obtain data to identify any unknown contaminant migration pathways. Indicator parameter data collected from uncertainty management wells will be compared to the GWPS. For wells located near known groundwater contaminant source areas, trend

analysis will be used to confirm the expected conditions that source strength and mass flux are decreasing over time. Data for the broader suite of constituents collected every 5 years will be reviewed to identify new groundwater constituents, if any.

5.1.4 Early Detection

Data for indicator constituents collected in Ogallala Aquifer wells will be compared to background levels or PQLs and GWPS. Trend analysis will also be used for naturally-occurring constituents and for low-level detections of non-naturally-occurring constituents to help identify impacts to the Ogallala Aquifer.

5.1.5 Natural Attenuation

In addition to regular monitoring of COC and daughter product concentrations, natural attenuation parameters will be collected from all perched wells on a two-year interval to permit screening and evaluation of natural degradation processes. These data will be compared to screening values that may indicate favorable conditions for natural attenuation to occur. The results of these comparisons will be combined with COC trend analysis results and estimates of plume migration and variability to determine if natural attenuation is occurring and to possibly estimate degradation rates. Quantitative analysis of natural attenuation for most COCs is not expected to be feasible until the second five-year review because of the anticipated slow attenuation rates.

5.2. QUARTERLY PROGRESS REPORTS

The quarterly progress reports are intended to provide intermediate data summaries for response action systems throughout the year without requiring time-intensive, comprehensive data analyses. The quarterly progress reports will address three of the five evaluations included in the annual progress report: response action effectiveness, uncertainty management, and early detection. Analysis of plume stability will not be provided quarterly because the analysis requires more data than what is collected each quarter. Because natural attenuation data are collected only every two years, no analysis of natural attenuation will be included in the quarterly reports. Analytical data reports and comparison of data to GWPS will be provided in the annual progress reports and will not be provided quarterly.

The evaluation of response action effectiveness for the ISB systems will include a statement of treatment zone status (e.g., maintenance of reducing conditions and need for amendment injection) and trend charts of target COCs and degradation products at downgradient performance monitoring locations. For the pump and treat systems, the evaluation will include a summary of operational efficiency for the quarter (such as a chart of monthly flow rate compared to a target flow rate) and graphs of treatment volumes and contaminant mass removed.

For uncertainty management and early detection objectives, the quarterly progress reports will provide summaries of any unexpected conditions or a statement that no unexpected conditions were observed.

5.3. FIVE-YEAR REVIEW

A five-year review is required under the IAG in accordance with CERCLA §121(c) and the NCP (40 CFR Part 300.430(f)(4)(ii)). Data collected for the LTM system will also support the five-year review. The evaluations performed for the annual report will be reviewed collectively to determine the performance of the response actions across a five-year time period to determine if the response actions need to be adjusted to better meet the RAOs. In addition, the LTM system design will be reevaluated using similar

methods to those used for this report. Adjustments that need to be made to the network will be documented in an updated design report and submitted for approval.

5.4. EVALUATION METRICS

Most methods for the evaluation are based on simple comparisons to established values, such as the practical quantitation limit (PQL), background, or GWPS. Statistical analyses of concentration trends in each well will be conducted using the methods described in the following sections. Well hydrographs will be provided for all monitoring wells, and a linear regression trend analysis will be used to determine if water levels are declining as stated in the cleanup objectives for the perched groundwater.

5.4.1.1 Statistical Concentration Trend Analysis

The general change in concentration, or trend, of a particular constituent in a well can be quantified using a statistical trend analysis method. The methods to be used, including a nonparametric Mann-Kendall analysis and a parametric linear regression, were adapted from the AFCEE Monitoring And Remediation Optimization System (MAROS) Software. The following descriptions of the statistical trend analysis methods were adapted from the MAROS Version 2.2 User's Guide (AFCEE, 2007).

With actual site measurements, apparent concentration trends may often be obscured by data scatter arising from non-ideal hydrogeologic or sampling and analysis conditions. However, even though the scatter may be of such magnitude as to yield a poor fit (typically characterized by a low correlation coefficient, e.g., $R^2 \ll 1$) for the first-order relationship, parametric and nonparametric methods can be utilized to obtain confidence intervals on the estimated first-order coefficient, i.e., the slope of the log-transformed data. Nonparametric tests such as the Mann-Kendall test for trend are suitable for analyzing data that do not follow a normal distribution. Nonparametric methods focus on the location of the probability distribution of the sampled population, rather than specific parameters of the population. The outcome of the test is not determined by the overall magnitude of the data points, but depends on the ranking of individual data points. Assumptions on the distribution of the data are not necessary for nonparametric tests. The Mann-Kendall test for trend is a nonparametric test which has no distributional assumptions and irregularly spaced measurement periods are permitted. The advantage gained by this approach involves the cases where outliers in the data would produce biased estimates of the least squares estimated slope.

Parametric tests such as first-order regression analysis make assumptions on the normality of the data distribution, allowing results to be affected by outliers in the data in some cases. However, more accurate trend assessments using parametric methods result from data where there is a normal distribution of the residuals. Therefore, when the data are normally distributed, the nonparametric Mann-Kendall test is not as efficient.

5.4.1.1.1 Mann-Kendall Analysis

General

The Mann-Kendall test is a non-parametric statistical procedure that is well suited for analyzing trends in data over time (Gilbert, 1987). The Mann-Kendall test can be viewed as a nonparametric test for zero slope of the first-order regression of time-ordered concentration data versus time. The AFCEE MAROS Tool includes this test to assist in the analysis of groundwater plume stability. The Mann-Kendall test does not require any assumptions as to the statistical distribution of the data (e.g. normal, lognormal, etc.) and can be used with data sets which include irregular sampling intervals and missing data. The Mann-Kendall test is designed for analyzing a single groundwater constituent, multiple constituents are analyzed

separately. For this evaluation, a decision matrix was used to determine the “Concentration Trend” category for each well, as presented in Table 5-1.

Mann-Kendall Statistic (S)

The Mann-Kendall statistic (S) measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. The strength of the trend is proportional to the magnitude of the Mann-Kendall Statistic (i.e., large magnitudes indicate a strong trend). Data for performing the Mann-Kendall Analysis must be in time sequential order. The first step is to determine the sign of the difference between consecutive sample results. $\text{sgn}(x_j - x_k)$ is an indicator function that results in the values 1, 0, or -1 according to the sign of $(x_j - x_k)$, where $j > k$. The function is calculated as follows:

$$\text{sgn}(x_j - x_k) = 1 \quad \text{if } x_j - x_k > 0$$

$$\text{sgn}(x_j - x_k) = 0 \quad \text{if } x_j - x_k = 0$$

$$\text{sgn}(x_j - x_k) = -1 \quad \text{if } x_j - x_k < 0$$

The Mann-Kendall statistic (S) is defined as the sum of the number of positive differences minus the number of negative differences or

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^n \text{sgn}(x_j - x_k).$$

The ***confidence in the trend*** for the Mann-Kendall statistic is calculated using a Kendall probability table (e.g. Hollander, M. and Wolfe, D.A., 1973). By assessing the S result along with the number of samples, n, the Kendall table provides the probability of rejecting the null hypothesis (H_0 = no trend) for a given level of significance. MAROS calculates a “confidence level” percentage by subtracting the probability (p) from 1 (Confidence = $1 - p$ %). Confidence of 90% represents a significance level of $\alpha = 0.1$, and 95% confidence corresponds to $\alpha = 0.05$. The resulting confidence in the trend is applied in the Mann Kendall trend analysis.

Average

The arithmetic mean of a sample of n values of a variable is the average of all the sample values written as

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

Standard Deviation

The standard deviation is the square root of the average of the square of the deviations from the sample mean written as

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}.$$

The standard deviation is a measure of how the value fluctuates about the arithmetic mean of the data.

Coefficient of Variation (COV)

The Coefficient of Variation (COV) is a statistical measure of how the individual data points vary about the mean value. The coefficient of variation, defined as the standard deviation divided by the average or

$$C.O.V. = \frac{s}{\bar{x}}$$

Values less than or near 1.00 indicate that the data form a relatively close group about the mean value. Values larger than 1.00 indicate that the data show a greater degree of scatter about the mean.

Results and Interpretation of Results: Mann-Kendall Analysis

The concentration data are used to calculate COV and S for each well with at least four sampling events. A “Concentration Trend” and “Confidence in Trend” are reported for each well with at least four sampling events. If data are insufficient, the well trend analysis is not conducted.

The COV is a statistical measure of how the individual data points vary about the mean value. Values less than or near 1.0 indicate that the data form a relatively close group about the mean value. Values larger than 1.0 indicate that the data show a greater degree of scatter about the mean. The Mann-Kendall statistic (S) measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. The strength of the trend is proportional to the magnitude of S (i.e., larger magnitudes indicate a stronger trend). The “Confidence in Trend” (1-*p*) is the statistical probability that the constituent concentration is increasing (S>0) or decreasing (S<0). The null hypothesis (no trend) is rejected for confidence above 90%.

The “Concentration Trend” for each well is determined according to the rules in the decision matrix (Table 5-1), where COV is the coefficient of variation. The MAROS Mann-Kendall Analysis Decision Matrix was developed by Groundwater Services Inc. for AFCOE. Strongly increasing or decreasing trends indicate a higher level of statistical significance. The confidence can be used as a qualitative measure of the statistical strength of the trend when evaluating the overall stability of the plume.

5.4.1.1.2 Linear Regression Analysis

General

Linear regression is a parametric statistical procedure that is typically used for analyzing trends in data over time. However, with the usual approach of interpreting the log slope of the regression line, concentration trends may often be obscured by data scatter arising from non-ideal hydrogeologic or sampling and analysis conditions. Even though the scatter may be of such magnitude as to yield a poor goodness of fit (typically characterized by a low correlation coefficient, e.g., $R^2 \ll 1$) for the first-order relationship, confidence intervals can nonetheless be constructed on the estimated first-order coefficient, i.e., the slope of the log-transformed data. Using this type of analysis, a higher degree of scatter simply corresponds to a wider confidence interval about the average log slope. Assuming the sign (i.e., positive or negative) of the estimated log slope is correct, a level of confidence that the slope is not zero can be easily determined. Thus, despite a poor fit, the overall trend in the data may still be ascertained, where low levels of confidence correspond to “Stable” or “No Trend” conditions (depending on the degree of scatter) and higher levels of confidence indicate the stronger likelihood of a trend. The coefficient of variation, defined as the standard deviation divided by the average, is used as a secondary measure of

scatter to distinguish between “Stable” or “No Trend” conditions for negative slopes. The linear regression analysis is designed for analyzing a single groundwater constituent, multiple constituents are analyzed separately. For this evaluation, a decision matrix was used to determine the “Concentration Trend” category for each well, as presented in Table 5-1.

Linear Regression

The objective of linear regression analysis is to find the trend in the data through the estimation of the log slope as well as placing confidence limits on the log slope of the trend. Regression begins with the specification of a model to be fitted. A linear relationship is one expressed by a linear equation. The linear regression analysis is performed on log(concentration) versus time. The regression model assumes that for a fixed value of x (sample date) the expected value of y (log concentration) is some function. For a particular value, x_i or sample date the predicted value for y (log concentration) is given by

$$\hat{y}_i = a + bx_i$$

The fit of the predicted values to the observed values (x_i, y_i) are summarized by the difference between the observed value y_i and the predicted value $\hat{y}_i$ (the residual value). A reasonable fit to the line is found by making the residual values as small as possible. The method of least squares is used to obtain estimates of the model parameters (a, b) that minimize the sum of the squared residuals, S^2 or the measure of the distance between the estimate and the values we want to predict (the y's).

$$S^2 = \sum_{i=1}^n (y_i - \hat{y}_i)^2$$

The values for the intercept (a) and the slope (b) of the line that minimize the sum of the squared residuals (S^2), are given by

$$b = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^n (x_i - \bar{x})^2} \quad \text{and} \quad a = \bar{y} - b\bar{x}$$

where $\bar{x}$ and $\bar{y}$ are the mean x and y (log concentration) values in the dataset.

In order to test the confidence on the regression trend, there is a need to place confidence limits on the slope of the regression line. In this stage of the trend analysis, it is assumed that for each x value, the y-distribution is normal. A t-test may be used to test that the true slope is different from zero. This t-test is preferentially used on data that is not serially correlated or seasonally cyclic or skewed.

The variance of y_i (σ^2) is estimated by the quantity $S^2_{y|x}$ where this quantity is defined as

$$S^2_{y|x} = \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{n - 2}$$

where n is the number of samples.

The estimation of the standard deviation or standard error of the slope (s.e.b.) is defined as

$$s.e.b. = \sqrt{\frac{S_{y|x}^2}{\sum_{i=1}^n (x_i - \bar{x}_i)^2}}$$

To test significance of the slope calculated, the following t-test result can be used to find the confidence interval for the slope.

$$t = \frac{b}{s.e.b.}$$

The t result along with the degrees of freedom (n-2) are used to find the confidence in the trend by utilizing a t-distribution table found in most statistical textbooks (e.g. Fisher, L.D. and van Belle, G., 1993). The resulting confidence in the trend is utilized in the linear regression trend analysis.

Results and Interpretation of Results: Linear Regression Analysis

The concentration data are used to calculate the COV and the first-order coefficient (log slope) for each well with at least four sampling events. A “Concentration Trend” and “Confidence in Trend” are reported for each well with at least four sampling events. If data are insufficient, the well trend analysis is not conducted.

The COV is a statistical measure of how the individual data points vary about the mean value. Values less than or near 1.0 indicate that the data form a relatively close group about the mean value. Values larger than 1.0 indicate that the data show a greater degree of scatter about the mean.

The Log Slope measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time.

The “Confidence in Trend” is the statistical probability that the constituent concentration is increasing (log slope > 0) or decreasing (log slope < 0).

The “Concentration Trend” for each well is determined according to the rules in the decision matrix (Table 5-2), where COV is the coefficient of variation. The MAROS Linear Regression Analysis Decision Matrix was developed in-house by Groundwater Services Inc. for AFCEE.

5.4.1.2 Water Level Trend Analysis

A similar linear regression trend analysis will be used with water level measurements to determine if water levels are declining as stated in the cleanup objectives for the perched groundwater. For water level trend analysis, the measured water levels are the y values. These values are not log-transformed before applying the regression analysis.

5.4.1.3 Comparison to GWPS

Data collected at each well will be directly compared to the GWPS for each constituent to determine if concentrations exceed the GWPS. Wells that exceed the GWPS will be highlighted.

5.4.1.4 Dry

Dry wells will be checked semi-annually for water. If sufficient water is found to allow sample collection, the well will be sampled according to the appropriate indicator list, and the data collected will be evaluated accordingly.

5.5. EXPECTED CONDITIONS

The expected condition designated for each well provides a context for evaluating the monitoring data from the well based on the monitoring history, knowledge of plume movement and source area conditions, and expected impacts of remedial action systems. The range of expected conditions were classified into seven categories presented below.

Below background/PQL and GWPS: Concentrations are not expected to exceed background/PQL or the GWPS. This condition applies to wells that are located outside the extent of a plume or that have not produced exceedances of RRS1 in historical sampling data.

Stable or decreasing trend below GWPS: Concentrations are below the GWPS and are expected to remain stable or decrease over time. This condition applies to wells that have exhibited a decline of concentrations to below the GWPS or that have a history of detections below the GWPS.

Decreasing water levels, Long-term stabilization of concentrations: These wells are within the influence of the groundwater extraction systems, so water levels are expected to decline over time. Concentrations are expected to stabilize as the pump and treat systems continue to remove contaminant mass from the perched groundwater.

Below GWPS in 2–5 years: These wells are downgradient of the ISB systems, so concentrations are expected to decrease as groundwater passing through the treatment zone migrates to the wells. The decrease in concentrations may not be evident until sufficient time has passed to allow treated groundwater to travel the distance from the treatment zone to the well at the pore water velocity.

Below GWPS in 5-10 years: These wells are also downgradient of the ISB systems, so concentrations are expected to decrease as groundwater passing through the treatment zone migrates to the wells. However, these wells are installed further away from the treatment zone so it will take longer for treated water to reach these locations.

Long-term decreasing trend: These wells are outside the zone of influence of the groundwater extraction systems and are not downgradient of an ISB system. Concentrations in these wells are expected to slowly decrease through natural attenuation processes including dispersion, dilution, and degradation.

Limited water: These wells are either installed in areas of limited perched groundwater thickness or along the fringes of the extent of perched groundwater in areas that are not likely under the effects of remedial actions. These wells have been observed to have variable low water levels, likely due to slight perched aquifer expansion or other hydrogeologic conditions in these areas, but are not expected to have measured water over 5 feet in the screened interval. These wells have been assigned a sampling frequency and expected conditions in Table 2-2 and will be attempted to be sampled each event, but if there is not enough water in the screened interval for sampling, the well is dry, or a slight increasing water level trend is calculated, these will not be considered to be unexpected conditions.

Remain dry: These wells are well beyond the extent of perched saturation in areas likely affected by remedial actions and serve as plume stability wells. These wells will be monitored for perched

groundwater and contaminant plume expansion in these areas. The expected condition for these wells is that water will not be observed in the screen.

Table 5-1. MAROS Mann-Kendall Analysis Decision Matrix

Mann-Kendall Statistic	Confidence in Trend	Concentration Trend
$S > 0$	$> 95\%$	Increasing
$S > 0$	90–95%	Probably Increasing
$S > 0$	$< 90\%$	No Trend
$S \leq 0$	$< 90\%$ and $COV \geq 1$	No Trend
$S \leq 0$	$< 90\%$ and $COV < 1$	Stable
$S < 0$	90–95%	Probably Decreasing
$S < 0$	$> 95\%$	Decreasing

Table 5-2. MAROS Linear Regression Analysis Decision Matrix

Log Slope	Confidence in Trend	Concentration Trend
Positive	$> 95\%$	Increasing
Positive	90–95%	Probably Increasing
Positive	$< 90\%$	No Trend
Negative	$< 90\%$ and $COV \geq 1$	No Trend
Negative	$< 90\%$ and $COV < 1$	Stable
Negative	90–95%	Probably Decreasing
Negative	$> 95\%$	Decreasing

6. SUMMARY AND CONCLUSIONS

This report documents several updates to the long-term groundwater monitoring well network, primarily due to recommendations in the first Five-Year Review Report. The changes include:

- The addition of five perched aquifer LTM wells
- The plugging, abandonment, and replacement of one Ogallala Aquifer LTM Well
- The conversion of three LTM wells installed downgradient of the Zone 11 ISB system to ISPM wells
- The adjustment of expected conditions of several perched aquifer monitoring wells based on the effects of remedial actions, as well as slight changes in water level along the fringes of perched groundwater

No changes to the monitoring objectives, monitoring of soil release units, or methods for evaluation of the response actions are recommended at this time.

The LTM network will be evaluated and this document will be updated as necessary as part of the next Five-Year Review, scheduled for completion in 2018.

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Appendix B

Groundwater Monitoring Network Optimization (GSI, 2012)

Groundwater Monitoring Network Optimization 2012

Perched Groundwater Unit, Pantex Plant

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) supports the use of a suite of practical methods to maximize resource efficiency and enhance technical decision making during environmental cleanup projects. The process, known as remediation optimization, is a systematic review of site information, at any phase of the clean-up process, by a team of independent technical experts. The purpose of remediation optimization is to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency; and to facilitate progress toward site completion. One component of remediation optimization is known as Long-Term Monitoring Optimization (LTMO), a technical review of a groundwater monitoring network to optimize data collection to support site decision making.

The purpose of the following report is to review the current Pantex Plant perched groundwater monitoring program and provide recommendations for improving the efficiency and accuracy of the network for supporting site remedial goals. The monitoring network plays a key role in evaluating the efficacy of chosen remedies and documenting progress toward remedial goals.

The Pantex perched groundwater unit monitoring network was evaluated in 2007, prior to the installation of several active remedies and before the final approval of the Record of Decision (ROD). At that time, a recommendation was made to review the network after additional remedial systems had been installed. The following review has been conducted to support the Five-Year Review of remedial activities at the Pantex Plant. The goals and objectives of the report are to evaluate the current long-term monitoring (LTM) network as outlined in the Pantex 2009 *Long-Term Monitoring System Design Report*, determine if sufficient data are being collected to meet monitoring goals and objectives and provide recommendations to improve the network over the next five years. Data reviewed for this report include groundwater analytical data collected between 2008 and 2011 as well as annual monitoring reports and regulatory documents produced between 2007 and 2012.

Section 1 of the following report identifies the goals and objectives of the review. Section 2 summarizes the Pantex Plant Conceptual Site Model (CSM) including the site background, hydrogeology and geology, sources and descriptions of constituents and response actions. The CSM is reviewed in order to help identify potential data gaps in understanding site processes. The analytical methods used to evaluate the network are discussed in Section 3 and results of the analyses are presented in Section 4. Conclusions and Recommendations for the Pantex Plant LTM network are presented in Section 5.

The ultimate goal of the perched monitoring network is to confirm that Remedial Action Objectives (RAOs) are being met. Data collected from the monitoring network are used to evaluate the performance of the response actions and are used to compare actual conditions to expected site conditions. Three primary monitoring objectives have been identified for the Pantex perched groundwater network:

- Evaluate plume stability;

- Evaluate efficacy of the response action;
- Uncertainty management – confirm expected conditions and identify any deviations from expectations.

Each well in the LTM network has been assigned at least one primary monitoring objective under the LTM Plan. Many wells have also been designated as point of compliance (POC) or Point of Exposure (POE) wells under the Compliance Plan as per Texas Risk Reduction Rules. The Pantex Plant monitoring network has been reviewed and optimized around these monitoring objectives. Wells in the current program used in this analysis, along with the monitoring objectives for each well are listed in Table 1.

Results

Perched groundwater below the Pantex Plant was divided into three areal sectors for analysis. Investigation wells were grouped into networks based on the direction of groundwater flow, source areas and major constituents associated with each sector. The Southeast Sector monitoring network consists of wells in perched groundwater extending south from Playa 1 and east and south of industrial Zones 11 and 12. The Southwest Sector monitoring network includes and extends west and south of Zone 11. Investigation wells south of Zone 12 were included in both the Southwest and Southeast Sector spatial analyses to account for possible variability in groundwater flow. The North Sector includes groundwater north of Zones 11 and 12 in the vicinity of Playa 1. Statistical and qualitative evaluations of Pantex Plant perched groundwater analytical data have been conducted with results summarized below:

Southeast Sector

- Priority constituents in the Southeast Sector include RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and 4-amino,2,6-dinitrotoluene (4ADNT). Groundwater affected by other constituents of potential concern (COPCs) is within the extent of groundwater affected by RDX. Hexavalent chromium (Cr(VI)) affects perched groundwater in a smaller area in and between the Southeast and Southwest Sectors and was considered in the analysis of both monitoring networks.
- No statistical inconsistencies were found in wells monitoring the extraction and *In Situ* Bioremediation (ISB) remedies. The monitoring networks in these areas appear adequate to evaluate remedy performance.
- Estimates of total dissolved mass over time indicate RDX is increasing within the main body of the plume while the source area accounts for relatively little of the total mass in the plume. Estimates of dissolved mass of 4ADNT exhibit a stable trend. Overall trends support the conclusion that the source area is depleting.
- Estimates for the center of mass for the RDX and 4ADNT fairly stable conditions 2008 – 2011.
- A line of increasing RDX trends runs from the southeast part of Zone 12 to the southeast edge of the perched unit along the flow gradient. These locations appear to be responsible for the increasing total mass estimate for the plume. Overall, however, there are fewer increasing concentration trends than was found in 2007. 4ADNT concentrations appear to be stabilizing across the plume.
- For the majority of the Southeast Sector, there is low concentration uncertainty between monitoring points. Areas of concentration uncertainty do exist within the

plume at the southeast extent of the perched zone (downgradient from the increasing concentration trends for RDX) and south of Zone 12, west of the ISB remedy.

- No redundant (unnecessary) well locations were identified and no results indicated a change in monitoring frequency was needed.

Southwest Sector

- Priority constituents in the Southwest Sector include trichloroethene (TCE) and perchlorate. Groundwater affected by high explosives (HE) exists under the industrial area of Zone 11, but is not as widespread or high in concentration as that of the Southeast Sector.
- Strongly decreasing trends for perchlorate are found for wells upgradient of the ISB remedy. Recently increasing concentration trends for perchlorate are found south of Zone 11 and downgradient from the ISB remedy (PTX06-1148, 1149 and 1150). Increasing TCE trends are found on the western edge of the network at PTX06-1151 and some locations upgradient of the ISB system.
- Estimates for plume-wide total dissolved mass of perchlorate and TCE show no definite trends. Estimates for the change in center of mass and spread of mass show stable or no trends indicating the plumes may be stabilizing around the ISB remedy.
- No redundant locations were identified and no results indicated a change in monitoring frequency was needed.

North Sector

- The only area-wide priority constituent identified for the North Sector is RDX, but detections are clustered around Playa 1 and are not widespread.
- The majority of monitoring locations in the North Sector are not affected by constituents above regulatory screening levels.
- Concentration trends for RDX in the North Sector show decreasing trends just west of Playa 1. An increasing RDX trend was found at PTX08-1002 indicating possible influence of the extraction wells drawing mass from the Playa 1 source.
- No redundant locations were identified and no results indicated a change in monitoring frequency was needed.

Recommendations

The following general recommendations are made based on the findings summarized above and those described in Section 3 below. General recommendations for monitoring are based on a combination of statistical results of analyses for priority COCs and a consideration of qualitative issues such as hydrogeology, potential receptors and monitoring goals. Detailed recommendations are presented in Section 5 and summarized on Table 16 and Figure 9.

Overall recommendations for the monitoring network include:

- Overall, the monitoring networks in the North, Southeast and Southwest sectors are largely adequate to support the stated monitoring objectives. Recommended changes to the network are listed below.

- Four new perched groundwater monitoring wells are recommended to define plumes emanating from Zones 11 and 12. The wells are needed to delineate plumes that come south of the developed areas of the Plant. These locations will also contribute groundwater elevation data to help refine understanding of the gradients in these areas.
- No wells are recommended for removal from the monitoring network at this time.
- Dry wells should be checked annually to confirm unsaturated conditions. Pumping and recharge may change the shape of the perched unit on the edges.
- While an analysis of sampling frequency was performed, there are no strong recommendations for changing the sampling frequency detailed in the 2009 Pantex LTM report.
- The current analyte list for the groundwater samples includes 172 analytes. It may be possible to reduce the number of analytes, particularly volatile organic compounds (VOCs) that are not detected or are found intermittently.
- Continue to monitor groundwater elevations south of Zones 11/12 in the area of the groundwater divide to monitor the effect of groundwater extraction in the Southeast on plumes in the Southwest.

Recommendations specific to the Southeast Sector include:

- 2 new wells are recommended for the Southeast Sector (see locations Figure 9).
 - One location west of PTX06-1103A is recommended to assess RDX transport toward the ISB system on the west side, confirm saturated conditions, monitor Cr(VI) and boron concentrations southeast of PTX06-1052.
 - One new monitoring well is recommended to delineate the far southeast edge of the perched groundwater, southeast of PTX06-1034.
- A line of increasing concentrations extends from the southeast edge of Zone 12 to the southeast edge of the perched zone. No additional wells are recommended in the area, but continued assessment of the effect of the remedies (both extraction and injection) in this area is recommended.
- Continue sampling PTX06-1133A to monitor groundwater elevations and the stability of the RDX plume in this area. Continue sampling formerly dry wells PTX06-1120 and 1121. Continue to check for the presence of perched groundwater at sampling location PTX06-1103, and collect samples if water is encountered again.

- Cr(VI) concentrations are increasing at PTX06-1010, possibly as a result of historic injection of treated water at PTX06-INJ02. Injections at this location have ceased. While no new monitoring wells are recommended in this area, continued monitoring in the area of PTX06-1010 may provide more information on the potential presence of dissolved metals in this area. Well PTX08-1007 should be monitored for Cr(VI) annually.

Recommendations specific to the Southwest Sector include:

- Two new monitoring wells are recommended for the Southwest Sector:
 - o West of PTX06-1151: A new well is recommended in this area to delineate TCE west of high and increasing concentrations at PTX06-1151.
 - o West of PTX06-1155 and east of PTX06-1035: An additional delineation well is recommended to confirm stability of the perchlorate plume. Concentrations in this area may be below cleanup goals for both TCE and perchlorate, but increasing trends west of the ISB require long-term downgradient delineation to evaluate remedy performance and plume stability.

Recommendations specific to the North Sector include:

- Sampling frequency analysis indicated that no more frequent than annual monitoring is appropriate for all wells in the North Sector. Most wells have been recommended for annual to biennial sampling. However, sampling frequencies outlined in the 2009 LTM Report provide sufficient data to accomplish monitoring goals.
- No new wells are recommended for the North Sector at this time.

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Appendices

Appendix A:	Spatial Analysis Method
Appendix B:	MAROS Reports
Appendix C:	Electronic Data Files

ABBREVIATIONS

2ADNT	2-Amino, 4,6-dinitrotoluene
24DNT	2,4-Dinitrotoluene
26DNT	2,6-Dinitrotoluene
4ADNT	4-Amino, 2,6-dinitrotoluene
AEC	Atomic Energy Commission
AMSL	Above Mean Sea Level
AOC	Area of Concern
AR	Area Ratio
B&W Pantex	Babcock & Wilcox Technical Services Pantex, LLC
BGS	Below Ground Surface
BRA	Baseline Risk Assessment
BWD	Blackwater Draw
C	Carcinogenic
CES	Cost Effective Sampling
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CMS	Corrective Measure Study
COC	Constituent of Concern
COPC	Constituent of Potential Concern
COV	Coefficient of Variation
CR	Concentration Ratio
Cr III	Trivalent chromium
Cr VI	Hexavalent chromium
CSM	Conceptual Site Model
DOE	United States Department of Energy
DNX	Hexahydro-1,3-Dinitroso-5-Nitro-1,3,5-Triazine
FGZ	Fine Grained Zone
FS	Feasibility Study
GAC	Granular activated carbon
GIS	Geographic Information System
GPD	Gallons per day
GW-Res	TCEQ Standard No. 2 Groundwater MSC for Residential Use

HE	High explosive
HMX	High melting explosive (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
HSU	Hydrostratigraphic Unit
IAG	Interagency Agreement
ICM	Interim Corrective Measures
ISB	<i>In Situ</i> Bioremediation
ISM	Interim Stabilization Measure
LR	Linear Regression
LTM	Long-Term Monitoring
LTMO	Long-Term Monitoring Optimization
MAROS	Monitoring and Remediation Optimization Software
MCES	Modified Cost Effective Sampling
MCL	Maximum Contaminant Level
MXN	Hexahydro-1-Nitroso-3,5-Dinitro-1,3,5-Triazine
MK	Mann-Kendall Trend
MOA	Memorandum of Agreement
MSC	Medium Specific Concentration
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NC	Non-carcinogenic
NNSA	National Nuclear Security Administration
NPL	National Priorities List
O&M	Operation and Maintenance
OU	Operable Unit
P1PTS	Playa 1 Pump and Treat System
PGPTS	Perched Groundwater Pump and Treat System
PLSF	Preliminary Location Sampling Frequency
POC	Point of Compliance
POE	Point of Exposure
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
PRP	Potentially-Responsible Party
RAO	Remedial Action Objectives

RCRA	Resource Conservation and Recovery Act
RDX	Research Department Explosive (Hexahydro-1,3,5-trinitro-1,3,5-triazine)
RE	Relative Error
RFI	Resource Conservation and Recovery Act Facility Investigation
RI	Remedial Investigation
ROD	Record of Decision
RRR	Risk Reduction Rules
SEPTS	Southeast Pump and Treat System
SF	Slope Factor
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TNT	Trinitrotoluene
TNX	Hexahydro-1,3,5-Trinitroso-1,3,5-Triazine
TTU	Texas Tech University
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WMG	Waste Management Group
WWTF	Waste Water Treatment Facility

Units

gpd	gallons per day
gpm	gallons per minute
ug/L	microgram per liter
mg/L	milligram per liter
ft	feet

1.0 INTRODUCTION

The Pantex Plant is located approximately 17 miles northeast of Amarillo, Texas in Carson County in US Environmental Protection Agency (EPA) Region VI. The plant covers roughly 10,000 acres with additional property consisting of a 1,000 acre tract at Pantex Lake and over 5,000 acres owned by Texas Tech University (TTU) as a buffer around the site. Industrial operations occur on approximately 2,000 acres.

The Pantex Plant is an active facility owned by the United States Department of Energy/National Nuclear Security Administration (DOE/NNSA). The primary mission of the plant is to assemble, disassemble and evaluate nuclear weapons from the US stockpile, to develop, fabricate and test explosives and explosive components and provide secure storage for material from the above activities. The Pantex Plant is permitted as a hazardous waste facility under the Resource Conservation and Recovery Act (RCRA) and is a National Priorities Listed (NPL) site administered under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, Superfund). Environmental regulatory oversight of the Pantex Plant is, therefore, exercised under RCRA and CERCLA as well as other applicable Texas state regulations.

Historic waste management activities have resulted in impacts to soil and perched groundwater above risk-based standards. A corrective action program has been developed to address unacceptable risks for soil and perched groundwater at the facility. Corrective measures for perched groundwater are designed to stabilize and control migration while reducing the mass of contaminants. The following report focuses on response actions and remedial activities for perched groundwater, more specifically the groundwater monitoring program supporting site remedial decisions.

Groundwater monitoring plays a critical role in long-term environmental restoration of the Pantex Plant Site. Long-term monitoring optimization (LTMO) is part of overall remediation optimization for affected groundwater. The perched groundwater network was the subject of an LTMO in 2007 with results published in a report *Groundwater Monitoring Network Optimization: Perched Groundwater Unit, Pantex Plant*. (GSI 2008). The evaluation included groundwater data collected between 2000 and 2007.

The purpose of the following evaluation is to review the groundwater monitoring network since installation of several remedial components and provide recommendations for improving the efficiency and accuracy of the network for supporting site management decisions. The evaluation includes data collected from 2008 to 2011. Documents and data sources used in the analysis are listed under References.

2.0 SITE BACKGROUND AND CONCEPTUAL SITE MODEL

2.1 Site History and Regulatory Background

Pantex Plant operations began in 1942 under the Army Ordnance Corps, manufacturing conventional munitions and high explosives (HE) such as trinitrotoluene (TNT). The Plant was briefly deactivated at the end of the World War II, and the property sold to TTU. In 1951, the site was reclaimed for use by the Atomic Energy Commission (AEC) to produce both nuclear weapons and HE compounds. Radioactive materials have not been manufactured at the facility but components containing radioactive materials are managed at the site. Compounds such as TNT, High Melting Explosive (HMX, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and Research Department Explosive (RDX, Hexahydro-1,3,5-trinitro-1,3,5-triazine) have been manufactured, tested and disposed of at the site.

The Pantex Plant is currently managed as a government-owned, contractor-operated facility, overseen by the DOE/NNSA and operated by Babcock & Wilcox Technical Services Pantex, LLC (B&W Pantex). As the prime contractor, B&W Pantex also directs environmental activities including investigation and remediation of areas impacted by past waste management practices.

In 1988, the EPA conducted a *RCRA Facility Assessment* of the Pantex Plant, identifying Solid Waste Management Units (SWMUs) and Areas of Concern (AOC) containing environmental media possibly subject to interim corrective measures (ICMs). The RCRA Facility Investigation (RFI) identified operational areas at the site and groupings of corrective action units in common watersheds termed waste management groups (WMGs). The Pantex Plant was proposed for NPL listing in 1991 and formally listed in 1994. The Pantex Plant is, therefore, subject to the provisions of CERCLA in addition to RCRA and State of Texas requirements.

In 2008, an Interagency Agreement (IAG) went into effect between EPA, USDOE/NNSA and Texas Commission on Environmental Quality (TCEQ), setting forth the roles and responsibilities of each of the agencies for performance and oversight of remedial activities. The IAG is a binding agreement between the parties outlining procedures to ensure that remediation is accomplished pursuant to requirements under CERCLA and related statutes. The DOE/NNSA is the lead federal agency to investigate, assess, plan and remediate affected media at the Pantex Plant. The TCEQ and EPA share oversight of remedial requirements under the 1994 Memorandum of Agreement (MOA) and the IAG. All non-radiological environmental restoration activities under both state and federally-authorized programs at the Pantex Plant are conducted under the State of Texas Risk Reduction Rules (RRR) (30 TAC §335 Subchapter S, 1993).

The Corrective Measure Study/Feasibility Study (CMS/FS) was completed in 2007 and conditionally approved by TCEQ and EPA in 2008 with the Pantex Site Wide Record of Decision (ROD) finalized in the same year. The CM/FS and ROD outline the interim corrective and stabilization measures (ICMs and ISMs respectively) for the perched unit. A comprehensive long-term groundwater monitoring strategy (LTM Report) supporting assessment of the proposed remedies was developed and finalized in 2009

(B&WPantex 2011). The monitoring network described in the 2009 document is the subject of the following evaluation. Figure 2 illustrates the location of monitoring wells in the program and the approximate location of the Southeast, Southwest and North Sectors used in the analysis.

2.2 Geology and Hydrogeology

The Pantex Plant lies on the High Plains portion of the Great Plains Physiographic Province in the Texas Panhandle. The area, known as the Llano Estacado is a broad, flat, plateau with topographic elevation across the site ranging between 3,501 feet above mean sea level (ft amsl) to 3,595 ft amsl. A distinguishing feature of the area is the presence of numerous shallow circular basins called *playas*. Playas are ephemerally moist depressions that are the location of much of the recharge to the perched aquifers in the region. When inundated the playas form shallow lakes and wetlands, contributing to animal and plant diversity in the region. The average topographic slope across the Plant area is approximately 0.006 feet, and Plant surface water tends to drain to the onsite playas.

The uppermost hydrostratigraphic unit (HSU) at the Pantex Plant is the Blackwater Draw (BWD). The BWD extends up to 90 ft below ground surface (bgs) at the site, and is largely unsaturated. The unit consists of silts and sands and an approximately 20-foot thick lower unit composed of silty sand and caliche. The playas are depressions in the BWD.

The Ogallala Formation underlies the Blackwater Draw and is composed of coarse-grained fluvial sequences including channel sands and gravels overlain by finer overbank deposits. The Ogallala Formation in Texas is the southernmost extension of a major water-bearing unit that extends north to Nebraska and is exploited for municipal water supplies as well as crop irrigation and industrial water supplies. The Ogallala Aquifer is the principal municipal water supply for the city of Amarillo. The city operates a municipal well field north of the Pantex Plant. The Ogallala Aquifer has historically provided potable and industrial water for the Pantex Plant as well as agricultural water for the surrounding properties.

A Caliche Caprock layer generally defines the top of the Ogallala Formation, but is not continuous across the entire Pantex Plant. The Caprock consists of a hard, dense and finely crystalline caliche. In the Pantex area, the Ogallala Formation consists of upper and lower permeable units separated by a Fine Grained Zone (FGZ). The FGZ consists of low-permeability silts and clays and varies in thickness from over 150 ft to less than 10 ft. The FGZ slopes down toward the southeast corner of the Pantex Plant.

The upper unit of the Ogallala formation contains discontinuous areas of perched groundwater underlain by the FGZ. Prior to industrial activities at the Pantex Plant, the area of perched groundwater was most likely small and discontinuous across the site. The deeper Ogallala Aquifer (High Plains Aquifer) resides in the lower permeable unit beneath the FGZ. Underlying the Ogallala Formation are the lower permeability Dockum Group and Permian Quartermaster Formation, where the Dockum Group is not present.

Groundwater

Perched groundwater is found in three main areas under the Pantex Plant. The largest area of perched groundwater is associated with recharge from Playas 1, 2 and 4 and drainage ditches associated with industrial Zones 11 and 12 (see Figure 1). Historically, waste water from plant operations was discharged to the ditches and drained, primarily, to Playa 1. Groundwater elevation is highest under Playa 1 with radial flow to the north and to the south beneath Zones 11 and 12, pinching out on the TTU property to the south and off-site to the east (see Figure 1). Groundwater flow direction in the Southeast Sector is predominantly to the south/southeast. In the Southwest Sector, flow is to the south/southwest (see Figure 1 for groundwater elevations). Isolated areas of perched groundwater also occur under the Burning Ground (near Playa 3) and in the northeast corner of the Pantex Plant (near Pratt Playa).

Saturated thickness of perched groundwater varies across the unit with a high of approximately 70 feet beneath Playa 1 to 0 feet at the extreme edges of the unit. Depth to groundwater varies from about 215 feet near Playa 1 to approximately 280 feet south of the main perched unit under TTU property. Beneath the perched groundwater, the FGZ consists of low permeability silts and clays. The FGZ tends to isolate perched water from deeper strata; however, the FGZ becomes more coarse, thin and permeable in areas to the south and east of the main Plant.

Because of mounding in the vicinity of Playa 1 and the topography of the FGZ, groundwater flow in the main perched unit tends to be radial, with the surface sloping to the southeast, south and east of Zone 12, and sloping to the southwest, west of Zone 11. Groundwater north of Playa 1 tends to flow to the north. Radial flow within the main perched unit is the reason why the monitoring network was divided into sectors for the LTMO analysis (see Sectors identified on Figure 2 and described under Section 2.1.1). Groundwater elevations from December 2011 are shown on Figure 1.

The lower Ogallala (High Plains) Aquifer is encountered at depths of 400 to 500 feet bgs beneath the Pantex Plant with the water table sloping from southwest to northeast locally under the influence of the city of Amarillo municipal well field. The saturated thickness of the Ogallala varies from less than 30 feet to over 400 feet. Removal of water from the Ogallala aquifer for municipal, industrial and large-scale agricultural uses has reduced the saturated thickness in many areas of the aquifer. The following report does not cover monitoring of the deeper Ogallala Aquifer.

While groundwater in the perched units meets the technical definition of a potential drinking water source, no water supply wells are drilled into the unit for either drinking water or industrial water supply on-site and all public drinking water supply wells in the vicinity are drilled into the Ogallala Aquifer, with the exception of one perched groundwater well on offsite property north of the northeast corner of Pantex near Pratt Playa. The perched groundwater does not discharge to surface water bodies and hydraulic connection with the Ogallala is limited by the FGZ.

2.3 Constituents and Sources

From the early 1950's to the 1980's portions of the main perched groundwater were impacted by constituents of potential concern (COPCs) and artificially high recharge originating from plant industrial processes. The primary sources of COPC to groundwater at the Pantex Plant arose from infiltration of historic wastewater discharges through areas of focused recharge to the vadose zone and perched groundwater unit. Effluent from industrial processes, sanitary wastewater, cooling water discharge and storm water runoff were released to unlined ditches and discharged to Playas 1, 2 and 4 creating linear sources as well as point sources to the subsurface. Subsequent infiltration has resulted in numerous co-mingled plumes and an artificially expanded perched groundwater unit under Playa 1 and areas southwest and southeast of the main industrial facilities.

All wastewaters are currently directed to the sanitary sewer system and to the Pantex Plant Waste Water Treatment Facility (WWTF). Treated wastewater is no longer discharged to the playas and, after treatment, is directed to the agricultural irrigation system. Treated perched groundwater is reused beneficially in this same manner, although injection back into the perched unit in the southeast is still possible, but not preferred. Current industrial activities do not contribute constituent mass to the groundwater; however, constituents may remain in the vadose zone from historic practices.

Zone 12

The primary area of origin of industrial waste water was Zone 12, with discharge in the eastern ditch running to Playa 1. Industrial operations in Zone 12 included development, testing and manufacture of HE components. Historic wastewater discharge from Zone 12 varied between approximately 200,000 and 300,000 gallons per day (gpd). Discharges originating in Zone 12 infiltrated along the unlined ditch and Playa 1, resulting groundwater mounding under Playa 1 and plumes exceeding drinking water standards in the north, east and southeast. Contamination is present to the extent of the groundwater unit to the east and southeast. Constituents remaining in the vadose zone may represent a continuing source of contamination to the perched unit.

Constituents in wastewater from Zone 12 included RDX, TNT; and other HEs, chromium from cooling waters and some chlorinated VOCs. TNT is photo-reactive, decaying to products like 2-Amino-4,6-Dinitrotoluene (2ADNT) and 4-Amino-2,6-Dinitrotoluene (4ADNT) resulting in the characteristic colored 'red water' discharge. RDX degrades to TNX, MNX and DNX under anaerobic conditions stimulated by the ISB remedies. These constituents, which are often short-lived, are monitored for remedy effectiveness rather than as priority risk drivers. RDX and degradation products of TNT are the priority constituents of concern (COCs) originating from Zone 12 and define the extent of affected groundwater in the southeast. Hexavalent chromium (Cr(VI)) is found in limited areas in the Southeast Sector from specific sources such as cooling systems.

Zone 11

Industrial operations in Zone 11 were diverse, consisting of quality assurance testing and machining operations that included cleaning of components with chlorinated solvents. Discharges from Zone 11 also infiltrated along ditches to the north and to Playa 1 resulting in a linear source extending north to Playa 1 and southwest with groundwater flow. The groundwater flow from Zone 11 is predominantly to the southwest, but part of some plumes cross to the southeast area, particularly under the influence of extraction wells in the southeast. Constituents associated with Zone 11 include chlorinated solvents such as TCE and perchlorate as well as limited areas of Cr(VI).

Burning Ground and Northern Property

The Burning Ground area is northwest of the main Zone 11 and 12 areas and west of Playa 1. The Burning Ground has a small and, apparently, isolated perched groundwater unit associated with Playa 3. The Burning Ground is an active operation area used for thermal treatment of HE. Historic activities have resulted in some releases to shallow and deep soils. Perched groundwater below the Burning Ground has limited detections of chlorinated VOCs and some HEs.

Most of the area north of Playa 1 did not have known industrial sources. An isolated perched groundwater unit is present in the northeast corner of the main property. A historic wastewater treatment facility was located in the area, but no residual contamination from the facility has been found in perched groundwater. Monitoring wells in this area do not indicate consistent or high concentrations of constituents north of Playa 1.

Constituents of Concern

Groundwater analyses indicate that several contaminants are found above drinking water standards in perched groundwater. Constituents and standards used for optimization of the monitoring network are listed in the table below along with the maximum concentration results from the 2007 – 2011 timeframe. The constituent list was derived from a review of the 172 analytes routinely evaluated in the perched unit. Constituents with multiple results above screening levels were identified and included in the input files for statistical analysis of the LTM network. Boron concentrations are below drinking water standards but do exceed background values for the aquifer, posing potential problems for agricultural application. The standard for boron for the statistical analysis was set to the background value of 194 ug/L.

Constituents evaluated in perched groundwater monitoring network

Constituent Name	Standard [ug/L]	Maximum Concentration 2008 – 2011 [ug/L]	Basis of Standard
1,2-Dichloroethane	5	190	MCL
1,4-Dioxane	7.7	120	GWRESc
2,4-Dinitrotoluene	1	99.1	PQL
2-Amino-4,6-Dinitrotoluene	1.2	32	GW ResNC Adj
4-Amino-2,6-Dinitrotoluene	1.2	78.8	GW ResNC Adj
Arsenic	12	134	Background
Barium	2000	20500	MCL
Boron	7300*	2270	*GW-ResNC (Background = 194 ug/L)
Chromium, Hexavalent	100	7148	MCL
Chromium, Total	100	9040	MCL
cis-1,2-Dichloroethene	70	89	MCL
DNX (Hexahydro-1,3-Dinitroso-5-Nitro-1,3,5-Triazine)	2	100	EPA Lifetime HA for RDX
HMX (Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine)	360	767	GW ResNC Adj
Lead	15	0.711	MCL
Manganese	1715.5	34100	
MNX (Hexahydro-1-Nitroso-3,5-Dinitro-1,3,5-Triazine)	2	278	EPA Lifetime HA for RDX
Molybdenum	182.5	460	
Perchlorate	26	3090	GW ResNC
RDX (Hexahydro-1,3,5-Trinitro-1,3,5-Triazine)	2	4300	EPA Lifetime HA
Selenium	50	41.3	MSC
Tetrachloroethene	5	16.9	MCL
TNT (2,4,6-Trinitrotoluene)	3.6	120	GW-ResNC Adj
TNX (Hexahydro-1,3,5-Trinitroso-1,3,5-Triazine)	2	1000	EPA Lifetime HA for RDX
Trichloroethene	5	1500	MCL

GW-Res—TCEQ Standard No. 2 Groundwater MSC for Residential Use

MCL—EPA Maximum Contaminant Level

PQL—Practical Quantitation Limit

C—Carcinogenic

NC—Noncarcinogenic

ug/L—Micrograms per liter

HA – Hazard Assessment

* Boron exceeds background, posing potential threat to agricultural applications. Remedial goal is background concentration of 194 ug/L.

2.4 Remedies

The following section summarizes the response actions to mitigate contamination in the perched groundwater. Interim remedies implemented at the Pantex Plant were described in the 2003 Compliance Plan for Industrial Solid Waste Management Sites and the 2010 update to the Compliance Plan (TCEQ 2010) as well as the 2008 ROD. Remedy components are summarized in the table below and are illustrated on Figure 3.

Performance of the selected remedies is evaluated through groundwater monitoring implemented as described in the *Long-Term Groundwater Monitoring Plan* (B & W Pantex 2009a), developed as part of the Remedial Design, in accordance with the IAG. The expected performance of the remedies has been identified based on the Conceptual Site Model (CSM), groundwater modeling and engineering estimates. Results of groundwater monitoring are compared to expected performance in annual reports. Significant deviation from expected remedy performance may result in modifications to response actions. Contingency plans for remedies are detailed in the *Pantex Plant Ogallala Aquifer and Perched Groundwater Contingency Plan* (B&WPantex 2009b) and are summarized below.

Remedial Action Objectives (RAOs) for perched groundwater have been developed with the primary goals of restoring perched groundwater to drinking water standards and protecting the deeper Ogallala aquifer. Specific RAOs include:

- Reduce the risk of exposure to perched groundwater through prevention of human or ecological contact;
- Achieve cleanup standards for all COCs;
- Prevent growth of the perched groundwater contaminant plumes;
- Prevent contaminants from exceeding cleanup standards in the Ogallala Aquifer.

The overall remedy strategy for the perched unit is to reduce the volume and driving force of groundwater upgradient, particularly in the area of Playa 1. Downgradient portions of the plumes are treated using biological and geochemical reduction of contaminants. The individual remedy components are designed to work together to stabilize plumes in the perched unit and to reduce contaminant mass and mobility.

Plumes within the perched groundwater unit are somewhat unique relative to most groundwater plumes in that the abiotic, natural attenuation processes of advection, dilution and dispersion are not anticipated to reduce constituent concentrations due to the contained nature of the unit. Biological attenuation mechanisms are also not expected to be strong, as the primary constituents are not significantly labile to aerobic processes. For these reasons, several active remedies were recommended in the regulatory decision documents.

Playa 1 Pump and Treat System

A groundwater extraction and treatment system (pump and treat) was installed in the Playa 1 area consisting of 10 extraction wells and lines conveying water to a treatment plant. Water treatment consists of granular activated carbon (GAC) and ion exchange

units capable of removing contaminants from approximately 250 gallons per minute (gpm). The goal of the Playa 1 Pump and Treat System (P1PTS) is to reduce groundwater mounding in the area of Playa 1, the area of highest groundwater elevation and to remove contaminant mass. Treated water is discharged to the irrigation system supporting agricultural crops covering much of the Pantex and TTU properties. It is expected that the infiltration of irrigation water will not exceed evapo-transpiration losses, thereby preventing additional water from entering the perched unit.

Success of the P1PTS is defined as reduction in the groundwater elevation mound in the area, reducing flux of contaminants to the edges of the perched unit. The P1PTS is anticipated to reduce saturated thickness in the Playa 1 area two to five years after installation.

Monitoring to confirm performance of the P1PTS includes measuring groundwater elevation in the area of Playa 1 and developing potentiometric surface maps for the north-central Pantex Plant. Additionally, RDX concentrations are expected to decrease in the Playa 1 area and RDX mass flux to the southeast should be reduced. Decreases in mass are anticipated to level off after several years of pumping. Should the P1PTS fail to meet performance objectives for head reduction, the proposed contingent remedy includes addition of extraction wells and treatment capacity. Monitoring locations for the North Sector along with monitoring objectives are listed in Table 1.

Southeast Pump and Treat System

The Southeast Pump and Treat System (SEPTS) was piloted in 1995 and has been expanded to full scale in the intervening years. The SEPTS was a part of the ISM in the original Compliance Plan. The system consists of 62 groundwater extraction wells and lines conveying extracted water to a 300 gpm treatment plant with granular activated carbon (GAC), chromium ion exchange and boron ion exchange units. Treated water is used for industrial purposes, discharged to the irrigation system, and, when necessary, re-injected through three wells into the southeast perched unit. Monitoring locations and individual well objectives for the Southeast Sector are listed in Table 1.

The SEPTS is anticipated to reduce groundwater volume and lateral flux in the southeast portion of the perched unit, reducing transport potential to the edges of the plume and possible vertical migration to the lower Ogallala aquifer. The SEPTS is also anticipated to reduce mass and mass flux of RDX and other HEs in the southeast, stabilizing the plumes. The SEPTS is designed to work in concert with both the P1PTS and the ISB remedy in the southeast.

The function of the monitoring network relative to the SEPTS is to demonstrate reduction in groundwater elevation and to monitor concentrations in the southeast area. Potential concerns for the SEPTS include migration of constituents from the southwest and redistribution of mass in the plume toward the extraction wells away from the original sources.

Several conditions may result in under performance of the remedy, triggering possible contingency actions. If the P1PTS does not reduce flux to the south, additional

extraction wells may be added around Playa 1 and the P1PTS treatment plant expanded. Infiltration from the 5/12a Ditch could be greater than expected, overloading the SEPTS. In this case, the contingent action would involve re-grading or lining portions of the 5/12a Ditch to reduce infiltration. If the irrigation system is unable to handle the treated groundwater, reinjection of treated water may be necessary, undermining the volume reduction function of the SEPTS. For this scenario, expansion of the irrigation system or finding alternative uses for the treated water may be required. If perchlorate is detected in the extraction wells at levels that exceed discharge criteria, then the extraction from wells closest to the perchlorate plume migrating from Zone 11 will need to be modified temporarily until the treatment system can be upgraded to treat perchlorate.

Southeast In Situ Bioremediation (ISB) System

The Southeast ISB system is designed to create strongly reducing geochemical conditions on the southeast edge of the perched unit to facilitate biological reduction of RDX. The system consists of 42 injection wells where a mixture of bioavailable carbon and nutrients are injected approximately every 18 – 24 months to stimulate anaerobic conditions. Installation and preliminary injections were completed in March 2008. The second injection was completed in May 2010 and a third was completed in May 2012. Contaminant concentrations in the treatment zone will determine if the system is achieving its objective. RDX (and other HEs) and Cr(VI) approximately 200 feet downgradient of the treatment zone are expected to show strongly decreasing trends.

The function of the monitoring network relative to the ISB system is to provide data to demonstrate the efficacy of treatments downgradient from the injection points. One challenge for the monitoring network design is locating wells in areas of adequate saturated thickness so that representative samples can be collected. Several wells drilled in the area are either dry or apparently dry for some time after drilling.

Should monitoring data indicate the remedy is not performing as expected the contingent remedy includes changing the amendments to respond to specific geochemical needs, bioaugmentation with microorganisms targeting chlorinated solvents or installation of additional injection wells. Biofouling of the injection wells or formation may require more rigorous maintenance or reconfiguration of the system

Zone 11 In Situ Bioremediation System

An ISB system has been installed in the southwest portion of the Pantex Plant similar to the installation in the southeast. The purpose of the system is to create anaerobic conditions conducive to biological break down of chlorinated solvents such as TCE. The system consists of 32 injection wells using the same amendments as the Southeast ISB. Installation of the system was completed in 2009. Monitoring locations and objectives for the Southwest Sector are listed in Table 1.

The function of the ISB monitoring network is to confirm that amendments are causing biodegradation of chlorinated compounds (TCE) and perchlorate. Concentrations of parent compounds should decrease, approaching cleanup goals over the next five-year

period. Contingent remedies for the Zone 11 ISB include installation of upgradient extraction wells to reduce the flow of water through the area. Biofouling of the injection wells or formation may require more rigorous maintenance or reconfiguration of the system. Breakthrough of perchlorate above cleanup goals may require reformulation of the amendments delivered to the subsurface to optimize treatment of this constituent.

Perched Groundwater Remedies

Location	Remedy	Goal	Contingency
Playa 1	P1PTS –GW Extraction and Treatment – GAC and boron Ion Exchange; Effluent to industrial supply or irrigation system	Reduce GW elevation and head causing downgradient movement; reduce mass of RDX, other HEs and boron	Additional Extraction Wells and expanded treatment
Southeast	SEPTS - GW Extraction and Treatment Effluent – GAC, Cr and Boron Ion Exchange; Effluent to industrial supply, irrigation system or re-injection	Reduce GW elevation and mass of RDX and other HE, VOCs and Cr(VI)	Expand P1PTS, improve irrigation system or find alternatives for disposal of treated water; Addition of perchlorate treatment unit; re-grading ditch
Southeast	In-Situ Bioremediation -- Injection of carbon and nutrients to create reducing conditions	Create conditions supporting biological reduction of RDX	Change formulation for amendment, addition of more injection points, maintenance for biofouling
Zone 11	In-Situ Bioremediation -- Injection of carbon and nutrients to create reducing conditions	Create conditions supporting biological reduction of TCE (VOCs), and perchlorate	Change formulation for amendment, addition of more injection points, maintenance for biofouling
Site-Wide	Institutional Controls	Prevent human and ecological exposure and potential cross-contamination	None

GW = Groundwater

2.5 Current Monitoring Program and Optimization Efforts

The current groundwater monitoring program at Pantex was designed in a formal process that included setting monitoring objectives, evaluating the function of each well relative to the objectives and using statistical, mathematical, and qualitative tools to locate wells spatially. The monitoring network for the perched unit is described in the 2009 Long-Term Monitoring System Design Report (LTM Report) (B&WPantex 2009a).

The ultimate goal of a monitoring network is to confirm that RAOs are being met. Data collected from the monitoring network are used to evaluate the performance of the remedies and are used to compare actual conditions to expected site conditions. Three primary monitoring objectives have been identified for the Pantex perched groundwater network:

- Evaluate plume stability – identify areas of increasing and decreasing concentrations on the edge of the plumes and identify where the plume may be expanding into clean areas.
- Efficacy of the response action – the response action will be evaluated based on its ability to reduce the elevation of groundwater in the Playa 1 area, reduce the mass in the Playa 1 area, reduce the mass in the southeast area, and reduce the spread of contamination in the southeast and southwest areas.
- Uncertainty management – confirm expected conditions identified in the RFI exist and identify any deviations; compare results to expected conditions, identify deviations that may alter assumptions about existing conditions

Each well in the LTM network has been assigned at least one monitoring objective under the LTM Plan. Many wells have also been designated as point of compliance (POC) or Point of Exposure (POE) wells under the Compliance Plan as per Texas RRR. Wells in the current program used for this analysis, along with the monitoring objectives for each well are listed in Table 1 and shown on Figure 2.

Secondary objectives of the monitoring network include:

- Delineation of groundwater exceeding applicable regulatory standards (and delineation of the extent of saturation in the perched zone);
- Provide sufficient data to evaluate risks (under State of Texas RRR);
- Support calibration and development of site groundwater models;
- Provide early warning for potential impacts to the lower High Plains Aquifer (lower Ogallala);
- Comply with regulatory requirements.

For the following report, 113 individual LTM program locations were evaluated. Of these wells, 17 are intermittently or permanently dry, and help define the extent of perched groundwater. No ISB or extraction remedy wells were included in the monitoring network analysis. Nine well locations not in the LTM program were included in the spatial analysis to prevent recommending additional wells where decommissioned wells currently exist.

3.0 ANALYTICAL METHOD

Evaluation of the groundwater monitoring network for the Pantex Plant consisted of both quantitative and qualitative methods. A quantitative statistical evaluation of the site was conducted using tools in the Monitoring and Remediation Optimization System (MAROS) software (versions 2.2 and 3.0 Beta). The qualitative evaluation reviewed hydrogeologic conditions, well construction and placement as well as contaminant geochemistry. Both quantitative statistical and qualitative evaluations were combined using a 'lines of evidence' approach to recommend a final groundwater monitoring strategy to support site monitoring objectives. The analytical method for the current report is similar to that conducted for the 2008 *Perched Groundwater Monitoring Network Optimization* (GSI 2008) (referred to below as the 2007 evaluation).

MAROS is a collection of tools in one software package that is used in an explanatory, non-linear but linked fashion to statistically evaluate groundwater monitoring programs. The tool includes models, statistics, heuristic rules, and empirical relationships to assist in optimizing a groundwater monitoring network system. Results generated from the software tool can be used to develop lines of evidence, which, in combination with professional judgment, can be used to inform decisions for safe and economical long-term monitoring of groundwater plumes. A summary description of each tool used in the analysis is provided in User Manual (AFCEE, 2004, 2012) or Aziz, et al. (2003).

3.1 Input Data and Reports Reviewed

Groundwater analytical data collected between 2008 and 2011 from the Pantex Plant LTM network were supplied by B&W Pantex from the site database. Data from the previous LTM investigation (GSI 2008) (2000 – 2007 timeframe) were used to supplement analyses of long-term trends. As in the 2008 analysis, wells were grouped according to the area of general groundwater flow from the elevation maximum under Playa 1. Wells used in the analysis, their monitoring objectives and sector location are shown in Table 1. The spatial sectors defined for the analysis are illustrated on Figure 2. Aquifer parameters used in the analyses are listed on Table 2, and were taken from the 2007 LTMO analysis.

The analyte list for the analysis was limited to constituents found above regulatory screening levels (and in the case of boron, over background concentrations). Analytes included in the MAROS input files are listed in the constituent table above. The MAROS software includes an algorithm to identify priority COCs by toxicity (concentrations normalized by the cleanup goal), prevalence (number of wells exceeding cleanup goals) and mobility (sorption coefficient). Priority COCs for each sector were confirmed by the algorithm, and the monitoring networks were designed around these priority constituents using statistical metrics calculated in the software. Details of COCs chosen and analyses performed are located in the Results section of this report and in the 2008 LTMO report.

The MAROS software also identifies priority constituents at each individual monitoring location based on both average and historic maximum concentrations normalized by the

cleanup goal. Identifying priority constituents at each location can better refine network monitoring objective priorities.

Several documents published since the 2008 LTM evaluation were reviewed for the new analysis. The *Long-Term Monitoring System Design Report* (B&WPantex 2009a) provided an overview of the current monitoring program. Significant regulatory documents reviewed include the 2008 ROD (B&WPantex 2008), the 2010 Compliance Plan (TCEQ 2010), the 2009 Contingency Plan and the 2007 CMS/FS (B&WPantex 2007). Pantex Plant Annual Progress reports from 2008, 2009 and 2010 were reviewed. A complete list of references is provided at the end of this report.

3.2 Monitoring Goals and Objectives

The ultimate goal of a monitoring network is to support site decision making and to evaluate progress toward achieving RAOs. Pantex site managers have developed three primary objectives for monitoring data collection and each well in the network is designated as addressing at least one of these objectives.

A summary of the monitoring objectives is provided in Section 2.3 above and in Table 1. The review and optimization of the groundwater monitoring network has been conducted to attain the goals of assessing plume stability, remedy effectiveness and uncertainty in distribution of contaminants in the perched groundwater unit.

3.3 Individual Well Statistics

Within MAROS, historical analytical data are analyzed to develop a conclusion about plume stability. If a plume is found to be stable, in many cases, the number of locations and monitoring frequency can be reduced without loss of information. Conversely, if individual well statistics indicate increasing concentrations or unexpected conditions, more sampling, either through increased number of wells or frequency of sampling, may be recommended. Plume stability results are assessed from time-series concentration data, with the application of three levels of statistical tools: individual well concentration statistics, trend analyses (including Mann-Kendall and Linear Regression trends) and plume-level analyses.

A statistical review of concentration versus time data for individual well/COC combinations was conducted for the recent data (2008 – 2011). The MAROS software was used to generate detection frequency, summary statistics (e.g. minimum and maximum concentrations, mean, variance, etc.) and concentration trends for each monitoring well in the network for the priority constituents in each sector. Variability, as assessed by the coefficient of variation (COV) and trend, is used to identify wells with stable (predictable) or fluctuating concentrations. High variability can indicate concentrations influenced by variable environmental conditions (e.g. variable pumping from extraction wells) or formations that may not provide representative data or areas of high uncertainty about plume processes. High variability at a location indicates the source of variability should be identified and the location should be evaluated for suitability of data for the monitoring objective.

Summary statistics for each sector of the network are summarized below and detailed in the Tables section of the report. In addition to summary statistics and trends, MAROS 3.0 Beta was used to determine a data distribution for each location in the Southeast and Southwest Sectors and to find potential outliers in the dataset.

3.4 Plume-Level Analysis

Plume-level analyses include the Moment and Aggregate Trend analyses in the MAROS software. The Moment Analysis estimates total dissolved mass, center of mass and spread of mass trends for plumes over time. The Aggregate Trend analysis groups individual wells in a specific location (e.g. Source or ISB areas) and determines an aggregate trend for the area from the individual Mann-Kendall trends.

To ensure a consistent number and identity of wells for the plume-level analyses, site data were consolidated annually for the analysis. An average concentration for each well for each year and COC was calculated by the software. Estimates of total dissolved mass, center of mass and spread of mass were calculated for each year 2008 – 2011 based on the average concentration at each monitoring point for each year. Trends for each of the moments as well as aggregate trends for specific areas are reported in the Results section below.

MAROS 3.0 has a module that uses spatial geometry to define a two-dimensional area around a well (Voronoi Area) and estimates the amount of mass in the area using a uniform saturated thickness. The module identifies the percentage of the total plume area monitored based on the region defined by the Voronoi Area for each well and the percentage of total plume mass monitored by the well. This tool is used to identify wells that monitor either large areas or areas high in mass. Wells that represent a large percentage of the total mass should not be removed from the network.

3.5 Spatial Analysis

Spatial analysis modules in MAROS recommend elimination of sampling locations that have little impact on the historical characterization of a contaminant plume while identifying areas in the plume where additional data are needed. For details on the redundancy and sufficiency analyses in MAROS, refer to the User's Manual (AFCEE, 2004).

Sample locations are evaluated in MAROS for their importance in providing information to define concentrations within the groundwater plume. Wells identified as providing information redundant with surrounding wells are recommended for elimination from the program. (Note: elimination from the analytical monitoring program does not necessarily mean plugging and abandoning the well, as the well may still be important in evaluating groundwater elevations). Well sufficiency is evaluated in MAROS using the same spatial analysis as for redundancy. Areas identified as having unacceptably high or unexplained levels of concentration uncertainty are recommended for additional monitoring locations. MAROS 3.0 Beta has a Decision Logic tool that uses multiple statistical metrics to identify locations for new wells and wells that are in the lowest 25% of importance in the network.

The primary method of evaluating well redundancy and sufficiency is calculation of Slope Factors (SF) and Relative Error (RE). SF and RE values are computed by comparing the actual concentration at each location with concentrations estimated from the wells' nearest neighbors. SF is calculated by dividing the difference between the actual and estimated concentrations by the maximum of the actual or estimated concentration to return a result between 0 and 1. Values close to 1 indicate important locations providing unique information. RE is calculated by dividing the difference between the estimated and actual concentration by the actual concentration. RE values can vary over orders of magnitude, with higher values indicating more spatial uncertainty between points. Low SF or RE indicate the well does not provide unique information and may be a candidate for removal.

SF's and RE's were calculated for all wells in the Southeast and Southwest Sectors of the Pantex Plant and the results were used to determine the importance of each well in the network for defining the extent of concentrations for the primary COCs in these areas. Monitoring locations in the North Sector have limited hydrologic connection, either by virtue of discontinuous groundwater, very low concentrations or because of variable flow directions. For this reason, quantitative spatial analysis in the North Sector provides limited information, and network recommendations are based on individual well trends and qualitative information.

3.6 Frequency Analysis

MAROS uses a Modified Cost Effective Sampling (MCES) method to optimize sampling frequency for each location based on the magnitude, direction, and uncertainty of its concentration trends. The MCES method was developed on the basis of the Cost Effective Sampling (CES) method developed by Ridley et al. (1995). The MCES method estimates a conservative lowest-frequency sampling schedule for a given groundwater monitoring location that still provides needed information for regulatory and remedial decision-making.

The MAROS software recommended a preliminary location sampling frequency (PLSF) for each monitoring location for perched groundwater at the Pantex Plant based on a combination of recent (2008 – 2011) and long-term trends (2000 – 2011) and the magnitude and rate of concentration change. The PLSF has been reviewed qualitatively and a final optimal sampling frequency has been recommended consistent with monitoring objectives and regulatory requirements. It is understood that sampling frequencies specified in the Compliance Plan may not be open to change, but recommended frequencies have been provided to confirm that sufficient samples are being collected to capture changes in the plume geometry.

3.7 Qualitative Review

The primary consideration in developing any monitoring network is to ensure that information, collected efficiently, supports site management decisions. Site information needs are reflected in the monitoring objectives for the network. For this reason, any proposed changes to the network are reviewed to be consistent with and supportive of

the stated monitoring objectives. The qualitative review process includes evaluating each monitoring location for the role it plays supporting site monitoring objectives. Additionally, heterogeneities in subsurface conditions, remedy performance and other physical conditions cannot be fully represented by automated statistical analyses. For this reason, all results were 'reality checked' against the Pantex Plant CSM to ensure that all recommendations are consistent with known site conditions.

4.0 RESULTS

4.1 Southeast Sector

Sixty four borings were considered in the Southeast Sector analysis. Of the 64 locations, 54 are wells in the current LTM program with analytical data collected between 2008 and 2012. Data from extraction or ISB wells were not considered in the formal analysis. Other sampling locations are dry or inactive in the LTM program and have no analytical data. Additional locations not in the current program were considered in the spatial analysis to prevent recommendations to add wells in dry areas or areas with existing decommissioned wells. Some locations are considered for both the Southeast and Southwest or Southeast and North Sectors as plumes are comingled in several areas.

Priority constituents for each individual well in the Southeast Sector are indicated on Table 1. The priority constituent was identified as the COC with the maximum value for the average concentration normalized by the cleanup goal (calculated in MAROS 3.0 Beta). (Wells with no constituents above remedial goals have 'none' in the Priority COC column.) While RDX is the predominant individual well COC, source area wells PTX06-1008, 1010 and 1011 monitor areas of higher total chromium and other locations show individual higher exceedances for 4ADNT, 2ADNT, TCE and boron. Exceedances for metals such as barium and arsenic may be related to oxidation/reduction changes stimulated by the ISB remedy.

A sector-wide evaluation of priority COCs was performed in the MAROS software and the results are indicated in Table 3 MAROS COC Assessment for the Southeast Sector. Based on toxicity and prevalence metrics, the two priority COCs for design of the monitoring network for the Southeast Sector are RDX and 4ADNT, as was found in the 2007 LTMO analysis. The monitoring network was optimized for these constituents. Boron was not considered in the 2007 analysis, and is not prioritized here because the cleanup value is a secondary standard (for plant irrigation). TNX, DNX and MNX are degradation products of RDX and are monitored to evaluate biodegradation of RDX. The Cr(VI) plume originating in Zone 11/12 is discussed below and under the Southwest Sector as more than one source area may exist and the plume crosses the groundwater divide between the sectors (see plume maps in 2010 Pantex Annual Report (B&W Pantex, 2010)).

4.1.1 Individual Well Statistics

Individual well statistical results for the Southeast Sector are shown in Tables 4 and 5 and are summarized in the table below. Mann-Kendall trend results and average concentrations for RDX are shown on Figure 4. Detection frequencies, maximum and average concentrations indicate that the majority of well locations are either significantly over the MSC or largely unaffected, which is consistent with both the CSM and the monitoring objectives of the program.

Individual well concentration trends were determined using the Mann-Kendall non-parametric trend method. Results of the trend analysis for individual wells for RDX and

4ADNT are shown on Table 4 and illustrated on Figures 4 and 5. Included in Table 4 are trend results from the 2007 LTMO analysis for comparison.

Wells PTX06-1013, PTX06-1014, PTX06-1030, and PTX06-1031, approximately located along the picket of extraction wells (near FM 2373), showed strongly increasing RDX trends prior to 2007 but have stabilized or started decreasing since the previous analysis. This group of wells is in central/north relative to the extent of the perched unit in the Southeast Sector and may indicate that the extraction wells along FM 2373 are stabilizing the plume in this area.

Monitoring wells immediately downgradient from the ISB remedy show some strongly decreasing trends (PTX06-1037 and PTX06-1123) and some variable trends (PTX06-1153 and 1154). No trend (or variable) results may be expected from disturbances caused by the injections. For PTX06-1154, sample results after 2010 indicate a dramatic drop in concentration, but a larger dataset is needed to achieve a statistically significant decreasing trend. Overall, no statistical inconsistencies were seen in wells monitoring the Southeast ISB.

Southeast Sector Individual Well Trend Summary

COC	Total Wells	Pantex Plant Southeast Perched Groundwater Mann-Kendall Trend Results by Number of Wells				
		<i>Nondetect</i>	<i>Decreasing or Probably Decreasing</i>	<i>Stable</i>	<i>Increasing or Probably Increasing</i>	<i>No Trend or Insufficient Data</i>
RDX	54	8 (15%)	9 (17%)	9 (17%)	7 (13%)	21 (39%)
4ADNT	54	13 (24%)	10 (18%)	12 (22%)	4 (19%)	15 (28%)

A summary of trend results is shown in the table above. Overall RDX trend results from 2008 – 2011 include many more ‘no trend’ results than the 2007 analysis. No trend results may be a consequence of the smaller datasets. However, some areas may be showing some variation prior to stabilizing under the influence of the remedial systems. An additional indication of potential stability is the number of wells where data have a normal data distribution (see Table 5).

An area of increasing RDX concentrations is located at well PTX08-1002 in the north near Playa 1. The increasing trend is most likely due to the proximity of P1PTS extraction wells drawing RDX from the historic Playa 1 source area.

The other area of increasing RDX trends appears to be among wells extending from the southeast corner of Zone 12 to the edge of the perched unit. This phenomenon is indicated by increasing trends at wells PTX06-1095A, PTX06-1102, PTX06-1015 to the southeast edge of the perched unit at well PTX06-1034. Well PTX08-1009 also shows an increasing trend for RDX, but concentrations are low and the well is cross-gradient from the majority of the plume. Trends for 4ADNT are strongly decreasing at this well. Wells PTX06-1047A and PTX06-1034 had a consistently increasing trend from 2000 – 2011. Increasing trends at PTX06-1034 are of particular significance as the well delineates the extent of the perched unit and is outside of the influence of the remedies. The increasing trend at downgradient delineation well PTX06-1034 is an indication that

an additional well may be necessary at the limit of the saturated unit farther downgradient.

The area of increasing trends appears to run roughly between the extraction wells and the ISB remedy. While location PTX06-1031 near this flow path has a decreasing trend, the strength of the line of increasing trends may indicate a trend of mass movement in this area. Increasing concentrations at this group of wells are responsible for an overall increasing estimate of total dissolved mass in the plume (See Plume Analysis below).

Decreasing RDX trends are found at various locations in the Southeast. Source area wells PTX06-1002A and PTX06-1088 show decreasing concentrations. Decreasing trends in the source area may be a sign of source exhaustion for RDX and 4ADNT.

Individual well concentration trends for 4ADNT show very few increasing trends and more non-detect, stable and decreasing locations relative to RDX. The difference in concentration responses between RDX and 4ADNT may be a result of differences in the original source release mechanisms and geometry.

Chromium

Cr(VI) is found in a comingled, U-shaped plume that crosses the divide between the Southeast and Southwest Sectors. The Cr plume is contained within the Southeast and Southwest monitoring networks, so does not tend to drive decisions for adding/removing well locations. Well PTX06-1010 is located near one suspected source of the plume and near INJ-02, historically used to inject treated water. The increasing trend from 2009 - 2011 may be a result of injection of treated water. Downgradient well PTX06-1088 has a decreasing trend for Cr(VI) while neighboring well PTX06-1011 has a stable trend. Well PTX06-1052 located near another historic source has the highest current concentration in the network and exhibits a stable trend. The table below includes a list of Cr(VI) monitoring wells for both the Southeast and Southwest Sectors with the highest concentrations and the Mann-Kendall trends. Wells where individual high concentration data points appear to be outliers are not included (e.g. PTX06-1101).

Well ID	Cr (VI) Trend	Maximum Concentration 2008 -2011 [mg/L]
PTX06-1052	Stable	7.1
PTX06-1010	Increasing	2.8
PTX08-1008	Decreasing	1.4
PTX08-1007	(Insufficient Data)	1.06
PTX06-1118	No Trend	0.325
PTX06-1088	Decreasing	0.16
PTX06-1153	Increasing	0.12

4.1.2 Plume Analysis

Mann-Kendall trends for total dissolved mass, center of mass and spread of mass were calculated for annually consolidated data 2008-2011. Calculation of these trends is

intended to provide a measure of plume stability. Trend estimates of the zeroth, first and second moments for both RDX and 4ADNT for the Southeast Sector are summarized in the table below, and first moments (center of mass) for RDX and 4ADNT are illustrated on Figure 5. MAROS reports for zeroth, first and second moments for other COCs are located in Appendix B. The number of wells in the annually consolidated dataset varied between 43 in 2008 to 50 in 2010 from the total of 54 wells in the dataset. This reflects variation in the number, identity and analyte list of wells sampled in the time frame of interest.

The zeroth moment analysis (estimate of total dissolved mass) shows an increasing trend for RDX. The center of mass of RDX along with the spread of mass did not show a trend over the 2008 to 2011 time frame. These results are most likely due to the increasing concentrations along the southeast flow path, as described above. Results for 4ADNT are stable for all metrics indicating high overall stability of this plume relative to the RDX plume.

A visual comparison of the center of mass for RDX indicates that the center shifted somewhat between 2008 and 2009 – 2011 with 2008 closer to the source. This result may be an artifact of the addition of data from wells PTX06-1146 and PTX06-1147 in 2009, which shows fairly high concentrations of RDX to the east of FM 2373.

Southeast Sector Moment Analysis Results

Moment Type	Constituent	
	RDX Trend	4ADNT Trend
<i>Zeroth (Total Dissolved Mass)</i>	Increasing	Stable
<i>First (Center of Mass)</i>	No Trend	Stable
<i>Second (Spread of Mass)</i>	No Trend/Stable	Stable/Stable

*Result for uniform saturated thickness

The estimates of total dissolved mass and center of mass for Cr(VI) in the Southeast Sector show largely stable trends. Second moments, indicating the spread (dilution) of mass relative to the center show increasing trends. The results indicate that the Cr(VI) plume in the Southeast has stabilized in terms of mass but may be diluting as it spreads to the edges.

Aggregate trends for areas within the Southeast Sector plumes were evaluated based on grouping of individual well trends. Aggregate trends were found for the Source area (near the original line release from Zone 12 to Playa 1), the Tail (non-source wells), the ISB Southeast remedy area and the area along the picket of extraction wells to the east along FM 2373.

The number of wells in each group is indicated in the table below and the identity of wells in the group is provided in Table 1. Wells in the southeast source area (Zone 12) include PTX06-1002A, PTX06-1003, PTX06-1005, PTX06-1010, PTX06-1011, and PTX06-1088. The source area shows a low proportion of total mass in the plume and an overall probably decreasing trend for RDX and 4ADNT, consistent with decreasing source strength.

The majority of plume mass is in the 'Tail' region. Overall, wells in the tail of the plume show a stable trend – which likely indicates a combination of decreasing trends in the central/north and increasing trends in the southeast. Wells along the FM 2373 extraction picket show no trend, in the aggregate. The center of mass of the plume is approximately along the picket of extraction wells and this is reflected in the estimate of the percentage of plume mass in this area (46% of RDX and 61% for 4ADNT).

Monitoring locations in the area of the Southeast ISB remedy in the far south of the plume show an aggregate stable trend and represent approximately 17% and 8% of plume mass for RDX and 4ADNT respectively. The stable trend is a result of some decreasing and some variable individual well trends as noted above. The percentage mass estimates for the extraction and ISB areas show the difference in distribution of 4ADNT and RDX in the plume overall.

Aggregate trends for RDX and 4ADNT in the Southeast Sector

Area	Number of Wells	RDX Aggregate Trend	RDX Aggregate Mass %	4ADNT Aggregate Trend	4ADNT Aggregate Mass %
Source	6	PD	7%	PD	4%
Tail	47	S	93%	S	96%
SE ISB	14	S	17%	S	8%
SEPTS	10	NT	46%	S	61%

The Percent of Mass by Well analysis for RDX for 2011 (annually consolidated data) indicated wells that monitor areas of high mass based on concentration and distance between other monitoring locations. The following wells showed the highest estimated percentage of RDX monitored in the plume: PTX06-1030 (14%), PTX06-1038 (11%), and PTX06-1146 (14%). Other wells represented mass of less than 5%. Each of the wells monitoring high percentages of mass is on the eastern side of the Southeastern Sector, away from the source in the vicinity of the extraction picket.

Mann-Kendall concentration trends for the high mass locations are stable for PTX06-1030 and no trend for PTX06-1038 and PTX06-1146. The combination of high mass due to movement under the influence of the extraction wells and the large distance between wells (resulting in large monitoring area for each well thus higher total mass) result in these wells being very important in the network. The stable and no trend results indicate that the extraction remedy may be stabilizing concentrations in this area. Even though these wells monitor large areas of higher mass, no new wells are recommended in this area due to the largely stable trends and low concentration uncertainty between neighboring points. The MAROS report for Percentage of Mass by Well is in Appendix B.

4.1.3 Spatial Analysis

The adequacy of the number of monitoring locations in the Southeast was evaluated using the spatial analysis tools in MAROS. The primary statistics used to evaluate spatial sufficiency are the SF and RE and the COV of these factors shown in Table 6. A graphical representation of uncertainty in the RDX plume is shown on Figure 6. Locations with high SF or RE display more spatial uncertainty between monitoring locations, meaning that neighboring locations have very different concentrations.

Locations with high COV in SF and RE show high variability in concentrations between neighboring locations, and are, therefore, less predictable over time.

For the majority of the Southeast Sector, there is low concentration uncertainty. The well network near the extraction wells is sufficient to characterize both the groundwater elevations and concentrations to assess both plume stability and remedial performance even though there are large distances between wells. There is low spatial uncertainty between wells such as PTX06-1146, PTX06-1030 and PTX06-1147, as the concentrations are high but reasonably stable.

Qualitatively, much greater uncertainty exists in the extent of saturation in the eastern and southeastern perched unit.

As with the 2007 spatial analysis, the majority of spatial uncertainty is located south of Zones 11 and 12 in the area of the groundwater flow divide. Some of the uncertainty arises from the installation of the ISB remedies. The pilot ISB system appears to have driven down concentration near the PTX06-1100 series wells relative to the surrounding groundwater. Another source of uncertainty is the delineation of the RDX plume between higher concentration wells in the ISB area such as PTX06-1153, PTX06-1037 and PTX06-1118 and low or non-detect (RDX) wells PTX06-1052 and PTX06-1036. The ISPM wells in the area of the ISB injections show concentration variability (as indicated by the no trend results), which contributes to higher concentration uncertainty between locations. Low saturation conditions contribute to uncertainty. Well PTX06-1103 is not routinely sampled (one sample event in 2009), because that area of the perched unit went dry.

Two new wells are recommended to assess plume stability and remedial performance in the Southeast Sector:

- The first well is recommended for the far southeastern extent of saturation, southeast of PTX06-1034. The Well Sufficiency Decision Logic in MAROS 3 Beta identified this area for a new well due to the increasing trends at PTX06-1034, which is a 'boundary' well for the plume.
- The second new location is recommended for the area west of the ISB and east of the Zone 11 groundwater flow divide. The approximate potential new well locations are shown on Figures 6 and 9.

No wells in the LTM program were found to be redundant for COCs and none are recommended for elimination from the network at this time.

4.1.4 Frequency Analysis

Table 7 summarizes the results of the MAROS preliminary sampling frequency analysis. Recent (2007-2011) and overall rates (2000-2011) of concentration change for RDX were determined along with the recent and overall Mann-Kendall trends with MAROS recommending a final sampling frequency based on both trend and rate of change data. The table also shows the current sampling frequency based on the 2009 LTM report

(B&WPantex 2009a). Locations with less than 4 sample events in the recent timeframe return a default 'Quarterly' sampling recommendation.

The Network Frequency module in MAROS 3 uses decision logic based on the rate of change of total dissolved mass (zeroth Moment) to recommend a network-wide sampling frequency. The result was a recommendation for general Annual sampling in the Southeast Sector. The current average sampling frequency for the Sector is Annual.

Detailed results of the individual well frequency analysis are shown on Table 7 with final sampling recommendations after a qualitative review listed on Table 8. The sampling frequency suggested by the software (MAROS Recommended Frequency) was compared against the 2009 LTM report frequency and site monitoring goals as well as the velocity of groundwater. A recommended sampling frequency based on the analysis is provided, but the overall recommendation is that sampling frequency remain the same as outlined in the 2009 Pantex LTM report.

4.2 Southwest Sector

Thirty seven locations were considered in the analysis of the Southwest Sector. Of the 37 investigation well locations, 34 had analytical data for the 2008 – 2011 timeframe. The remaining well locations were included in the spatial analysis to prevent recommendations for wells at existing locations. The Southwest Sector is characterized by large areas of very low to non-detect results with isolated areas of higher concentrations. COC plumes above MSCs include TCE and perchlorate plumes underlying Zone 11 as well as areas affected by Cr(VI) (discussed above) and some HEs.

Priority constituents for each individual well in the Southwest Sector are indicated on Table 1. The analytical dataset includes some results that may be outliers, so not all priority constituents identified on Table 1 are detected consistently at each location. Cr(VI) or total Cr are identified as priority COCs for a limited number of wells in the Southwest Sector. The priority COCs for the design of the Southwest Sector monitoring network are perchlorate and TCE with monitoring for Cr for limited areas in both the Southeast and Southwest Sectors.

4.2.1 Individual Well Statistics

Individual well statistical results for the Southwest Sector are shown in Tables 10 and 11 and are summarized in the table below. Mann-Kendall trend results and average concentrations relative to the cleanup goals for TCE and perchlorate are shown on Figure 7.

The highest current concentrations of TCE are in the area of the ISB remedy. High concentrations are found at locations PTX06-1012, PTX06-1155, and PTX06-1126. These wells are key remedy performance monitoring locations. The recent trends for these locations are increasing to no trend, most likely as a result of disturbance from injections of reductant. The maximum concentration for PTX06-1155 reached a maximum in March 2011 and may be decreasing in response to the treatment.

An area of increasing TCE trends exists west/southwest from the Zone 11 industrial area along the direction of groundwater flow. Wells PTX08-1006, PTX08-1005 and PTX06-1151 show recent increasing trends. The trends indicate the TCE concentrations may not be fully delineated to the west. Well PTX06-1151 is west of the ISB remedy. Upgradient of PTX08-1005, trends for TCE are largely stable. Downgradient wells are ND for TCE (PTX06-1035 and PTX06-1134) indicating the plume is delineated to the southwest.

Individual well trends for perchlorate show areas of both increasing and decreasing concentrations. Wells with the some of the highest concentrations of perchlorate include remedy performance monitoring wells PTX06-1126 and PTX06-1127, which show strongly decreasing trends. Well PTX06-1156 shows the highest recent concentrations of perchlorate and a stable trend. Wells PTX06-1151, PTX06-1155, and PTX08-1008

show decreasing or probably decreasing trends for perchlorate indicating the plume is not expanding to the west and east.

The line of wells south of the ISB treatment system including PTX06-1150, PTX06-1149 and PTX06-1148 show increasing trends for perchlorate. Initial concentrations at these locations were low and the increasing trends may be related to injections at the ISB wells upgradient, as appears to be the case with some TCE performance monitoring wells.

Upgradient wells PTX08-1006, PTX08-1005 and PTX06-1006 show increasing trends for RDX (RDX is the priority constituent at PTX08-1006), but, as these wells are upgradient from the ISB remedy, the monitoring network downgradient is sufficient to delineate the plume.

Southwest Sector Individual Well Trend Summary

COC	Total Wells	Pantex Plant Southeast Perched Groundwater Mann-Kendall Trend Results by Number of Wells				
		<i>Nondetect</i>	<i>Decreasing or Probably Decreasing</i>	<i>Stable</i>	<i>Increasing or Probably Increasing</i>	<i>No Trend or Insufficient Data</i>
TCE	34	7 (20%)	2 (6%)	7 (20%)	5 (15%)	13 (38%)
Perchlorate	27	2 (7%)	7 (26%)	4 (15%)	4 (15%)	10 (37%)

As with the Southeast Sector, concentrations in the Southwest show a number of no trend results. No trend is often observed when concentrations are largely stable, but have some variability in sample results (particularly over the short term) or have peaked and are decreasing. In many cases, larger sample sets (collected over time) can reduce some of the uncertainty in the trend estimate.

4.2.2 Plume Analysis

Trend estimates of the zeroth, first and second moments for both TCE and perchlorate for the Southwest Sector are summarized in the table below. Total dissolved mass estimates for TCE show an overall increasing trend, reflecting concentration increases at wells cited above. The center of mass of TCE was fairly stable between 2008 and 2011 (no trend) located roughly between PTX08-1006 and PTX08-1005. The center of mass is pulled to the west due to concentrations measured at PTX06-1151. The spread of mass relative to the center of mass (second moment) is stable indicating that the plume is not becoming more dilute (or concentrated) at the edges relative to the center.

Southwest Sector Moment Analysis

Moment Type	Constituent	
	TCE Trend	Perchlorate Trend
<i>Zeroth (Total Dissolved Mass)</i>	Increasing	No Trend
<i>First (Center of Mass)</i>	No Trend	No Trend
<i>Second (Spread of Mass)</i>	Stable/Stable	Stable/No Trend

*Result for uniform saturated thickness

The perchlorate plume shows no trend in total dissolved mass and no trend in the movement of the center of mass. The center of mass is located near well PTX08-1006 and may be moving toward the south, but the data are insufficient to demonstrate a trend at this time. As with the TCE plume, second moments are largely stable.

Total dissolved mass and center of mass estimates for Cr(VI) in the Southwest Sector are both stable. The center of mass for Cr(VI) is located near well PTX08-1008 where the highest concentrations have been found historically.

Aggregate trends for TCE and Perchlorate in the Southwest Sector

Area	Number of Wells	TCE Aggregate Trend	TCE Aggregate Mass %	Perchlorate Aggregate Trend	Perchlorate Aggregate Mass %
Source	10	NT	21%	PD	47%
Tail	24	S	79%	S	53%
ISPM 11	7	S	60%	S	43%
Zone 11/Zone 12 Divide	9	S	1%	NT	9%

An evaluation of mass percentage by well for 2011 shows that the wells accounting for the majority of mass of TCE include PTX06-1151 (36%), PTX06-1155 (14%), PTX06-1012 (14%), PTX06-1126 (16%) and PTX08-1005 (12%). The majority of mass of perchlorate is monitored by wells PTX08-1006 (31%) and PTX06-1148 (15%) with significant contributions from PTX06-1127 (6%), PTX06-1151 (~7%) and PTX06-1156 (6.5%). MAROS reports on Percentage Mass by Well can be found in Appendix B.

Aggregate trends were estimated for well groups in the Southwest. Ten upgradient source area wells were identified in the developed area of the plant. Source wells account for roughly 21% of total TCE and 47% of perchlorate mass in the plume. Tail wells (the other 24 wells) represent 79% of the TCE and only 54% of perchlorate mass. Seven ISPM wells were identified for the Zone 11 ISB remedy and represent roughly 60% of TCE and 43% of perchlorate mass. Wells between the Southeast and Southwest Sectors currently do not account for a large percentage of mass relative to the source and response action areas.

Aggregate trends for all well groups are largely stable due to the diversity of trend results within each well group. The variability in trends between wells in the Southwest may be due to perturbations from installation of the remedy and the relatively small sample set.

4.2.3 Spatial Analysis

Spatial statistics (SF and RE) and the COV of these factors are shown in Table 12. For the majority of the Southwest Sector, there is low concentration uncertainty between locations. As in the Southeast Sector, the distances between monitoring locations is fairly large and the differences in concentration can be relatively low.

The Decision Logic Module in MAROS 3.0 Beta uses several decision metrics to identify areas that may require additional wells. The Decision Logic Module identified the area around PTX06-1155 and PTX06-1035 as a potential location for additional

characterization for perchlorate. The software also identified the area around PTX06-1148 and PTX06-1150 for a potential new well. Because concentrations at these wells may have been influenced by installation of the remedy and because downgradient well PTX06-1053 delineates the flow direction, no new wells are recommended in this location at this time. The area around PTX06-1148 - 1150 should be reviewed in five years after a larger dataset has been collected.

For TCE, the area around PTX06-1151 was highlighted for an additional monitoring location. The area north of the ISB treatment system was also identified as a potential location for a new well, but as this area is upgradient of the treatment zone and additional wells are downgradient, this recommendation was not carried forward. A new well upgradient of the ISB does not contribute to the primary monitoring objectives.

Areas that may benefit from additional monitoring for both TCE and perchlorate were identified based on individual and plume-level concentration trends, decision logic and the stated monitoring objectives. New wells recommended to evaluate plume stability and remedy performance are indicated on Figure 9 and are recommended for:

- West of PTX06-1151 to evaluate plume stability and manage uncertainty for TCE;
- Between PTX06-1035, PTX06-1151 and PTX06-1155 to evaluate plume stability for perchlorate and TCE.

The area south of PTX06-1150, 1149 and 1148 should be monitored for response to the remedy installation. The expected response is a leveling or decrease in concentrations of perchlorate over the next three years. The two new wells are recommended to assess plume stability and response action performance in the areas west of the ISB. New well locations are recommended for both concentration and groundwater elevation sampling.

No wells in the LTM program were found to be redundant for all COCs and none are recommended for elimination from the network at this time.

4.2.4 Frequency Analysis

Sampling frequency in the Southwest Sector was evaluated by considering the monitoring goals for each location along with the rate of change of concentration, reporting frequency and contaminant transport velocity. Table 13 summarizes the results of the MAROS preliminary sampling frequency analysis for the Southwest Sector. Recent (2007-2011) and overall rates (2000-2011) of concentration change for TCE and perchlorate were determined along with the recent and overall Mann-Kendall trends. The table also shows the current sampling frequency based on the 2009 LTM report (B&WPantex 2009a) and the software recommended sampling frequency.

Overall rates of concentration change are low for most locations, consistent with relatively low seepage velocity and large distances. Annual to Biennial (every two years) monitoring is recommended for many wells. However, the objective of tracking the performance of the remedy may require more frequent sampling. Locations identified for frequent monitoring include PTX06-1012, PTX06-1126, PTX06-1151 and PTX06-1155

with increasing trends for TCE and PTX06-1148 through PTX06-1150 and PTX08-1006 for perchlorate. Detailed results of the analysis are shown on Table 13 with final sampling recommendations after a qualitative review listed on Table 14.

A recommended sampling frequency based on the analysis is provided for all locations, but the overall recommendation is that sampling frequency remain the same as outlined in the 2009 Pantex LTM report to remain consistent with the monitoring objectives for each location.

4.3 North Sector

Thirty two locations were considered in the North Sector analysis, many of them were also considered in the analysis of the Southwest and Southeast Sectors. Twenty eight locations had data results for the 2008 – 2011 timeframe. Priority constituents for each individual well in the North Sector are indicated on Table 1. Most locations do not exceed MSCs and the primary COC identified in Table 1 may not be detected routinely at the location.

A sector-wide evaluation of priority COCs was performed in the MAROS software. The only COC identified as a priority sector-wide constituent was RDX. Other constituents are present in perched groundwater at low levels or over limited spatial extents. Isolated areas of perched groundwater are found underlying the Burning Grounds and in the far northeast area of the property. Perched groundwater in these areas is characterized by low detections of site COPCs and limited opportunity for mobility.

4.3.1 Individual Well Statistics

Results of the individual well analysis for the North Sector are detailed in Table 15. Many wells north of Zones 11 and 12 are uncertainty management wells and have low to no detections of site COCs. Table 15 shows detection percentages and trends for RDX, 4ADNT, perchlorate and TCE. Additional statistics were not calculated for North Sector wells as the percentage of ND results are too high for meaningful results.

One Increasing trend for RDX was found at PTX08-1002, as noted in the Southeast Sector analysis. PTX08-1002 is a source well for the Southeast RDX plume and concentrations are most likely influenced by the extraction wells to the south. Prior to 2008, PTX08-1002 showed a strongly decreasing trend. In the 2007 network analysis, well PTX06-1050 showed a strongly increasing trend for RDX. Current data indicate a strongly decreasing trend. Trends at these locations may be influenced by varying recharge from rainfall to Playa 1, from heavy rains in 2010 and drought conditions in 2011.

Other RDX concentration trends in the North are stable to decreasing. 4ADNT is not widely encountered in the North, and locations with enough data to estimate a trend are stable to decreasing.

The only location in the North Sector with concentrations above cleanup goals for perchlorate is PTX08-1001, south of Playa 1. The perchlorate trend at this well is strongly decreasing.

Sporadic detections of chromium in the North Sector appear to be related to corrosion in wells constructed with stainless steel components. Corrosion has been documented in several wells by video investigation and the detections of other constituents of stainless steel such as iron, nickel, molybdenum, manganese and vanadium. Based on the CSM, no sources of chromium exist in the North Sector.

4.3.2 Plume Analysis

The moment analysis was not conducted for the North Sector as fewer than six wells were present in any individual network monitoring a common source area and groundwater flow direction. Outside of the main perched groundwater unit, COCs are not detected above MSCs on a consistent basis. Plume stability for affected groundwater in the North Sector was determined by evaluating delineation and individual well concentration trends.

Aggregate trends were estimated for well groups in the North. The well groups are indicated in Table 1. Four source area wells were identified near Playa 1. Source wells account for roughly 96% of total RDX mass in the plume and show no trend. Tail wells (the other 24 wells) represent only 4% of the RDX mass and show an overall probably decreasing trend. Fifteen wells around Playa 1 were evaluated for an aggregate trend and percentage of the total mass. The 15 wells represent 98% of the total RDX mass in the North Sector and show an aggregate stable trend. The well accounting for the majority of mass estimated for the RDX plume in the north is PTX06-1050 (78%).

Aggregate trends for RDX in the North Sector

Area	Number of Wells	RDX Aggregate Trend	RDX Aggregate Mass %
Source	4	NT	96%
Tail	24	PD	4%
Playa 1	15	S	98%

4.3.3 Spatial Analysis

As with the moment analyses, the network spatial analyses require greater than six monitoring locations with detections in an area of continuous groundwater to evaluate stability using tools in the MAROS software. For the North Sector, well redundancy and sufficiency were evaluated using qualitative methods and consideration of site monitoring objectives.

In the 2007 analysis, the area west of PTX06-1050 was recommended for a new monitoring location to delineate RDX to the west. The new well PTX06-1136 has delineated the affected area and concentrations at PTX06-1050 are decreasing. No additional wells are required in this area. No additional monitoring points are recommended downgradient of the increasing RDX trend PTX08-1002, as it is upgradient from the Southeast Sector network. No additional wells are recommended for the isolated perched water unit at the Burning Ground and along the northern border of the Plant.

No wells are recommended for removal from the network at this time.

4.3.4 Frequency Analysis

A sampling frequency analysis was performed for the North Sector. As most wells are ND or close to ND, the rate of concentration change calculations are not particularly meaningful. MAROS sampling frequency analysis indicated that no more frequent than annual monitoring is recommended for any wells in the North Sector. Most wells have been recommended for annual to biennial and up to every five years sampling after a qualitative review. The results of the qualitative and quantitative frequency analysis do not support a major change from the 2009 LTM report sampling frequency.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The primary goal of reviewing the monitoring network at the Pantex Plant is to create a dataset that fully supports site monitoring objectives while minimizing time and expense associated with collecting and interpreting analytical data. A summary of the final recommended monitoring network is presented on Table 17 and illustrated on Figure 9.

The recommended network increases data collection effort in some areas to provide a dataset that fulfills plume stability, response action evaluation and uncertainty management goals in the perched groundwater unit. The recommended network includes the addition of four new wells in areas where further characterization would support site monitoring goals.

Part of the network optimization process is to identify possible gaps in site characterization that may require additional sampling locations or site investigation. Based on well locations, screened intervals and hydrogeologic characteristics, affected groundwater in perched units is fairly well characterized and delineated. Areas that may benefit from additional delineation have been identified in the Southwest and Southeast Sectors.

Overall recommendations for the monitoring network include:

- Four new wells are recommended to define plumes emanating from Zones 11 and 12. The wells are needed to delineate plumes that comingle south/southwest and east of the developed areas of the Plant (see table below). These locations will also contribute groundwater elevation data to help refine understanding of the gradients and the extent of saturation in this area.
- No statistical inconsistencies were found in wells monitoring the extraction and *In Situ* Bioremediation (ISB) remedies. The monitoring networks in these areas appear adequate to evaluate remedy performance.
- No wells are recommended for removal from the monitoring network at this time.
- Dry wells should be checked annually to confirm unsaturated conditions. Pumping and recharge may change the shape of the perched unit on the edges.
- While an analysis of sampling frequency was performed, there are no strong recommendations for changing the sampling frequency detailed in the 2009 Pantex LTM report.
- Distances between monitoring locations are very large at the Pantex Plant and groundwater flow is relatively slow. Concentration response times might be expected to be on the order of years at most locations. Overall, rates of concentration change are low for most locations and annual to biennial (every two years) monitoring is recommended based on the MAROS analysis. However, early warning of changing conditions and collection of a statistically

significant dataset are high priorities for the site so semi-annual data collection is recommended for many locations, particularly those monitoring response actions.

- The current analyte list for the groundwater samples includes 172 analytes. While there are many COPCs at the site, it may be possible to reduce the number of analytes, particularly volatile organic compounds that are not detected or are found intermittently.

Summary of Proposed New Well Locations

New Well	Area	LTM Objective	Report Metric
1	Southeast, Near ISB	Plume Stability	Trend/Compare to GWPS
2	Southeast, far southeast extent of perched unit	Plume Stability	Detection/Compare to GWPS
3	Southwest, near PTX06-1035	Plume Stability	Detection/Compare to GWPS
4	Southwest, west of PTX06-1151	Plume Stability / Response Action Effectiveness	Trend/Compare to GWPS

5.1 Southeast Sector

Recommendations specific to the Southeast Sector include:

- 2 new wells are recommended for the Southeast Sector.
 - o One location west of PTX06-1103A is recommended to assess RDX transport toward the ISB system on the west side, define the Cr(VI) plume in the Southeast and monitor boron concentrations. This location was identified in the spatial analysis as showing high uncertainty in plume concentrations. The recommended location is close to the edge of the saturated zone and will monitor the extent of the RDX plume as well as help estimate groundwater concentrations entering the western end of the (Southeast) ISB treatment area.
 - o One location is recommended at the farthest southeast extent of the perched unit. This location was recommended by the Decision Logic module of MAROS 3 Beta due to the increasing RDX concentration at PTX06-1034, a boundary well for the network.
- A line of increasing concentrations extends from the southeast edge of Zone 12 to the southeast edge of the perched zone. No additional wells are recommended in the area, but continued assessment of the efficacy of the remedies in this area is recommended.

- Continue sampling PTX06-1133A to monitor groundwater elevations and the stability of the RDX plume in this area. Continue sampling formerly dry wells PTX06-1120 and 1121. Continue monitoring location PTX06-1103A to detect saturated conditions.
- Overall, the Cr(VI) plume is stable; however, Cr(VI) concentrations are increasing at PTX06-1010 and other metals have been detected at this location. Trends may be increasing due to the gradient caused by historic injections wells in the SEPTS. While no new monitoring wells are recommended in this area, continued monitoring in the area of PTX06-1010 may provide more information on the long-term strength of the Cr(VI) (and other metals) source. Well PTX08-1007 should be monitored for Cr(VI) annually.

5.2 Southwest Sector

Recommendations specific to the Southeast Sector include:

- Two new monitoring wells are recommended for the Southwest Sector
 - o West of PTX06-1151: A new well is recommended in this area to delineate TCE west of high and increasing concentrations at PTX06-1151. This well will help define trends down a groundwater gradient from PTX08-1006 and PTX08-1005. This area lies to the west of the ISB remedial system and may not be captured by the remedy. The location of the well is based on a qualitative review of trend data rather than quantitative estimates of uncertainty. Semi-annual monitoring frequency is recommended until data from four sample events can be evaluated for concentration trends and variability.
 - o West of PTX06-1155 and east of PTX06-1035: An additional delineation well is recommended to confirm stability of the perchlorate plume. Concentrations in this area may be below cleanup goals for both TCE and perchlorate, but increasing trends west of the ISB require long-term downgradient delineation.
- Continue to evaluate groundwater elevations south of Zones 11/12 in the area of the groundwater divide to assess the effect of extraction wells in the Southeast on gradients in the Southwest.

5.3 North Sector

Recommendations specific to the North Sector include:

- No changes in well locations in the network are recommended.
- Sampling frequency analysis indicated that not greater than annual monitoring frequency is appropriate for all wells in the North Sector. Most wells have been recommended for annual to biennial sampling with some recommended for sampling once every five years. However, sampling frequencies outlined in the 2009 LTM Report provide sufficient data to accomplish monitoring goals.
- No new wells are recommended for the North Sector at this time.

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**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

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TABLE 1
PANTEX PLANT MONITORING WELLS: PERCHED GROUNDWATER

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 PANTEX PLANT
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Well Name	Earliest Sample Date ³	Most Recent Sample Date	Number of Samples (2008-2011)	Primary COC at Well	Monitoring Objective			Compliance		Status or MAROS Group
					PS	RA	UM	POE	POC	
Southeast Sector										
PTX06-1002A	4/22/2008	11/14/2011	11	RDX		x	x			Source
PTX06-1003	8/4/2008	7/20/2010	3	RDX		x	x			Source
PTX06-1005	4/22/2008	11/15/2011	11	RDX		x	x			Source
PTX06-1008	8/27/2008	5/11/2011	4	TOTAL CHROMIUM			x			Source
PTX06-1010	4/24/2008	12/8/2011	8	TOTAL CHROMIUM			x			Source
PTX06-1011	4/24/2008	5/12/2011	4	TOTAL CHROMIUM			x			Source
PTX06-1013	4/17/2008	11/30/2011	9	BORON		x				
PTX06-1014	2/27/2008	7/20/2011	8	RDX		x				SEPTS
PTX06-1015	2/20/2008	11/2/2011	12	RDX		x				SEPTS
PTX06-1023	4/3/2008	8/10/2011	8	BORON		x			x	
PTX06-1030	4/7/2008	11/28/2011	11	RDX		x				SEPTS
PTX06-1031	4/7/2008	11/28/2011	11	RDX		x			x	SE ISB
PTX06-1034	4/7/2008	11/29/2011	12	RDX		x			x	SE ISB
PTX06-1036	2/26/2008	4/13/2011	6	RDX	x					
PTX06-1037	8/28/2008	10/19/2011	10	RDX		x				SE ISB
PTX06-1038	2/19/2008	7/14/2011	11	RDX		x				
PTX06-1039A	4/22/2008	7/14/2011	11	RDX		x				SEPTS
PTX06-1040	2/19/2008	7/14/2011	11	RDX		x				SEPTS
PTX06-1041	4/22/2008	7/20/2011	11	RDX		x				SEPTS
PTX06-1042	2/19/2008	7/20/2011	11	RDX		x			x	SEPTS
PTX06-1045	8/28/2008	5/12/2010	5	RDX		x			x	SE ISB
PTX06-1046	2/20/2008	8/2/2011	11	RDX		x			x	SE ISB
PTX06-1047A	4/23/2008	8/2/2011	11	RDX		x				SE ISB
PTX06-1052	2/26/2008	8/9/2011	8	TOTAL CHROMIUM		x			x	
PTX06-1053	2/26/2008	12/1/2011	10	4ADNT	x		x			
PTX06-1069	4/3/2008	7/12/2011	5	None	x					
PTX06-1088	4/24/2008	12/8/2011	11	RDX		x	x			Source
PTX06-1095A	2/27/2008	11/15/2011	9	RDX		x	x			
PTX06-1098	5/6/2008	5/31/2011	4	ARSENIC		x				
PTX06-1099	5/6/2008	5/6/2008	2	RDX				Pilot test well		
PTX06-1100	5/6/2008	5/31/2011	4	BARIUM		x				
PTX06-1101	5/5/2008	5/26/2011	5	BARIUM		x				
PTX06-1102	4/23/2008	8/2/2011	5	RDX		x				SEPTS
PTX06-1103	6/9/2009	12/2/2009	5	RDX	Replaced, then Dry in 201, sampled for saturation					
PTX06-1104	11/24/2008	10/27/2010	10	RDX						
PTX06-1105	11/24/2008	10/27/2010	10	RDX						
PTX06-1106	11/24/2008	10/27/2010	5	ARSENIC**						
PTX06-1107	11/24/2008	10/28/2010	4	BORON						
PTX06-1118	3/20/2008	8/5/2009	11	RDX		x				SE ISB
PTX06-1120	10/13/2010	12/15/2011	3	RDX	x					SE ISB
PTX06-1121	10/13/2010	12/15/2011	3	RDX	x					SE ISB
PTX06-1123	3/17/2008	10/19/2011	18	RDX		x				SE ISB
PTX06-1130	9/2/2009	8/9/2011	6	RDX		x			x	SEPTS
PTX06-1133A	12/15/2011	12/15/2011	1	None	x					SE ISB
PTX06-1135	12/11/2008	11/2/2011	6	2ADNT	x					
PTX06-1146	9/2/2009	8/9/2011	5	RDX	x				x	SEPTS
PTX06-1147	9/2/2009	11/28/2011	6	RDX	x					SEPTS
PTX06-1153	10/27/2009	10/19/2011	10	RDX		x			x	SE ISB
PTX06-1154	10/27/2009	10/19/2011	7	RDX		x			x	SE ISB
PTX08-1002	4/17/2008	11/14/2011	7	RDX		x	x			
PTX08-1007	3/4/2008	5/16/2011	4	TOTAL CHROMIUM			x			Source
PTX08-1008	2/21/2008	11/16/2011	7	HEXAVALENT CHROMIUM		x	x			Source
PTX08-1009	4/17/2008	11/15/2011	8	4ADNT		x	x			
PTX10-1013	8/19/2008	8/17/2009	2	TCE			x			Inactive
PTX10-1014	10/21/2010	5/11/2011	2	TCE			x			Source
PTX06-1051	Dry	--								
PTX06-1089	Dry	--								
PTX06-1093	Dry									
PTX06-1094	Dry	--								
PTX06-1124	Dry	--								
PTX06-1125	Dry	--								
PTX06-1148	See SW Sector									

See Notes End of Table

TABLE 1
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LONG-TERM MONITORING OPTIMIZATION
 PANTEX PLANT
 Carson County, Texas

Well Name	Earliest Sample Date ³	Most Recent Sample Date	Number of Samples (2008-2011)	Primary COC at Well	Monitoring Objective			Compliance		Status or MAROS Group
					PS	RA	UM	POE	POC	
Southwest Sector										
1114-MW4	4/28/2008	7/27/2011	16	TCE			x			Source
PTX06-1006	4/24/2008	5/16/2011	10	TOTAL CHROMIUM	x					Source
PTX06-1007	8/27/2008	5/11/2011	8	TOTAL CHROMIUM			x			Source
PTX06-1008	8/27/2008	5/11/2011	8	TOTAL CHROMIUM			x			Source
PTX06-1012	2/21/2008	10/11/2011	30	TCE	x	x				ISB 11
PTX06-1035	2/21/2008	11/30/2011	24	4ADNT	x					ISB 11
PTX06-1036	2/26/2008	4/13/2011	10	RDX	x					
PTX06-1052	2/26/2008	8/9/2011	16	TOTAL CHROMIUM		x			x	
PTX06-1053	2/26/2008	12/1/2011	20	4ADNT	x		x			Divide
PTX06-1073A	4/30/2008	4/30/2008	1	TCE	x					Dry
PTX06-1077A	8/25/2008	4/14/2011	8	TCE			x			
PTX06-1085	8/31/2009	4/13/2011	6	None			x			
PTX06-1086	9/3/2009	4/13/2011	6	None			x			
PTX06-1126	2/7/2008	11/16/2011	46	TCE	x		x		x	ISB 11
PTX06-1127	2/7/2008	11/16/2011	24	PERCHLORATE	x		x		x	ISB 11
PTX06-1131	8/24/2009	7/27/2011	12	None			x			
PTX06-1134	8/27/2009	12/1/2011	12	4ADNT	x					ISB 11
PTX06-1148	8/30/2008	12/7/2011	14	PERCHLORATE	x	x				Divide
PTX06-1149	8/30/2008	12/1/2011	14	PERCHLORATE	x					Divide
PTX06-1150	8/30/2008	12/7/2011	14	PERCHLORATE	x	x				Divide
PTX06-1151	4/7/2009	8/15/2011	20	TCE	x					
PTX06-1155	10/26/2009	10/11/2011	24	TCE		x			x	ISB 11
PTX06-1156	10/26/2009	10/11/2011	18	PERCHLORATE		x			x	ISB 11
PTX07-1Q01	9/3/2009	7/19/2011	6	None			x			
PTX07-1Q02	3/4/2008	7/19/2011	6	None			x			
PTX07-1Q03	9/3/2009	7/19/2011	6	None			x			
PTX08-1003	4/28/2008	8/15/2011	8	TOTAL CHROMIUM	x					
PTX08-1005	4/28/2008	8/15/2011	20	TCE			x			Source
PTX08-1006	4/28/2008	8/15/2011	18	RDX			x			Source
PTX08-1007	3/4/2008	5/16/2011	8	TOTAL CHROMIUM			x			Source
PTX08-1008	2/21/2008	11/16/2011	16	HEXAVALENT CHROMIUM		x	x			Source
PTX08-1009	4/17/2008	11/15/2011	16	4ADNT		x	x			
PTX10-1013	8/19/2008	8/17/2009	2	TCE	Inactive - replaced by PTX10-1014					Inactive
PTX10-1014	10/21/2010	5/11/2011	2	TCE			x			Source
PTX07-1P02	See North Sector									
PTX07-1P05	See North Sector									
PTX08-1001	See North Sector									

See Notes End of Table

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LONG-TERM MONITORING OPTIMIZATION
 PANTEX PLANT
 Carson County, Texas

Well Name	Earliest Sample Date ³	Most Recent Sample Date	Number of Samples (2008-2011)	Primary COC at Well	Monitoring Objective			Compliance		Status or MAROS Group
					PS	RA	UM	POE	POC	
North Sector										
OW-WR-38	9/21/2009	8/10/2011	3	TOTAL CHROMIUM*		x	x			Playa 1
PTX01-1001	4/16/2008	11/29/2011	8	TOTAL CHROMIUM*			x		x	
PTX01-1002	4/16/2008	4/25/2011	5	None			x			
PTX01-1008	2/27/2008	11/29/2011	8	None			x		x	
PTX04-1001	7/13/2011	7/21/2011	1	None			x			
PTX04-1002	2/18/2008	7/13/2011	7	None			x			
PTX06-1013	4/17/2008	11/30/2011	9	RDX		x				
PTX06-1023	4/3/2008	8/10/2011	8	BORON		x			x	Playa 1
PTX06-1048A	2/14/2008	4/25/2011	5	None	x	x				Playa 1
PTX06-1049	8/31/2009	11/3/2011	4	4ADNT	x		x			Playa 1
PTX06-1050	4/15/2008	8/10/2011	12	RDX		x	x		x	Source/Playa 1
PTX06-1069	4/3/2008	7/12/2011	5	None	x					Playa 1
PTX06-1071	7/13/2011	7/21/2011	1	None			x			
PTX06-1080	2/14/2008	7/18/2011	6	None			x			
PTX06-1081	2/14/2008	7/18/2011	5	None			x			
PTX06-1117	3/5/2008	11/13/2008	2	TOTAL CHROMIUM*	Inactive					
PTX06-1136	9/14/2009	11/3/2011	5	1,2-DCE	x					Playa 1
PTX07-1O01	4/15/2008	8/11/2011	7	RDX	x	x	x			Source/Playa 1
PTX07-1O02	2/28/2008	8/11/2011	10	1,4-DIOXANE (P-DIOXANE)	x	x	x		x	Playa 1
PTX07-1O03	4/15/2008	8/11/2011	4	RDX	x	x	x			Playa 1
PTX07-1P02	12/15/2009	11/14/2011	5	PERCHLORATE			x		x	Playa 1
PTX07-1P05	9/21/2009	4/27/2011	3	RDX			x			Playa 1
PTX07-1P06	8/26/2008	8/26/2008	1	RDX						Source
PTX07-1R03	4/25/2011	11/30/2011	1	MANGANESE			x			
PTX08-1001	4/10/2008	4/27/2011	4	RDX		x	x			Playa 1
PTX08-1002	4/17/2008	11/14/2011	7	RDX		x	x			Source/Playa 1
PTX08-1010	2/18/2008	7/21/2011	4	BORON			x			
PTX-BEG3	2/18/2008	1/22/2009	3	2,4-DINITROTOLUENE						
PTX01-1004	Dry									
PTX01-1009	Dry									
PTX06-1055	Dry									
PTX07-1O06	Dry									

Notes:

- Wells listed are investigation wells in current monitoring program. Wells that are dry or intermittently dry, as indicated in database (BWXT, 2012).
 Some wells included in more than one Sector for spatial analysis.
 PS = Plume Stability; RA = Remedial Assessment; UM = Uncertainty Management; POE = Point of Exposure;
 POC = Point of Compliance.
- Data from B&W Pantex Plant database received February, 2012 (BWXT, 2007a).
- Sampling dates for wells range from January 2008 (earliest sample dates) to December 2011 (most recent sample dates). Data before 2008 is available but were not used in the analysis.
- The priority chemical of concern (COC) at each well is the constituent detected at the highest level normalized by the MSC or appropriate RRS.
- Number of samples is the number of individual sample dates in the database for the priority COC, results from duplicate samples from the same date are averaged.
- Monitoring constituents are those where the average concentration 2008-2011 is above the MSC.
- RDX = Hexahydro, 1,3,5-trinitro, 1,3,5-triazine; TCE = trichloroethene; 4ADNT = 4-Amino, 2,6-dinitrotoluene; Cr(VI) = Hexavalent Chromium.
 26DNT = 2,6-dinitrotoluene; HMX = octahydro-1,3,5,6-tetranitro-1,3,5,7-terazocine
- MAROS Goup is the goup assigned for an aggregate trend determination: SEPTS = Extraction picket in SE Sector; SE ISB = Southeast *In Situ* Bioremediation
 ISB Zone 11 = In Situ Bioremediation Zone 11; Playa 1 = Perched unit beneath Playa 1.
- * = Wells with stainless steel construction can show false positive metal (Cr, Fe, Ni, etc.) detections.
 ** = ISPM wells can have transient high metals cocentration due to redox changes.

TABLE 2
AQUIFER INPUT PARAMETERS
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Parameter	Units	Southeast	Southwest	North
Current Plume Length	ft	7000	8000	Various
Maximum Plume Length	ft	7000	8000	Various
Plume Width	ft	6400	6000	Various
Seepage Velocity (ft/yr)*	ft/yr	140	62	70
Distance to Receptors	ft	8000	10000	8000
Groundwater Fluctuations	--	No	No	No
Source Treatment	--	Pump and treat		
Plume Type	--	Explosives, VOCs		
NAPL Present	--	No	No	No
Number of investigation wells	--	31	29	29
Parameter		Value		
Groundwater flow direction	--	S/SE	S/SW	Various (45)
Porosity	--	0.25	0.25	0.25
Source Location near Well	--	PTX06-1010	PTX08-1006	Playa 1 (various)
Source X-Coordinate	ft	639886.625	636400.4375	639580.323
Source Y-Coordinate	ft	3758067	3756761.75	3764100.313
Coordinate System	--	NAD 83 SP Texas North FT		
Average Saturated Thickness Perched Zone	ft	30		
Priority Constituents		MSC	Basis	Sectors Affected
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	ug/L	7.7	GW-Res _c	All
4-Amino-2,6-Dinitrotoluene (4ADNT)	ug/L	1.2	GW-Res _{NCAdj}	All
2-Amino-4,6-Dinitrotoluene (2ADNT)	ug/L	1.2	GW-Res _{NCAdj}	Southeast
2,4,6-Trinitrotoluene (TNT)	ug/L	3.6	GW-Res _{NCAdj}	Southeast
2,4-Dinitrotoluene (24DNT)	ug/L	1	PQL	Southeast
Chromium (VI)	ug/L	100	MCL	Southeast
Perchlorate	ug/L	26	GW-Res _{NC}	Southwest
Trichloroethene	ug/L	5	MCL	Southwest

Notes:

1. Aquifer data from CMS/FS (BWXT, 2007a).
2. Priority COCs defined by prevalence, toxicity and mobility.
3. Saturated thickness represents an estimated average for the perched unit, which ranges from 0 to 70 ft in saturated thickness.
4. * = a range of transmissivities are present in the aquifer, and groundwater velocity is estimated for each sector.
5. MSC = Medium Specific Concentration, from CMS/FS (BWXT, 2007b).
 GW-Resc = TCEQ Standard No. 2 Groundwater MSC for Residential Use; NC = Noncarcinogenic; C = Carcinogenic;
 Adj = Value adjusted for a cumulative hazard index of 1; PQL = Practical Quantitation Limit; MCL = USEPA Maximum Contaminant Level.

TABLE 3 COC ASSESSMENT SOUTHEAST SECTOR

MAROS COC Assessment

Project: Pantex SE**User Name:** mv**Location:** Southeast**State:** Texas**Toxicity:**

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIA	5.1E-01	7.7E-03	6531.8%
TNX	3.9E-02	2.0E-03	1844.5%
MANGANESE	2.3E-01	5.0E-02	350.9%
4-AMINO-2,6-DINITROTOLUENE	4.9E-03	1.2E-03	306.3%
BORON	6.4E-01	1.9E-01	230.1%
CHROMIUM, TOTAL	3.1E-01	1.0E-01	205.7%
2-AMINO-4,6-DINITROTOLUENE	2.6E-03	1.2E-03	115.2%
ARSENIC	1.8E-02	1.0E-02	76.5%
CHROMIUM, HEXAVALENT	1.5E-01	1.0E-01	51.1%
MNX	2.7E-03	2.0E-03	35.5%
DNX	2.3E-03	2.0E-03	15.2%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
BORON	MET	54	42	77.8%	54
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE	ORG	54	35	64.8%	45
TNX	ORG	54	34	63.0%	43
4-AMINO-2,6-DINITROTOLUENE	ORG	54	31	57.4%	39
2-AMINO-4,6-DINITROTOLUENE	ORG	54	20	37.0%	30
ARSENIC	MET	25	8	32.0%	19
MANGANESE	MET	54	17	31.5%	53
DNX	ORG	54	14	25.9%	35
CHROMIUM, TOTAL	MET	54	14	25.9%	50
MNX	ORG	54	10	18.5%	31
CHROMIUM, HEXAVALENT	MET	54	7	13.0%	35

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
TNX	
MNX	
DNX	
CHROMIUM, TOTAL	
BORON	

TABLE 4
MONITORING WELL TREND SUMMARY RESULTS SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION

PANTEX PLANT

Carson County, Texas

WellName	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend (2008 - 2011)	Mann-Kendall Trend (2000 - 2007)
RDx Southeast Sector									
PTX06-1002A	8	8	100%	58	Yes	47.9	Yes	D	S
PTX06-1003	3	3	100%	59	Yes	37.5	Yes	N/A	NT
PTX06-1005	8	8	100%	1,060	Yes	485	Yes	NT	PD
PTX06-1008	4	0	0%	ND	No	ND	No	ND	--
PTX06-1010	8	8	100%	6	No	3.6	No	S	D
PTX06-1011	4	1	25%	0.2	No	0.2	No	S	NT
PTX06-1013	8	8	100%	8	Yes	7	No	S	I
PTX06-1014	5	5	100%	942	Yes	643	Yes	D	I
PTX06-1015	8	8	100%	1,500	Yes	915.0	Yes	I	I
PTX06-1023	8	8	100%	3	No	2	No	S	S
PTX06-1030	8	8	100%	2,350	Yes	1490.0	Yes	S	I
PTX06-1031	8	8	100%	672	Yes	560.0	Yes	D	I
PTX06-1034	8	8	100%	357	Yes	79.8	Yes	I	I
PTX06-1036	5	5	100%	2	No	2	No	NT	I
PTX06-1037	8	8	100%	1,570	Yes	211	Yes	D	S
PTX06-1038	8	8	100%	1,240	Yes	796	Yes	NT	D
PTX06-1039A	8	8	100%	1,080	Yes	810	Yes	S	PD
PTX06-1040	8	8	100%	1,330	Yes	1030	Yes	NT	NT
PTX06-1041	8	8	100%	1,130	Yes	933	Yes	NT	NT
PTX06-1042	8	8	100%	872	Yes	659	Yes	PD	S
PTX06-1045	3	3	100%	2,200	Yes	2040	Yes	N/A	I
PTX06-1046	8	8	100%	1,460	Yes	1010	Yes	NT	I
PTX06-1047A	8	8	100%	620.0	Yes	550.0	Yes	I	I
PTX06-1052	8	0	0%	ND	No	ND	No	ND	ND
PTX06-1053	8	0	0%	ND	No	ND	No	ND	NT
PTX06-1069	5	0	0%	ND	No	ND	No	ND	S
PTX06-1088	8	8	100%	373	Yes	190	Yes	PD	PD
PTX06-1095A	8	8	100%	359.0	Yes	72.6	Yes	I	N/A
PTX06-1098	4	0	0%	ND	No	ND	No	ND	--
PTX06-1099	1	1	100%	225.0	Yes	225.0	Yes	N/A	--
PTX06-1100	4	0	0%	ND	No	ND	No	ND	--
PTX06-1101	4	0	0%	ND	No	ND	No	ND	--
PTX06-1102	4	4	100%	261.0	Yes	188.0	Yes	I	PD
PTX06-1103	2	2	100%	627	Yes	530.0	Yes	N/A	--
PTX06-1104	5	5	100%	2,600.0	Yes	1880.0	Yes	NT	--
PTX06-1105	5	5	100%	4,100	Yes	3190	Yes	S	--
PTX06-1106	5	5	100%	32	Yes	14	Yes	NT	--
PTX06-1107	4	4	100%	10.0	Yes	3.7	No	NT	--
PTX06-1118	5	5	100%	2,000	Yes	1540.0	Yes	S	--
PTX06-1120	3	3	100%	3,100.0	Yes	2620.0	Yes	N/A	--
PTX06-1121	3	3	100%	1,140	Yes	967	Yes	N/A	--
PTX06-1123	12	12	100%	4,300	Yes	804	Yes	D	--
PTX06-1130	5	5	100%	1,210.0	Yes	549.0	Yes	D	--
PTX06-1133A	1	0	0%	ND	No	ND	No	ND	--
PTX06-1135	5	5	100%	2.1	No	1.3	No	D	--
PTX06-1146	5	5	100%	1,820	Yes	1520	Yes	NT	--
PTX06-1147	5	5	100%	1,220	Yes	530	Yes	NT	--
PTX06-1153	9	9	100%	320.0	Yes	210.0	Yes	NT	--
PTX06-1154	7	5	71%	630	Yes	160.0	Yes	NT	--
PTX08-1002	7	7	100%	168.0	Yes	61.9	Yes	I	PD
PTX08-1007	4	4	100%	5	No	3	No	S	--
PTX08-1008	7	0	0%	ND	No	ND	No	ND	S
PTX08-1009	8	6	75%	0.6	No	0.4	No	I	NT
PTX10-1014	2	2	100%	1.8	No	1.4	No	N/A	--

See notes end of table

TABLE 4
MONITORING WELL TREND SUMMARY RESULTS SOUTHEAST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend (2008 - 2011)	Mann-Kendall Trend (2000 - 2007)
4ADNT Southeast Sector									
PTX06-1002A	7	5	71%	0.573	No	0.316	No	PD	S
PTX06-1003	3	3	100%	0.483	No	0.261	No	N/A	S
PTX06-1005	8	8	100%	6.32	Yes	4.34	Yes	S	PI
PTX06-1008	4	0	0%	ND	No	ND	No	ND	--
PTX06-1010	8	3	38%	0.202	No	0.191	No	PD	D
PTX06-1011	4	0	0%	ND	No	ND	No	ND	ND
PTX06-1013	8	0	0%	0.487	No	0.487	No	ND	ND*
PTX06-1014	5	4	80%	3.08	Yes	2.16	Yes	S	PD
PTX06-1015	8	8	100%	13.4	Yes	7.9	Yes	D	PD
PTX06-1023	8	0	0%	0.487	No	0.487	No	ND	ND
PTX06-1030	8	8	100%	16.7	Yes	11.9	Yes	S	PI
PTX06-1031	8	6	75%	3	Yes	1.82	Yes	D	I
PTX06-1034	8	8	100%	8.44	Yes	3.34	Yes	NT	I
PTX06-1036	5	2	40%	0.194	No	0.21	No	S	D
PTX06-1037	8	2	25%	16.9	Yes	2.18	Yes	PD	S
PTX06-1038	8	7	88%	22.4	Yes	13.7	Yes	NT	NT
PTX06-1039A	8	8	100%	78.8	Yes	32.8	Yes	S	PI
PTX06-1040	8	8	100%	24.5	Yes	13.7	Yes	S	S
PTX06-1041	8	8	100%	60.4	Yes	26.6	Yes	PI	NT
PTX06-1042	8	8	100%	10.2	Yes	7.3	Yes	PD	I
PTX06-1045	3	2	67%	13.6	Yes	7.6	Yes	N/A	NT
PTX06-1046	8	8	100%	9.63	Yes	6.87	Yes	D	I
PTX06-1047A	8	8	100%	8.89	Yes	5.86	Yes	PD	I
PTX06-1052	8	5	63%	0.333	No	0.223	No	S	ND
PTX06-1053	8	6	75%	11.9	Yes	3.45	Yes	NT	I
PTX06-1069	5	0	0%	0.487	No	0.487	No	ND	ND
PTX06-1088	7	7	100%	3.68	Yes	2.13	Yes	S	PI
PTX06-1095A	8	5	63%	3.2	Yes	0.822	No	I	ND
PTX06-1098	5	0	0%	0.2	No	0.2	No	ND	--
PTX06-1099	1	1	100%	5.6	Yes	5.6	Yes	N/A	--
PTX06-1100	4	0	0%	0.2	No	0.2	No	ND	--
PTX06-1101	4	0	0%	0.2	No	0.2	No	ND	--
PTX06-1102	4	4	100%	4.77	Yes	3	Yes	S	S
PTX06-1103	2	2	100%	6.18	Yes	5.24	Yes	N/A	--
PTX06-1104	5	5	100%	11	Yes	7.77	Yes	NT	--
PTX06-1105	5	4	80%	17	Yes	11	Yes	NT	--
PTX06-1106	4	0	0%	0.2	No	0.2	No	ND	--
PTX06-1107	5	0	0%	0.2	No	0.2	No	ND	--
PTX06-1118	5	5	100%	15	Yes	10.2	Yes	S	--
PTX06-1120	3	3	100%	8.99	Yes	5.69	Yes	N/A	--
PTX06-1121	3	3	100%	4.79	Yes	3.13	Yes	N/A	--
PTX06-1123	12	6	50%	22	Yes	3.75	Yes	D	--
PTX06-1130	5	5	100%	28.4	Yes	16.1	Yes	S	--
PTX06-1133A	1	0	0%	0.325	No	0.325	No	ND	--
PTX06-1135	5	0	0%	0.325	No	0.325	No	ND	--
PTX06-1146	5	5	100%	34.9	Yes	24	Yes	NT	--
PTX06-1147	5	5	100%	9.34	Yes	4.67	Yes	S	--
PTX06-1153	8	6	75%	2.6	Yes	1.5	Yes	I	--
PTX06-1154	8	1	13%	1.2	Yes	0.288	No	NT	--
PTX08-1002	7	4	57%	10.9	Yes	2.61	Yes	I	NT
PTX08-1007	4	0	0%	0.487	No	0.487	No	ND	S
PTX08-1008	8	0	0%	0.487	No	0.487	No	ND	PI
PTX08-1009	8	5	63%	1.84	Yes	0.67	No	D	--
PTX10-1014	2	0	0%	0.325	No	0.325	No	ND	--

Notes

- Trends were evaluated for data collected between January 2008 and December 2011. Trends from 2000 - 2011 indicated.
- Number of Samples is the number of samples for the compound at this location during 2008 - 2011.
 Number of Detects is the number of samples where the compound was detected at this location.
- The maximum concentration for the COC is the maximum analytical result analyzed between 2008 and 2011. Results above MSCs are indicated in **Bold**.
- MSCs = Medium Specific Concentration from Corrective Measure Study. RDX = 7.7 ug/L; 4ADNT = 1.2 ug/L.
- Values above MSCs shown in **Bold**.
- D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
 NT = No Trend; ND = well has all non-detect results for COC; ND* = one detection for compound, may be unaffected.
- Recent Mann-Kendall trend results are illustrated on Figure 3.

TABLE 5
SUMMARY STATISTICS RESULTS RDX SOUTHEAST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	RDX Concentration ug/L				95% UCL RDX	Distribution	Outlier
	Mean	Median	SD	COV			
RDX Southeast Sector							
PTX06-1002A	46.4	49.4	6.7	0.14	53.48	Normal	NO
PTX06-1003	37.5	59.0	19.5	0.52	85.99	Normal	NO
PTX06-1005	451.1	453.0	216.9	0.48	693.58	Lognormal	YES
PTX06-1008	0.2	0.0	0.0	0.00	0.25	ND	No
PTX06-1010	3.6	3.9	1.1	0.29	4.49	Normal	NO
PTX06-1011	0.2	0.0	0.0	0.00	0.26	Normal	NO
PTX06-1013	7.3	7.8	0.7	0.10	7.84	Normal	NO
PTX06-1014	711.0	929.5	199.5	0.28	933.42	Normal	NO
PTX06-1015	906.3	1270.0	298.1	0.33	1153.99	Normal	NO
PTX06-1023	1.6	2.6	1.2	0.74	2.66	Normal	NO
PTX06-1030	1482.7	1495.0	306.1	0.21	1794.81	No distribution	YES
PTX06-1031	585.3	637.5	87.9	0.15	641.93	Normal	NO
PTX06-1034	63.8	80.2	97.7	1.53	177.49	Lognormal	YES
PTX06-1036	2.0	2.3	0.2	0.12	2.38	Normal	NO
PTX06-1037	359.1	74.0	649.0	1.81	650.19	Lognormal	YES
PTX06-1038	715.1	991.0	301.1	0.42	1059.95	Normal	NO
PTX06-1039A	848.2	958.0	159.7	0.19	953.01	Normal	NO
PTX06-1040	1013.8	1090.0	168.8	0.17	1172.92	Normal	NO
PTX06-1041	942.1	1085.0	124.1	0.13	1047.00	Normal	NO
PTX06-1042	689.9	757.0	117.7	0.17	760.42	Normal	NO
PTX06-1045	2012.0	2000.0	110.8	0.06	2391.41	Normal	NO
PTX06-1046	979.9	976.0	209.0	0.21	1211.11	Normal	NO
PTX06-1047A	538.3	618.0	61.0	0.11	605.61	Normal	NO
PTX06-1052	0.2	0.0	0.0	0.00	0.23	ND	NO
PTX06-1053	0.2	0.0	0.0	0.00	0.23	ND	NO
PTX06-1069	0.2	0.0	0.0	0.00	0.27	ND	NO
PTX06-1088	372.0	0.0	0.0	0.00	271.23	Normal	NO
PTX06-1095A	64.8	20.5	121.8	1.88	179.41	Lognormal	NO
PTX06-1098	0.1	0.0	0.0	0.00	0.10	ND	NO
PTX06-1099	450.0	0.0	450.0	1.00	0.00	No distribution	NO
PTX06-1100	0.1	0.0	0.0	0.00	0.10	ND	NO
PTX06-1101	0.1	0.0	0.0	0.00	0.10	ND	NO
PTX06-1102	176.2	195.0	54.6	0.31	276.21	Normal	NO
PTX06-1103	753.0	604.5	N/A	0.00	N/A	No distribution	NO
PTX06-1104	1860.0	2050.0	303.5	0.16	2311.47	Normal	NO
PTX06-1105	3206.6	3300.0	146.2	0.05	3406.85	Normal	NO
PTX06-1106	13.9	18.0	11.5	0.83	28.15	Normal	NO
PTX06-1107	3.7	4.1	4.6	1.24	10.97	Normal	NO
PTX06-1118	1564.5	1742.0	247.3	0.16	1877.70	Normal	NO
PTX06-1120	2616.7	3100.0	633.1	0.24	4189.41	Normal	NO
PTX06-1121	967.3	1140.0	153.6	0.16	1348.84	Normal	NO
PTX06-1123	1268.4	3444.7	1514.2	1.19	1670.78	Lognormal	NO
PTX06-1130	510.7	918.0	445.6	0.87	1153.61	Normal	NO
PTX06-1133A	0.2	0.0	0.0	0.00	0.00	No distribution	NO
PTX06-1135	1.2	1.4	0.5	0.39	1.89	Normal	NO
PTX06-1146	1518.0	1590.0	228.1	0.15	1801.20	Normal	NO
PTX06-1147	502.0	376.0	352.4	0.70	1009.86	No distribution	YES
PTX06-1153	206.0	240.0	58.9	0.29	256.91	Normal	NO
PTX06-1154	160.1	490.0	285.8	1.79	415.53	No distribution	NO
PTX08-1002	61.9	137.0	67.0	1.08	123.84	Normal	NO
PTX08-1007	2.9	4.5	2.1	0.73	6.16	Normal	NO
PTX08-1008	0.2	0.0	0.0	0.00	0.24	ND	NO
PTX08-1009	0.3	0.4	0.2	0.70	0.51	Normal	NO
PTX10-1014	1.4	1.8	0.6	0.40	0.00	No distribution	NO

Notes:

- Summary statistics calculated using Kaplan Meier method.
- Distribution determined by Shapiro Wilk method. Normal = normal distribution, Lognormal = log normal distribution;
 No distribution = neither normal nor lognormal, other distributions not tested.
- Outlier in dataset determined by Dixon's method. Outliers are usually high values.
- N/A = insufficient data. ND = Non-Detect.

TABLE 6
SPATIAL ANALYSIS SUMMARY RESULTS SOUTHEAST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	RDX Average Slope Factor	RDX Average Relative Error	COV	4ADNT Average Slope Factor	4ADNT Average Relative Error	COV	Recommendation After Qualitative Review
PTX06-1002A	0.10	5.78	0.24	0.51	8220.23	0.58	Retain
PTX06-1003	0.12	6.98	0.40	0.71	4035.26	0.67	Retain
PTX06-1005	0.30	1.31	0.13	0.38	98.36	0.50	Retain
PTX06-1008	0.84	691.40	0.45	0.31	1159.06	0.43	Retain
PTX06-1010	0.30	26.81	0.21	0.70	755.84	0.20	Retain
PTX06-1011	0.86	426.98	0.21	0.66	751.43	0.20	Retain
PTX06-1013	0.31	6.30	0.03	0.58	307.74	0.18	Retain
PTX06-1014	0.05	1.01	0.01	0.27	173.41	1.67	Retain (4ADNT)
PTX06-1015	0.06	1.01	0.01	0.19	143.85	1.87	Retain (4ADNT)
PTX06-1023	0.57	14.94	0.42	0.49	178.95	0.18	Retain
PTX06-1030	0.17	1.00	0.00	0.26	45.78	1.82	Retain
PTX06-1031	0.07	1.01	0.00	0.27	147.27	1.73	Retain
PTX06-1034	0.24	1.04	0.02	0.28	33.06	1.77	Retain
PTX06-1036	0.37	20.13	0.15	0.48	227.95	0.37	Retain
PTX06-1037	0.20	3.61	1.39	0.88	460.08	1.02	ISPM well - variable concentrations
PTX06-1038	0.37	1.01	0.00	0.38	2.93	0.29	Retain
PTX06-1039A	0.18	1.01	0.00	0.38	2.09	0.27	Retain
PTX06-1040	0.13	1.00	0.00	0.30	10.07	1.58	Retain
PTX06-1041	0.13	1.00	0.00	0.31	1.94	0.22	Retain
PTX06-1042	0.08	1.01	0.00	0.31	55.16	1.86	Retain
PTX06-1045	0.22	1.00	0.00	0.62	239.61	1.70	Eliminated
PTX06-1046	0.06	1.00	0.00	0.12	107.30	1.91	Retain (4ADNT)
PTX06-1047A	0.13	1.00	0.00	0.25	50.37	1.84	Retain
PTX06-1052	0.82	146.19	0.25	0.65	154.66	0.36	Retain
PTX06-1053	0.77	42.18	0.34	0.58	20.25	1.45	Retain
PTX06-1069	0.88	15.51	0.24	0.75	33.69	0.32	Retain
PTX06-1088	0.45	1.11	0.04	0.50	12.98	0.30	Retain
PTX06-1095A	0.28	2.61	0.76	0.45	68.39	0.61	Retain
PTX06-1098	1.00	1044.86	0.14	1.00	1498.72	0.36	Retain - Pilot test area
PTX06-1099	0.99	N/A	N/A	0.99	N/A	N/A	Eliminated
PTX06-1100	1.00	931.25	0.10	1.00	1228.78	0.29	Retain - Pilot test area
PTX06-1101	1.00	204.86	0.06	1.00	253.82	0.17	Retain - Pilot test area
PTX06-1102	0.16	1.01	0.01	0.25	21.04	1.71	Retain
PTX06-1103	0.01	N/A	N/A	0.03	N/A	N/A	Retain - dry check for saturation
PTX06-1104	0.32	1.01	0.00	0.64	7.00	0.31	Eliminated
PTX06-1105	0.45	1.01	0.00	0.78	7.32	0.52	Eliminated
PTX06-1106	0.41	1.80	0.20	1.00	429.95	0.08	Eliminated
PTX06-1107	0.72	7.08	1.28	1.00	359.34	0.06	Eliminated
PTX06-1118	0.25	1.00	0.00	0.45	2.19	0.41	Retain
PTX06-1120	0.27	1.00	0.00	0.43	38.25	1.35	Retain
PTX06-1121	0.04	1.00	0.00	0.32	59.42	1.35	Retain (4ADNT)
PTX06-1123	0.28	1.62	0.73	0.70	111.34	1.11	Retain
PTX06-1130	0.08	1.00	0.00	0.14	1.29	0.12	Retain (delineation)
PTX06-1133A	0.93	N/A	N/A	0.83	N/A	N/A	Retain (delineation)
PTX06-1135	0.44	6.76	0.37	0.42	45.67	0.06	Retain
PTX06-1146	0.11	1.00	0.00	0.22	1.17	0.12	Retain
PTX06-1147	0.05	1.00	0.00	0.16	8.90	1.46	Retain
PTX06-1153	0.35	1.02	0.01	0.84	8.32	0.51	Retain
PTX06-1154	0.62	28.00	1.36	0.94	244.88	0.08	Downgradient, higher uncertainty
PTX08-1002	0.31	1.10	0.10	0.65	6.32	0.86	Retain
PTX08-1008	0.63	22.89	0.23	0.44	23.59	0.32	Retain
PTX08-1009	0.70	15.24	0.29	0.59	28.80	0.84	Retain
PTX10-1014	0.12	4.54	0.34	0.29	38.11	0.14	Retain

Notes:

- Slope Factor (SF) is the difference between the actual concentration and the concentration estimated from nearby wells normalized by the actual concentration. Slope factors close to 1 show the concentrations cannot be estimated from the adjacent wells, and the well is important in the network.
- Slope factors were calculated using data collected between July 2005 and May 2007.
- Well locations with slope factors below 0.3 and area ratios below 0.8 were considered for elimination.
- N/A = Locations with insufficient data between 2005 - 2007 to calculate a slope factor.
- Locations identified for future elimination should be reviewed, and possibly removed from the program after 5 years of data collection.
- PTX10-1013 not evaluated for RDX. Evaluated in SW Sector for TCE.

TABLE 7
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHEAST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2008-2011)	Sampling Frequency Based on Recent Data (2008-2011)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2011)	Sampling Frequency Based on Overall Data (2000 - 2011)	MAROS Recommended Sampling Frequency	2009 LTM Plan Sampling Frequency
RDX Southeast Sector								
PTX06-1002A	-1.42E-05	D	Annual	1.62E-06	NT	Annual	Annual	Semi-annual
PTX06-1003	0.00E+00	N/A	Annual	9.54E-06	NT	Annual	Annual	Annual
PTX06-1005	1.69E-04	NT	Annual	-1.07E-04	S	Annual	Annual	Semi-annual
PTX06-1008	--	ND	Biennial	-	ND	Annual	Annual	Semi-annual
PTX06-1010	-1.55E-06	S	Annual	-1.02E-04	D	Annual	Annual	Semi-annual
PTX06-1011	-8.08E-08	S	Annual	-1.54E-08	PD	Annual	Annual	Annual
PTX06-1013	-6.83E-07	S	Annual	1.32E-06	I	Annual	Annual	Semi-annual
PTX06-1014	-4.01E-04	D	Annual	-1.28E-04	S	Annual	Annual	Annual
PTX06-1015	5.30E-04	I	Quarterly	2.54E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1023	2.93E-07	S	Annual	-3.68E-07	S	Annual	Annual	Semi-annual
PTX06-1030	1.87E-04	S	Quarterly	1.17E-04	NT	Quarterly	Quarterly	Semi-annual
PTX06-1031	-1.35E-04	D	Quarterly	1.25E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1034	2.03E-04	I	Quarterly	3.06E-05	I	Quarterly	Quarterly	Semi-annual
PTX06-1036	2.03E-07	NT	Annual	8.29E-07	I	Annual	Annual	Annual
PTX06-1037	-1.08E-03	D	Annual	-6.11E-04	D	Annual	Annual	Semi-annual
PTX06-1038	3.36E-04	NT	Annual	-1.15E-05	S	Annual	Annual	Semi-annual
PTX06-1039A	-1.37E-04	S	Annual	1.77E-06	NT	Annual	Annual	Semi-annual
PTX06-1040	2.62E-04	NT	Quarterly	7.12E-05	I	Quarterly	Quarterly	Semi-annual
PTX06-1041	2.67E-05	NT	Annual	1.48E-05	NT	Annual	Annual	Semi-annual
PTX06-1042	-2.05E-04	PD	Annual	-1.60E-04	D	Annual	Annual	Semi-annual
PTX06-1045	0.00E+00	N/A	Quarterly	3.87E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1046	3.58E-04	NT	Quarterly	1.49E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1047A	9.72E-05	I	Quarterly	1.75E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1052	--	ND	Annual	--	ND	Annual	Biennial	Semi-annual
PTX06-1053	--	ND	Annual	4.80E-07	NT	Annual	Annual	Semi-annual
PTX06-1069	-8.57E-08	S	Annual	-5.38E-08	NT	Annual	Biennial	Annual
PTX06-1088	-1.07E-04	PD	Annual	-6.58E-05	D	Annual	Annual	Semi-annual
PTX06-1095A	1.99E-04	I	Quarterly	1.24E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1098	--	ND	Annual	--	ND	Annual	Biennial	Semi-annual
PTX06-1099	--	N/A	Quarterly	--	N/A	Quarterly	Quarterly	NA (Inactive)
PTX06-1100	--	ND	Annual	--	ND	Annual	Biennial	Annual
PTX06-1101	--	ND	Annual	--	ND	Annual	Biennial	Annual
PTX06-1102	1.07E-04	I	Annual	-5.72E-05	NT	Annual	Annual	Annual
PTX06-1103	0.00E+00	N/A	Quarterly	0.00E+00	N/A	Quarterly	Quarterly	Dry (Annual)
PTX06-1104	9.16E-04	NT	Quarterly	9.16E-04	NT	Quarterly	Quarterly	NA (Inactive)
PTX06-1105	-2.05E-04	S	Annual	-2.05E-04	S	Annual	Annual	NA (Inactive)
PTX06-1106	1.61E-05	NT	SemiAnnual	1.61E-05	NT	SemiAnnual	SemiAnnual	NA (Inactive)
PTX06-1107	-1.19E-05	NT	Annual	-1.19E-05	NT	Annual	Annual	NA (Inactive)
PTX06-1118	-1.02E-03	S	Annual	-1.02E-03	S	Annual	Annual	Annual
PTX06-1120	--	N/A	Quarterly	--	N/A	Quarterly	Quarterly	Formerly dry
PTX06-1121	--	N/A	Quarterly	--	N/A	Quarterly	Quarterly	Formerly dry
PTX06-1123	-2.46E-03	D	Annual	-2.45E-03	D	Annual	Annual	Semi-annual
PTX06-1130	-1.74E-03	D	Annual	-1.74E-03	D	Annual	Annual	Semi-annual
PTX06-1133A	--	N/A	Annual	--	N/A	Annual	Annual	Formerly dry
PTX06-1135	-1.63E-06	D	Annual	-1.62E-06	D	Annual	Biennial	Semi-annual
PTX06-1146	3.73E-04	NT	Quarterly	3.72E-04	NT	Quarterly	Quarterly	Semi-annual
PTX06-1147	8.83E-04	NT	Quarterly	8.84E-04	NT	Quarterly	Quarterly	Semi-annual
PTX06-1153	-1.71E-05	NT	Annual	-1.72E-05	NT	Annual	Annual	Quarterly
PTX06-1154	-9.27E-04	NT	Annual	-9.17E-04	NT	Annual	Annual	Quarterly
PTX08-1002	1.24E-04	I	Annual	-5.81E-05	PD	Annual	Annual	Semi-annual
PTX08-1007	-6.02E-07	S	Annual	0.00E+00	N/A	Annual	Annual	Annual
PTX08-1008	--	ND	Annual	-1.59E-08	NT	Annual	Biennial	Semi-annual
PTX08-1009	2.90E-07	I	Annual	2.13E-06	NT	Annual	Annual	Semi-annual
PTX10-1014	--	N/A	Quarterly	--	N/A	Quarterly	Quarterly	Semi-annual

Notes:

1. 'Recent' concentration rate of change and MK trends are calculated from data collected 2008 - 2011.
2. MK = Mann Kendall Trend; D = Decreasing, PD = Probably Decreasing, S = Stable, NT = No Trend, PI = Probably Increasing, I = Increasing, ND = Non-detect, N/A = insufficient data, less than 4 sample events for time interval indicated.
3. Overall rate of change and MK trend are for the full data set (2000-2011) for each well.
4. MAROS Recommended Sampling Frequency is the sampling frequency from MAROS based on both recent and overall trends.
5. 2009 LTM Plan (B&W Pantex, 2009a) is the sampling frequency currently implemented.
6. The final recommended sampling frequency is listed on Table 8, and is based on a combination of qualitative and statistical evaluations.

TABLE 8
FINAL RECOMMENDED MONITORING NETWORK SOUTHEAST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	RDX			4ADNT			Sampling Recommendation	Rationale
	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF		
Southeast Sector								
PTX06-1002A	100%	D	0.10	71%	PD	0.10	Annual	Source monitoring for RDX - Demonstrate decreasing source term
PTX06-1003	100%	N/A	0.12	100%	N/A	0.12	Annual	Downgradient from source, spatially important to track reduction in concentrations.
PTX06-1005	100%	NT	0.30	100%	S	0.30	Annual	Downgradient from source, spatially important to track reduction in concentrations.
PTX06-1008	0%	ND	0.84	0%	ND	0.84	Annual	Zone 11 - delineate plumes for Cr, TCE, Perchlorate
PTX06-1010	100%	S	0.30	38%	PD	0.30	Annual	Source area monitors decreasing trends for VOCs, Increasing trend for Cr(VI).
PTX06-1011	25%	S	0.86	0%	ND	0.86	Annual	Monitors near TCE plume, near variable groundwater flow direction.
PTX06-1013	100%	S	0.31	0%	ND	0.31	Annual	Delineates northern edge of Southeast Sector near Playa1.
PTX06-1014	100%	D	0.05	80%	S	0.05	Annual	Monitors response action for 4ADNT plume
PTX06-1015	100%	I	0.06	100%	D	0.06	Annual	Downgradient, center of plume, monitors movement of COCs toward edge of unit.
PTX06-1023	100%	S	0.57	0%	ND	0.57	Annual	Delineates northern most area of Southeast Sector near Playa 1.
PTX06-1030	100%	S	0.17	100%	S	0.17	Semi-annual	High concentrations are stabilizing, monitors edge of unit.
PTX06-1031	100%	D	0.07	75%	D	0.07	Semi-annual	Monitors response action, high concentration zone.
PTX06-1034	100%	I	0.24	100%	NT	0.24	Semi-annual	Easternmost well, monitors edge of plume before unit pinches out.
PTX06-1036	100%	NT	0.37	40%	S	0.37	Annual	Delineates southern edge of plume, monitors movement of COCs from south of Zones 11 and 12 toward southern edge of perched unit.
PTX06-1037	100%	D	0.20	25%	PD	0.20	Semi-annual	Monitors performance of ISB remedy
PTX06-1038	100%	NT	0.37	88%	NT	0.37	Annual	Monitors variable high mass area along FM2373, monitor response action
PTX06-1039A	100%	S	0.18	100%	S	0.18	Annual	Monitors variable high mass area along FM2373, monitor response action
PTX06-1040	100%	NT	0.13	100%	S	0.13	Annual	Monitors variable high mass area along FM2373, monitor response action
PTX06-1041	100%	NT	0.13	100%	PI	0.13	Annual	Monitors variable high mass area along FM2373, monitor response action
PTX06-1042	100%	PD	0.08	100%	PD	0.08	Annual	Monitors variable high mass area along FM2373, monitor response action

See Notes End of Table

TABLE 8
FINAL RECOMMENDED MONITORING NETWORK SOUTHEAST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	RDX			4ADNT			Sampling Recommendation	Rationale
	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF		
PTX06-1045	100%	N/A	0.22	67%	N/A	0.22	Semi-annual	Monitors ISB remedy performance near edge of groundwater, confirm saturation
PTX06-1046	100%	NT	0.06	100%	D	0.06	Semi-annual	Monitors southern extent of perched unit, high and variable concentrations of COCs.
PTX06-1047A	100%	I	0.13	100%	PD	0.13	Semi-annual	Monitors southern extent of perched unit, high and increasing concentrations of COCs.
PTX06-1052	0%	ND	0.82	63%	S	0.82	Semi-annual	Monitors chromium high concentration area.
PTX06-1053	0%	ND	0.77	75%	NT	0.77	Annual	Delineates 4ADNT plume to south, near groundwater flow divide, early warning for movement of COCs to south/southeastern extent of perched groundwater.
PTX06-1069	0%	ND	0.88	0%	ND	0.88	Annual	Delineation of northern sector of perched groundwater.
PTX06-1088	100%	PD	0.45	100%	S	0.45	Annual	Source area monitors decreasing trends, important for 1,3,5- trinitrobenzene.
PTX06-1095A	100%	I	0.28	63%	I	0.28	Semi-annual	Downgradient from source, spatially important to track increasing concentrations and remedy performance.
PTX06-1098	0%	ND	0.14				Annual	Monitor remedy effectiveness of pilot project
PTX06-1099	100%	N/A	0.99	100%	N/A	0.99	NA	No longer sampled
PTX06-1100	0%	ND	1.00	0%	ND	1.00	Biennial	Former pilot test area
PTX06-1101	0%	ND	1.00	0%	ND	1.00	Biennial	Former pilot test area
PTX06-1102	100%	I	0.16	100%	S	0.16	Semi-annual	Monitors increasing RDX trends in area of extraction wells.
PTX06-1103	100%	N/A	0.01	100%	N/A	0.01	Semi-annual	More data needed to evaluate location
PTX06-1104	100%	NT	0.32	100%	NT	0.32	NA	Removed from program
PTX06-1105	100%	S	0.45	80%	NT	0.45	NA	Removed from program
PTX06-1106	100%	NT	0.41	0%	ND	0.41	NA	Removed from program
PTX06-1107	100%	NT	0.72	0%	ND	0.72	NA	Removed from program
PTX06-1118	100%	S	0.25	100%	S	0.25	Annual	Monitor long-term stabilization of RDX mass and chromium plume stability.
PTX06-1120	100%	N/A	0.27	100%	N/A	0.27	Semi-annual	Recently found to be saturated, collect sufficient data to evaluate trend.
PTX06-1121	100%	N/A	0.04	100%	N/A	0.04	Semi-annual	Recently found to be saturated, collect sufficient data to evaluate trend.
PTX06-1123	100%	D	0.28	50%	D	0.28	Semi-annual	Monitor performance of ISB system.
PTX06-1130	100%	D	0.08	100%	S	0.08	Annual	Monitor performance of extraction system near FM 2373.
PTX06-1133A	0%	N/A	0.93	0%	N/A	0.93	Annual	Confirm level of saturation
PTX06-1135	100%	D	0.44	0%	ND	0.44	Annual	Delineates plumes south of Zone 11/12 divide
PTX06-1146	100%	NT	0.11	100%	NT	0.11	Semi-annual	Delineates plume to east - continue monitoring variable trends to evaluate remedial efficacy
PTX06-1147	100%	NT	0.05	100%	S	0.05	Semi-annual	Delineates plume to east - continue monitoring variable trends to evaluate remedial efficacy
PTX06-1153	100%	NT	0.35	75%	I	0.35	Semi-annual	Monitors performance of ISB remedy
PTX06-1154	71%	NT	0.62	13%	NT	0.62	Semi-annual	Monitors performance of ISB remedy
PTX08-1002	100%	I	0.31	57%	I	0.31	Annual	Monitors northern area in Playa 1 source
PTX08-1008	0%	ND	0.63	0%	ND	0.63	Annual	Chromium monitoring location near potential source
PTX08-1009	75%	I	0.70	63%	D	0.70	Annual	Delineates plume south of Zone 12
PTX10-1014	100%	N/A	0.12	0%	N/A	0.12	Annual	Delineates source area Zone 12/11.

Notes:

1. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine result; NT = No Trend; ND = well has all non-detect results for COC indicated.
2. Mann-Kendall trends for 2008 - 2011 are shown.
3. SF = Slope Factor. SF close to 1 indicates well provides unique information in network. SF near 0 indicates well may be redundant.
4. Percent detection is the ratio of the number of detections to the number of samples for the compound indicated multiplied by 100.
5. Some wells are evaluated for other COCs in results from Southwest and North Sectors.

MAROS COC Assessment

Project: Pantex SW**User Name:** MV**Location:** Southwest Area**State:** Texas**Toxicity:**

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
TRICHLOROETHYLENE (TCE)	3.6E-02	5.0E-03	615.8%
CHROMIUM, TOTAL	6.3E-01	1.0E-01	527.1%
PERCHLORATE	1.4E-01	2.6E-02	450.4%
CHROMIUM, HEXAVALENT	2.7E-01	1.0E-01	173.3%
4-AMINO-2,6-DINITROTOLUENE	2.0E-03	1.2E-03	62.6%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
PERCHLORATE	INO	35	15	42.9%	26
TRICHLOROETHYLENE (TCE)	ORG	36	14	38.9%	24
4-AMINO-2,6-DINITROTOLUENE	ORG	36	10	27.8%	19
CHROMIUM, TOTAL	MET	32	8	25.0%	27
CHROMIUM, HEXAVALENT	MET	32	3	9.4%	26

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
PERCHLORATE	
CHROMIUM, TOTAL	
4-AMINO-2,6-DINITROTOLUENE	0.0985
TRICHLOROETHYLENE (TCE)	0.297
CHROMIUM, HEXAVALENT	14

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

TRICHLOROETHYLENE (TCE)

PERCHLORATE

4-AMINO-2,6-DINITROTOLUENE

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZIN

CHROMIUM, HEXAVALENT

TABLE 10
MONITORING WELL TREND SUMMARY RESULTS SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend 2008 - 2011	Mann-Kendall Trend 2000 - 2007
TCE Southwest Sector									
1114-MW4	9	9	100%	12.4	Yes	11.4	Yes	S	PI
PTX06-1006	5	1	20%	0.5	No	0.5	No	S	N/A
PTX06-1007	4	0	0%	ND	No	ND	No	ND	S
PTX06-1008	4	4	100%	10.1	Yes	5.8	Yes	S	S
PTX06-1012	14	14	100%	580.0	Yes	189.0	Yes	I	PI
PTX06-1035	12	0	0%	ND	No	ND	No	ND	S
PTX06-1036	6	0	0%	ND	No	ND	No	ND	S
PTX06-1052	9	0	0%	ND	No	ND	No	ND	D
PTX06-1053	9	0	0%	ND	No	ND	No	ND	S
PTX06-1073A	1	1	100%	5.7	Yes	5.7	Yes	N/A	--
PTX06-1077A	4	3	75%	16.2	Yes	10.7	Yes	D	NT
PTX06-1085	3	0	0%	ND	No	ND	No	ND	S
PTX06-1086	4	0	0%	ND	No	ND	No	ND	S
PTX06-1126	10	10	100%	475.0	Yes	264.0	Yes	I	--
PTX06-1127	10	10	100%	22.0	Yes	13.4	Yes	D	--
PTX06-1131	5	0	0%	ND	No	ND	No	ND	--
PTX06-1134	5	0	0%	ND	No	ND	No	ND	--
PTX06-1148	6	4	67%	1.4	No	0.6	No	NT	--
PTX06-1149	6	1	17%	0.4	No	0.5	No	S	--
PTX06-1150	6	3	50%	1.3	No	0.7	No	NT	--
PTX06-1151	6	6	100%	195.0	Yes	143.0	Yes	I	--
PTX06-1155	9	9	100%	660.0	Yes	537.0	Yes	NT	--
PTX06-1156	9	9	100%	7.4	Yes	4.2	No	S	--
PTX07-1Q01	3	0	0%	ND	No	ND	No	ND	S
PTX07-1Q02	3	0	0%	ND	No	ND	No	ND	S
PTX07-1Q03	4	0	0%	ND	No	ND	No	ND	S
PTX08-1003	4	2	50%	3.2	No	1.3	No	NT	S
PTX08-1005	8	8	100%	164.0	Yes	103.0	Yes	PI	NT
PTX08-1006	9	9	100%	15	Yes	7.6	Yes	I	S
PTX08-1007	4	4	100%	15.2	Yes	10.9	Yes	S	S
PTX08-1008	9	7	78%	0.6	No	0.4	No	S	NT
PTX08-1009	9	4	44%	0.4	No	0.5	No	S	NT
PTX10-1013	2	2	100%	3.6	No	3.0	No	N/A	NT
PTX10-1014	2	2	100%	31	Yes	30.5	Yes	N/A	--

See Notes End of Table

TABLE 10
MONITORING WELL TREND SUMMARY RESULTS SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
 Carson County, Texas

Well Name	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend 2008 - 2011	Mann-Kendall Trend 2000 - 2007
Perchlorate Southwest Sector									
1114-MW4	9	9	100%	94.0	Yes	80.4	Yes	S	D
PTX06-1006	5	5	100%	145.0	Yes	111.0	Yes	D	S
PTX06-1007	4	4	100%	194.0	Yes	152.0	Yes	NT	S
PTX06-1008	4	2	50%	4	No	4.8	No	NT	NT
PTX06-1012	14	13	93%	341.0	Yes	143.0	Yes	PI	I
PTX06-1035	12	8	67%	12.2	No	7.0	No	I	S
PTX06-1036	5	0	0%	ND	No	ND	No	ND	ND
PTX06-1052	4	0	0%	ND	No	ND	No	ND	ND
PTX06-1053	9	0	0%	ND	No	ND	No	ND	D
PTX06-1073A	1	0	0%	ND	No	ND	No	ND	--
PTX06-1077A	4	4	100%	5.7	No	5.1	No	S	NT
PTX06-1126	10	10	100%	1,070.0	Yes	434.0	Yes	D	--
PTX06-1127	10	10	100%	1,170.0	Yes	821.0	Yes	D	--
PTX06-1134	5	5	100%	7	No	5.8	No	NT	--
PTX06-1148	6	6	100%	995.0	Yes	544.0	Yes	I	--
PTX06-1149	6	5	83%	526.0	Yes	116.0	Yes	I	--
PTX06-1150	6	6	100%	171.0	Yes	87.8	Yes	I	--
PTX06-1151	5	5	100%	149.0	Yes	126.0	Yes	D	--
PTX06-1155	9	7	78%	487	Yes	239.0	Yes	PD	--
PTX06-1156	9	7	78%	2,140.0	Yes	1260.0	Yes	S	--
PTX08-1003	4	4	100%	19.2	No	16.2	No	D	D
PTX08-1005	8	8	100%	28.7	Yes	22.2	No	NT	D
PTX08-1006	9	9	100%	1,600.0	Yes	1080.0	Yes	NT	D
PTX08-1007	4	1	25%	7	No	6.3	No	S	N/A
PTX08-1008	9	3	33%	5.3	No	5.6	No	PD	S
PTX10-1013	2	2	100%	5.2	No	4.9	No	N/A	S
PTX10-1014	2	1	50%	5.5	No	5.7	No	N/A	--

Notes

- Trends were evaluated for data collected between January 2008 and December 2011. Trends from 2007 analysis 2000 - 2007.
- Number of Samples is the number of samples for the compound at this location.
 Number of Detects is the number of samples where the compound was detected at this location.
- Maximum Result is the maximum concentration for the COC analyzed between 2008 and 2011. Results above MSCs are indicated in **Bold**.
- Screening level from Corrective Measure Study. TCE = 5 ug/L; Perchlorate = 26 ug/L.
- Maximum and average concentrations for wells with no detections are representative of the detection limits for the analyses.
- D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
 NT = No Trend; ND = well has all non-detect results for COC, ND* = one detection for compound, may be unaffected.

TABLE 11
SUMMARY STATISTICS RESULTS SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	TCE Concentration ug/L				95% UCL TCE	Distribution	Outlier
	Mean	Median	SD	COV			
TCE Southwest Sector							
1114-MW4	11.1	12.3	1.4	0.13	12.35	Normal	Yes
PTX06-1006	0.5	0.0	0.0	0.00	0.50	No Distribution	Yes
PTX06-1007	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1008	6.0	10.1	3.2	0.53	11.34	Normal	
PTX06-1012	187.7	370.0	197.7	1.05	332.37	Lognormal	
PTX06-1035	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1036	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1052	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1053	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1073A	11.4	0.0	11.4	1.00	0.00	No Distribution	
PTX06-1077A	10.9	16.2	6.4	0.59	21.82	Normal	Yes
PTX06-1085	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1086	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1126	241.9	296.3	69.6	0.29	326.20	Normal	Yes
PTX06-1127	13.5	17.0	3.8	0.28	16.23	Normal	
PTX06-1131	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1134	0.5	0.0	0.0	0.00	0.50	ND	
PTX06-1148	0.5	0.3	0.4	0.75	1.04	No Distribution	
PTX06-1149	0.5	0.0	0.0	0.00	0.54	No Distribution	
PTX06-1150	0.6	0.0	0.3	0.49	1.06	No Distribution	
PTX06-1151	127.8	139.0	39.3	0.31	189.01	No Distribution	
PTX06-1155	533.8	575.0	54.4	0.10	583.07	Normal	
PTX06-1156	4.3	4.5	1.4	0.33	5.36	Normal	
PTX07-1Q01	0.5	0.0	0.0	0.00	0.50	ND	
PTX07-1Q02	0.5	0.0	0.0	0.00	0.50	ND	
PTX07-1Q03	0.5	0.0	0.0	0.00	0.50	ND	
PTX08-1003	1.1	3.2	1.6	1.38	3.38	Normal	
PTX08-1005	104.4	120.5	38.2	0.37	140.67	Normal	
PTX08-1006	7.8	11.3	4.8	0.61	12.45	No Distribution	
PTX08-1007	11.1	15.2	3.6	0.33	17.36	Normal	
PTX08-1008	0.4	0.5	0.1	0.33	0.54	Normal	
PTX08-1009	0.5	0.0	0.0	0.00	0.51	No Distribution	
PTX10-1013	3.2	3.6	0.7	0.22	0.00	No Distribution	
PTX10-1014	30.6	30.8	0.4	0.01	0.00	No Distribution	

Notes:

- Summary statistics calculated using Kaplan Meier method.
- Distribution determined by Shapiro Wilk method. Normal = normal distribution, Lognormal = log normal distribution;
No distribution = neither normal nor lognormal, other distributions not tested.
- Outlier in dataset determined by Dixon's method. Outliers are usually high values.
- N/A = insufficient data. ND = Non-Detect.

TABLE 12
SPATIAL ANALYSIS SUMMARY RESULTS SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
 Carson County, Texas

Well Name	Perchlorate Average Slope Factor	Perchlorate Average Relative Error	COV	TCE Average Slope Factor	TCE Average Relative Error	COV	Recommendation After Qualitative Review
1114-MW4	0.19	1.64	0.26	0.17	9.06	0.49	Retain
PTX06-1006	0.16	1.23	0.14	0.54	126.07	0.14	Retain
PTX06-1007	0.50	1.22	0.11	0.55	76.24	0.40	Retain
PTX06-1008	0.27	7.61	0.17	0.28	8.41	0.59	Retain (TCE)
PTX06-1012	0.21	1.87	1.06	0.21	1.32	0.29	Retain
PTX06-1035	0.47	1.30	0.31	0.62	7.43	1.10	Retain
PTX06-1036	0.00	1.69	0.10	0.08	12.39	0.26	Retain (SE)
PTX06-1052	0.09	2.05	0.04	0.45	9.98	0.98	Retain
PTX06-1053	0.49	1.86	0.26	0.15	27.12	0.40	Retain (SE)
PTX06-1073A	0.48	--		0.02			Retain - (sample for saturation)
PTX06-1077A	0.57	1.37	0.16	0.42	3.67	1.26	Retain
PTX06-1085	--	--	--	0.00	8.69	0.47	Retain
PTX06-1086	--	--	--	0.33	7.68	0.54	Retain
PTX06-1126	0.23	1.01	0.01	0.61	1.04	0.02	Retain
PTX06-1127	0.33	1.01	0.01	0.18	1.47	0.09	Retain
PTX06-1131	--	--	--	0.43	5.95	0.77	Retain
PTX06-1134	0.56	1.87	0.16	0.65	15.71	0.20	Retain
PTX06-1148	0.36	1.04	0.07	0.39	33.54	0.54	Retain
PTX06-1149	0.43	1.53	0.34	0.53	33.36	0.20	Retain
PTX06-1150	0.21	1.29	0.33	0.60	19.01	0.35	Retain
PTX06-1151	0.16	1.01	0.01	0.24	1.01	0.01	Retain
PTX06-1155	0.31	1.56	0.50	0.25	1.01	0.01	Retain
PTX06-1156	0.36	1.03	0.07	0.23	2.70	0.71	Retain
PTX07-1Q01	--	--	--	0.12	12.22	0.00	Retain (4ADNT)
PTX07-1Q02	--	--	--	0.00	11.81	0.05	Retain (TCE)
PTX07-1Q03	--	--	--	0.37	6.66	0.26	Retain (SE)
PTX08-1003	0.40	1.03	0.01	0.52	2.54	0.55	Retain (SE)
PTX08-1005	0.50	1.03	0.02	0.20	1.04	0.04	Retain
PTX08-1006	0.46	1.00	0.00	0.12	1.54	0.28	Retain
PTX08-1007	0.50	1.11	0.14	0.39	1.23	0.26	Retain
PTX08-1008	0.61	1.09	0.06	0.61	8.73	0.64	Retain
PTX08-1009	--	--	--	0.35	3.71	0.52	Retain
PTX10-1013	0.18	1.55	0.05	0.20	1.93	0.24	Eliminated
PTX10-1014	0.16	1.41	0.02	0.48	1.10	0.00	Retain

Notes:

- Slope Factor (SF) is the difference between the actual concentration and the concentration estimated from nearby wells normalized by the actual concentration. Slope factors close to 1 show the concentrations cannot be estimated from the nearby wells, and the well is important in the network.
- Slope factors were calculated using data collected between July 2005 and May 2007.
- Well locations with slope factors below 0.3 and area ratios below 0.8 were considered for elimination. () = well retained for Southeast (SE) or for other COC indicated.
- N/A = Locations with insufficient data between 2005 - 2007 to calculate a slope factor.
- Wells recommended for elimination are not recommended for plugging and abandonment, but should be retained for hydrogeologic monitoring.
- * = Well included in Southeast network, recommendation based on COCs from Southeast Sector.

TABLE 13
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2008-2011)	Sampling Frequency Based on Recent Data (2008-2011)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2011)	Sampling Frequency Based on Overall Data (2000 - 2011)	MAROS Recommended Sampling Frequency	2009 LTM Plan Sampling Frequency
TCE Southwest Sector								
1114-MW4	-1.40E-06	S	Annual	1.64E-06	NT	Annual	Annual	Semi-annual
PTX06-1006	-7.26E-09	S	Annual	3.22E-09	NT	Annual	Biennial	Annual
PTX06-1007	--	ND	Annual	-2.64E-08	S	Annual	Biennial	Annual
PTX06-1008	-7.52E-06	S	Annual	-3.39E-06	D	Annual	Annual	Semi-annual
PTX06-1012	3.55E-04	I	Quarterly	1.02E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1035	--	ND	Annual	-1.81E-07	ND	Annual	Annual	Semi-annual
PTX06-1036	--	ND	Annual	-1.14E-07	ND	Annual	Annual	Annual
PTX06-1052	--	ND	Annual	-2.34E-07	D	Annual	Annual	Semi-annual
PTX06-1053	--	ND	Annual	-3.59E-07	ND	Annual	Annual	Semi-annual
PTX06-1073A	--	N/A	Quarterly	--	N/A	Quarterly	Quarterly	Dry
PTX06-1077A	-1.47E-05	D	Annual	3.22E-07	NT	Annual	Annual	Annual
PTX06-1085	--	N/A	Annual	--	ND	Annual	Biennial	Annual
PTX06-1086	--	ND	Annual	--	ND	Annual	Biennial	Annual
PTX06-1126	1.23E-04	I	Quarterly	1.23E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1127	-5.94E-06	D	Annual	-5.94E-06	D	Annual	Annual	Semi-annual
PTX06-1131	--	ND	Annual	--	ND	Annual	Biennial	Semi-annual
PTX06-1134	--	ND	Annual	--	ND	Annual	Biennial	Semi-annual
PTX06-1148	5.44E-07	NT	Annual	5.44E-07	NT	Annual	Biennial	Semi-annual
PTX06-1149	-8.42E-08	S	Annual	-8.42E-08	S	Annual	Biennial	Semi-annual
PTX06-1150	5.94E-07	NT	Annual	5.94E-07	NT	Annual	Biennial	Semi-annual
PTX06-1151	1.32E-04	I	Quarterly	1.32E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1155	7.41E-05	NT	Quarterly	7.41E-05	NT	Quarterly	Quarterly	Quarterly
PTX06-1156	-3.02E-06	S	Annual	-3.02E-06	S	Annual	Annual	Quarterly
PTX07-1P02	--	--	--	-6.38E-07	ND	Annual	Annual	Semi-annual
PTX07-1Q01	--	N/A	Annual	-2.57E-07	ND	Annual	Annual	Annual
PTX07-1Q02	--	N/A	Annual	-2.57E-07	ND	Annual	Annual	Annual
PTX07-1Q03	--	ND	Annual	-2.34E-07	ND	Annual	Annual	Annual
PTX08-1001	--	--	--	-5.87E-07	ND	Annual	Annual	Annual
PTX08-1003	2.07E-06	NT	Annual	1.27E-07	NT	Annual	Annual	Annual
PTX08-1005	8.06E-05	PI	Quarterly	2.23E-05	I	Quarterly	Quarterly	Semi-annual
PTX08-1006	8.05E-06	I	SemiAnnual	1.23E-06	I	Annual	Annual	Semi-annual
PTX08-1007	-5.30E-06	S	Annual	-1.15E-06	PD	Annual	Annual	Annual
PTX08-1008	-5.96E-08	S	Annual	-3.24E-07	D	Annual	Annual	Semi-annual
PTX08-1009	-2.53E-07	S	Annual	-1.43E-07	D	Annual	Biennial	Semi-annual
PTX10-1013	--	N/A	SemiAnnual	-2.60E-06	S	Annual	Annual	Inactive
PTX10-1014	--	N/A	Quarterly	--	N/A	Quarterly	Quarterly	Semi-annual

See Notes End of Table

TABLE 13
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2008-2011)	Sampling Frequency Based on Recent Data (2008-2011)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2011)	Sampling Frequency Based on Overall Data (2000 - 2011)	MAROS Recommended Sampling Frequency	2009 LTM Plan Sampling Frequency
Perchlorate Southwest Sector								
1114-MW4	-1.68E-05	S	Annual	-8.34E-05	D	Annual	Annual	Semi-annual
PTX06-1006	-5.71E-05	D	Annual	3.20E-05	NT	Annual	Annual	Annual
PTX06-1007	8.42E-05	NT	SemiAnnual	1.36E-05	NT	Annual	Annual	Annual
PTX06-1008	2.63E-06	NT	Annual	-2.34E-07	S	Annual	Biennial	Semi-annual
PTX06-1012	5.32E-05	PI	Annual	5.28E-05	I	SemiAnnual	SemiAnnual	Semi-annual
PTX06-1035	3.17E-06	I	Annual	7.86E-07	I	Annual	Annual	Semi-annual
PTX06-1036	--	ND	Annual	-4.01E-07	ND	Annual	Biennial	Annual
PTX06-1052	--	ND	Annual	4.49E-07	NT	Annual	Biennial	Semi-annual
PTX06-1053	--	ND	Annual	1.56E-07	PI	Annual	Biennial	Semi-annual
PTX06-1073A	--	N/A	Annual	--	N/A	Annual	Annual	NA
PTX06-1077A	-3.53E-07	S	Annual	-6.53E-07	D	Annual	Biennial	Annual
PTX06-1085	--	--	--	--	ND	Annual	Biennial	Annual
PTX06-1086	--	--	--	--	ND	Annual	Biennial	Annual
PTX06-1126	-2.87E-04	D	Annual	-2.87E-04	D	Annual	Annual	Semi-annual
PTX06-1127	-4.48E-04	D	Annual	-4.48E-04	D	Annual	Annual	Semi-annual
PTX06-1134	1.70E-06	NT	Annual	1.70E-06	NT	Annual	Biennial	Semi-annual
PTX06-1148	7.93E-04	I	Quarterly	7.93E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1149	3.38E-04	I	Quarterly	3.38E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1150	1.59E-04	I	Quarterly	1.59E-04	I	Quarterly	Quarterly	Semi-annual
PTX06-1151	-7.67E-05	D	Annual	-7.67E-05	D	Annual	Annual	Semi-annual
PTX06-1155	-7.53E-04	PD	Annual	-7.53E-04	PD	Annual	Annual	Quarterly
PTX06-1156	-2.64E-03	S	Annual	-2.64E-03	S	Annual	Annual	Quarterly
PTX07-1P02	--	--	--	--	ND	Annual	Biennial	Semi-annual
PTX07-1Q01	--	--	--	--	ND	Annual	Biennial	Annual
PTX07-1Q02	--	--	--	--	ND	Annual	Biennial	Annual
PTX07-1Q03	--	--	--	--	ND	Annual	Biennial	Annual
PTX08-1001	--	--	--	1.12E-05	NT	Annual	Annual	Annual
PTX08-1003	-5.66E-06	D	Annual	-6.41E-06	D	Annual	Annual	Annual
PTX08-1005	-4.38E-08	NT	Annual	-7.27E-05	D	Annual	Annual	Semi-annual
PTX08-1006	6.81E-04	I	Quarterly	3.17E-04	I	Quarterly	Quarterly	Semi-annual
PTX08-1007	-1.04E-06	S	Annual	-6.10E-07	S	Annual	Biennial	Annual
PTX08-1008	-8.27E-07	PD	Annual	-3.54E-07	PD	Annual	Annual	Semi-annual
PTX08-1009	--	--	--	-7.55E-07	ND	Annual	Biennial	Semi-annual
PTX10-1013	--	N/A	Annual	2.12E-07	S	Annual	Biennial	Inactive
PTX10-1014	--	N/A	Annual	--	N/A	Annual	Annual	Semi-annual

Notes:

1. 'Recent' concentration rate of change and MK trends are calculated from data collected 2008 - 2011.
2. MK = Mann Kendall Trend; D = Decreasing, PD = Probably Decreasing, S = Stable, NT = No Trend, PI = Probably Increasing, I = Increasing, ND = Non-detect, N/A = insufficient data, less than 4 sample events for time interval indicated.
3. Overall rate of change and MK trend are for the full data set (2000-2011) for each well.
4. MAROS Recommended Sampling Frequency is the sampling frequency from MAROS based on both recent and overall trends.
5. Current sampling frequency is the approximate sampling frequency currently implemented.
6. The final recommended sampling frequency is based on a combination of qualitative and statistical evaluations.
7. * = Well is dry or intermittently dry. Dry wells should be evaluated periodically for saturation.
8. Current sampling frequency from 2009 LTM Report (B&WPantex, 2009)

TABLE 14
FINAL RECOMMENDED MONITORING NETWORK SOUTHWEST SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	TCE			Perchlorate			Sampling Recommendation	Rationale
	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF		
Southwest Sector								
1114-MW4	100%	S	0.19	100%	S	0.19	Annual	Monitors area of high TCE and Perchlorate
PTX06-1006	20%	S	0.16	100%	D	0.16	Annual	Perchlorate plume, monitors decreasing trends.
PTX06-1007	0%	ND	0.50	100%	NT	0.50	Annual	Defines edge of perchlorate plume, stable trends.
PTX06-1008*	100%	S	0.27	50%	NT	0.27	Annual	Zone 11 - delineate plumes for Cr, TCE, Perchlorate
PTX06-1012	100%	I	0.21	92%	NT	0.21	Semi-annual	Defines area of high concentrations for TCE and perchlorate. Monitors ISB remedy effectiveness.
PTX06-1035	0%	ND	0.47	73%	I	0.47	Annual	Delineates plume to TCE non-detect at southern edge. Perchlorate detections.
PTX06-1036*	0%	ND	0.00	0%	ND	0.00	Annual	Delineates southern edge of plume, monitors movement of COCs from south of Zones 11 and 12 toward southern edge of perched unit.
PTX06-1052*	0%	ND	0.09	0%	N/A	0.09	Annual	Monitors chromium high concentration area.
PTX06-1053*	0%	ND	0.49	0%	ND	0.49	Annual	Delineates 4ADNT plume to south, near groundwater flow divide, early warning for movement of COCs to south/southeastern extent of perched groundwater.
PTX06-1073A	100%	N/A	0.48	0%	N/A	0.48	5 years	Dry - sample for saturation
PTX06-1077A	75%	D	0.57	100%	S	0.57	Annual	Delineated edge of perchlorate and TCE plume to north.
PTX06-1085	0%	N/A	--	--	--	--	Biennial	Delineates perched unit to the west of Playa 2, largely non-detect for all COCs.
PTX06-1086	0%	N/A	--	--	--	--	Biennial	Delineates western edge of plume, largely non-detect, reduce monitoring frequency.
PTX06-1126	100%	I	0.23	100%	D	0.23	Semi-annual	Monitors spread of TCE plume.
PTX06-1127	100%	D	0.33	100%	D	0.33	Semi-annual	Monitors spread of TCE plume, decreasing trends.

See notes end of table.

TABLE 14
FINAL RECOMMENDED MONITORING NETWORK SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
 Carson County, Texas

Well Name	TCE			Perchlorate			Sampling Recommendation	Rationale
	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF		
Southwest Sector								
PTX06-1131	0%	ND	--	--	--	--	Annual	Downgradient well, largely non-detect
PTX06-1134	0%	ND	0.56	100%	NT	0.56	Semi-annual	Delineates TCE plume to the southwest, some perchlorate detections
PTX06-1148	67%	NT	0.36	100%	I	0.36	Semi-annual	Monitors area south of Zone 11/12 near divide. Monitors increasing perchlorate trend.
PTX06-1149	17%	S	0.43	83%	I	0.43	Semi-annual	Monitors area south of Zone 11/12 near divide. Monitors increasing perchlorate trend.
PTX06-1150	50%	NT	0.21	100%	I	0.21	Semi-annual	Monitors area south of Zone 11/12 near divide. Monitors increasing perchlorate trend.
PTX06-1151	100%	I	0.16	100%	D	0.16	Semi-annual	Monitors area of increasing TCE trends.
PTX06-1155	100%	NT	0.31	78%	PD	0.31	Semi-annual	Monitors ISB remedy effectiveness.
PTX06-1156	100%	S	0.36	78%	S	0.36	Semi-annual	Monitors ISB remedy effectiveness.
PTX07-1Q01	0%	N/A	--	--	--	--	Biennial	Uncertainty management
PTX07-1Q02	0%	N/A	--	--	--	--	Biennial	Uncertainty management
PTX07-1Q03	0%	N/A	--	--	--	--	Biennial	Uncertainty management
PTX08-1003	50%	NT	0.40	100%	D	0.40	Annual	Monitors area north of Zone 11, perchlorate delineation
PTX08-1005	100%	PI	0.50	100%	NT	0.50	Semi-annual	Defines area of high concentrations for TCE and perchlorate.
PTX08-1006	100%	I	0.46	100%	NT	0.46	Semi-annual	Defines area of high concentrations for TCE and perchlorate
PTX08-1007	100%	S	0.50	25%	S	0.50	Annual	Delineates edge of TCE plume, largely stable trends. Chromium plume.
PTX08-1008*	75%	S	0.61	38%	PD	0.61	Annual	Chromium monitoring location near potential source.
PTX08-1009*	38%	NT					Annual	Delineates plume south of Zone 12
PTX10-1013	100%	N/A	0.18	100%	N/A	0.18	NA	Inactive - replaced by PTX1014
PTX10-1014*	100%	N/A	0.18	50%	N/A	0.18	Annual	SE and SW source area

Notes:

1. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend; NT = No Trend; ND = well has all non-detect results for COC indicated. NA = Not applicable, no longer in active.
2. Mann-Kendall trends for 2008 - 2011 are shown.
3. SF = Slope Factor. SF close to 1 indicates well provides unique information in network. SF near 0 indicates well may be redundant.
4. * = Well also evaluated for other Sectors.



TABLE 15
MONITORING WELL TREND SUMMARY RESULTS NORTH SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend
RDX North Sector								
OW-WR-38	3	3	100%	2.96	No	2.6	No	N/A
PTX01-1001	9	1	11%	0.245	No	0.2	No	S
PTX01-1002	6	0	0%	ND	No	ND	No	ND
PTX01-1008	9	0	0%	ND	No	ND	No	ND
PTX04-1001	1	0	0%	ND	No	ND	No	ND
PTX04-1002	6	3	50%	0.23	No	0.22	No	S
PTX06-1013	9	9	100%	8.39	Yes	7.36	No	S
PTX06-1023	9	9	100%	3.02	No	1.73	No	S
PTX06-1048A	6	0	0%	ND	No	0.5	No	ND
PTX06-1049	5	2	40%	0.761	No	0.4	No	NT
PTX06-1050	8	8	100%	282	Yes	194	Yes	D
PTX06-1069	5	0	0%	ND	No	ND	No	ND
PTX06-1071	1	0	0%	ND	No	ND	No	ND
PTX06-1080	5	0	0%	ND	No	ND	No	ND
PTX06-1081	6	0	0%	ND	No	ND	No	ND
PTX06-1117	2	1	50%	27	Yes	13.8	Yes	N/A
PTX06-1136	5	0	0%	ND	No	ND	No	ND
PTX07-1O01	7	7	100%	26	Yes	21.6	Yes	S
PTX07-1O02	8	7	88%	1.61	No	0.638	No	PD
PTX07-1O03	5	5	100%	27.9	Yes	24.3	Yes	S
PTX07-1P02	6	6	100%	3.17	No	1.12	No	S
PTX07-1P05	3	3	100%	10.6	Yes	9.27	Yes	N/A
PTX07-1P06	1	1	100%	5.98	No	5.98	No	N/A
PTX07-1R03	1	0	0%	ND	No	ND	No	ND
PTX08-1001	5	5	100%	16.6	Yes	5.24	No	NT
PTX08-1002	7	7	100%	168	Yes	61.9	Yes	I
PTX08-1010	5	2	40%	0.729	No	0.34	No	NT
PTX-BEG3	4	0	0%	ND	No	ND	No	ND

See Notes End of Table

TABLE 15
MONITORING WELL TREND SUMMARY RESULTS NORTH SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend
4ADNT North Sector								
OW-WR-38	3	0	0%	ND	No	ND	No	ND
PTX01-1001	9	0	0%	ND	No	ND	No	ND
PTX01-1002	6	0	0%	ND	No	ND	No	ND
PTX01-1008	9	0	0%	ND	No	ND	No	ND
PTX04-1001	1	0	0%	ND	No	ND	No	ND
PTX04-1002	6	0	0%	ND	No	ND	No	ND
PTX06-1013	9	0	0%	ND	No	ND	No	ND
PTX06-1023	8	0	0%	ND	No	ND	No	ND
PTX06-1048A	6	3	50%	0.18	No	0.19	No	D
PTX06-1049	5	3	60%	2.32	Yes	1.03	No	NT
PTX06-1050	8	8	100%	7.76	Yes	3.72	Yes	NT
PTX06-1069	5	0	0%	ND	No	ND	No	ND
PTX06-1071	1	0	0%	ND	No	ND	No	ND
PTX06-1080	5	0	0%	ND	No	ND	No	ND
PTX06-1081	6	0	0%	ND	No	ND	No	ND
PTX06-1117	2	0	0%	ND	No	ND	No	ND
PTX06-1136	5	0	0%	ND	No	ND	No	ND
PTX07-1O01	7	6	86%	0.55	No	0.33	No	PD
PTX07-1O02	8	0	0%	ND	No	ND	No	ND
PTX07-1O03	5	0	0%	ND	No	ND	No	ND
PTX07-1P02	6	0	0%	ND	No	ND	No	ND
PTX07-1P05	3	0	0%	ND	No	ND	No	ND
PTX07-1P06	1	0	0%	ND	No	ND	No	ND
PTX07-1R03	1	0	0%	ND	No	ND	No	ND
PTX08-1001	5	0	0%	ND	No	ND	No	ND
PTX08-1002	5	4	80%	11	Yes	3.56	Yes	NT
PTX08-1010	5	0	0%	ND	No	ND	No	ND
PTX-BEG3	4	4	100%	0.64	No	0.553	No	NT

See Notes End of Table



TABLE 15
MONITORING WELL TREND SUMMARY RESULTS NORTH SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend
Perchlorate North Sector								
PTX01-1001	9	4	44%	5.03	No	5.42	No	I
PTX01-1002	6	0	0%	ND	No	ND	No	ND
PTX01-1008	8	0	0%	ND	No	ND	No	ND
PTX04-1002	4	0	0%	ND	No	ND	No	ND
PTX06-1023	4	0	0%	ND	No	ND	No	ND
PTX06-1048A	4	0	0%	ND	No	ND	No	ND
PTX06-1069	3	0	0%	ND	No	ND	No	ND
PTX06-1080	4	0	0%	ND	No	ND	No	ND
PTX06-1081	4	0	0%	ND	No	ND	No	ND
PTX06-1117	2	0	0%	ND	No	ND	No	ND
PTX07-1P02	5	1	20%	4.03	No	5.61	No	S
PTX07-1P05	3	1	33%	0.07	No	4.02	No	N/A
PTX07-1P06	1	0	0%	ND	No	ND	No	ND
PTX08-1001	5	5	100%	64.0	Yes	35.9	Yes	D
PTX08-1010	4	0	0%	ND	No	ND	No	ND
PTX-BEG3	4	0	0%	ND	No	ND	No	ND

See Notes End of Table

TABLE 15
MONITORING WELL TREND SUMMARY RESULTS NORTH SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2008 - 2011)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend
TCE North Sector								
OW-WR-38	3	2	67%	0.42	No	0.42	No	N/A
PTX01-1001	9	9	100%	1.29	No	0.82	No	PD
PTX01-1002	6	0	0%	ND	No	ND	No	ND
PTX01-1008	9	0	0%	ND	No	ND	No	ND
PTX04-1001	1	1	100%	0.48	No	0.48	No	N/A
PTX04-1002	6	5	83%	0.83	No	0.54	No	PI
PTX06-1013	9	0	0%	ND	No	ND	No	ND
PTX06-1023	8	0	0%	ND	No	ND	No	ND
PTX06-1048A	6	5	83%	1.87	No	0.89	No	NT
PTX06-1049	6	5	83%	5.69	Yes	1.49	No	NT
PTX06-1050	8	0	0%	ND	No	ND	No	ND
PTX06-1069	5	0	0%	ND	No	ND	No	ND
PTX06-1071	1	0	0%	ND	No	ND	No	ND
PTX06-1080	5	0	0%	ND	No	ND	No	ND
PTX06-1081	6	6	100%	0.84	No	0.65	No	NT
PTX06-1117	2	0	0%	ND	No	ND	No	ND
PTX06-1136	5	1	20%	0.70	No	0.54	No	NT
PTX07-1O01	7	0	0%	ND	No	ND	No	ND
PTX07-1O02	8	8	100%	1.90	No	1.11	No	NT
PTX07-1O03	5	0	0%	ND	No	ND	No	ND
PTX07-1P02	6	0	0%	ND	No	ND	No	ND
PTX07-1P05	3	0	0%	ND	No	ND	No	ND
PTX07-1P06	1	0	0%	ND	No	ND	No	ND
PTX07-1R03	1	0	0%	ND	No	ND	No	ND
PTX08-1001	5	0	0%	ND	No	ND	No	ND
PTX08-1002	7	0	0%	ND	No	ND	No	ND
PTX08-1010	5	0	0%	ND	No	ND	No	ND
PTX-BEG3	4	1	25%	0.407	No	0.477	No	NT

Notes

- Only wells where the COC indicated was detected are shown. Trends were evaluated for data collected between January 2008 and December 2011.
- Number of Samples is the number of samples for the compound at this location during 2008 - 2011.
 Number of Detects is the number of samples where the compound was detected at this location.
- The maximum concentration for the COC is the maximum analytical result analyzed between 2008 and 2011. Results above MSCs are indicated in **Bold**.
- MSCs = Medium Specific Concentration from Corrective Measure Study. RDX = 7.7 ug/L; 4ADNT = 1.2 ug/L; TCE = 5ug/L; Cr = 100 ug/L;
 Perchlorate = 26ug/L.
- No exceedances of Cr(VI) were found in North Sector wells.
- D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
 NT = No Trend; ND = well has all non-detect results for COC; ND* = one detection for compound, may be unaffected.



TABLE 16
FINAL RECOMMENDED GROUNDWATER MONITORING NETWORK NORTH SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
 Carson County, Texas

Well Name	Priority COPC	Maximum Above MSC?	MK Trend	Sampling Frequency Recommendation	Rationale
North Sector					
OW-WR-38	Chromium, Total*	Yes	N/A	Annual	Chromium results may be an artifact of well construction. Sample Boron and RDX until statistically significant sample size attained.
PTX01-1001	Chromium, Total*	Yes	D	Annual	Chromium results may be an artifact of well construction. Monitors area around SWMU 28-36, isolated perched groundwater in area, low level detections of perchlorate and
PTX01-1002	None	No	--	Annual	Monitors area around SWMU 28-36, isolated perched groundwater in area, perchlorate statistically below MSCs.
PTX01-1008	None	No	--	Annual	Monitors area around SWMU 28-36, isolated perched groundwater in area, low level detections of TCE.
PTX04-1001	None	No	--	Annual	Detections of COCs below MSCs. Monitors SWMU 140, NE corner of DOE property.
PTX04-1002	None	No	--	Annual	Detections of TCE and RDX below MSCs. Monitors SWMU 140, NE corner of DOE property.
PTX06-1013	Boron	No	I	Annual	Edge of perched unit east of Playa 1. Monitor for boron and RDX.
PTX06-1023	Boron	No	D	Annual	Edge of perched unit east of Playa 1. Monitor for boron and RDX.
PTX06-1048A	None	No	--	Annual	Low level detections of TCE; Delineates north/northeast of perched unit.
PTX06-1049	4ADNT	No	NT	Annual	Recent increase in 4ADNT west of Playa 1. Monitor for plume stability.
PTX06-1050	RDX	No	D	Annual	Monitors area northwest of Playa 1, area of highest concentration in North Sector.
PTX06-1069	None	No	--	Annual	Monitors eastern extent of perched unit. Continue to monitor for plume stability.
PTX06-1071	None	No	--	Annual	Unaffected. Monitors SWMU 140, NE corner of DOE property.
PTX06-1080	None	No	--	Biennial	No confirmed detections of COPCs, Monitors SWMU 140, NE corner of DOE property.
PTX06-1081	None	No	--	Annual	TCE detected below MSCs. Monitors SWMU 140, NE corner of DOE property.
PTX06-1117	Chromium, Total*	Yes	N/A	Inactive	Chromium results may be an artifact of well construction. Sample for RDX until reaching a statistically significant sample size.
PTX06-1136	None	No	--	Annual	Delineates RDX plume west of PTX06-1050.

See Notes End of Table

TABLE 16
FINAL RECOMMENDED GROUNDWATER MONITORING NETWORK NORTH SECTOR
LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Priority COPC	Maximum Above MSC?	MK Trend	Sampling Frequency Recommendation	Rationale
North Sector					
PTX07-1001	RDX	Yes	S	Annual	Monitors SWMU 68b. Continue monitoring to characterize RDX plume in this area.
PTX07-1002	Chromium, Total*	Yes	N/A	Annual	Chromium results may be an artifact of well construction. Monitors SWMU 68b. Sample to characterize Cr(VI) plume in this area.
PTX07-1003	RDX	Yes	--	Annual	Monitors SWMU 68b. Continue monitoring to characterize RDX plume in this area.
PTX07-1P02	RDX	Yes	S	Annual	Monitor RDX plume west of Playa 1.
PTX07-1P05	RDX	Yes	N/A	Annual	Monitor RDX plume west of Playa 1.
PTX07-1P06	RDX	Yes	N/A	Annual	Monitor RDX plume west of Playa 1.
PTX07-1R03	None	No	--	Biennial	Monitors isolated area of groundwater.
PTX08-1001	RDX	Yes	NT	Annual	Monitor RDX and boron plumes south of Playa 1.
PTX08-1002	RDX	Yes	I	Annual	Increasing high trend for RDX. Monitor for plume stabilization.
PTX08-1010	None	No	--	Annual	Sporadic trace detections of COPCs, detections of HMX below MSCs, Monitors SWMU 140, NE corner of DOE property.
PTX-BEG3	None	No	--	Inactive	Inactive

Notes:

1. MSC = Medium Specific Concentration.
2. Student's T-test identifies groundwater statistically below MSC. N/C = Not calculated.
3. Sequential T-test identifies groundwater that has statistically achieved cleanup with high confidence. Attained = groundwater has attained cleanup; Continue Sampling = dataset does not achieve statistical significance; Not Attained = groundwater above limit.
4. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend; NT = No Trend; ND = well has all non-detect results for COC indicated; N/C not calculated.
5. Mann-Kendall trends for 2008 - 2011 are shown.
6. * = Chromium detections may be artifacts of corrosion in stainless steel wells.

TABLE 17
SUMMARY MONITORING NETWORK RECOMMENDATIONS

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

IndicatorArea	Well Locations	Primary COC at Well	MAROS Analysis Area	LTM Objectives	Frequency Analysis Result
Burning Ground	PTX01-1001	TOTAL CHROMIUM*	North	UM	Annual
Burning Ground	PTX01-1002	None	North	UM	Annual
Burning Ground	PTX01-1004	None	North	PS	Dry
Burning Ground	PTX01-1008	None	North	UM	Annual
Burning Ground	PTX01-1009	None	North	PS	Dry
ISPM Southeast	PTX06-1037	RDX	Southeast	RA	Semi-annual
ISPM Southeast	PTX06-1045	RDX	Southeast	RA	Semi-annual
ISPM Southeast	PTX06-1118	RDX	Southeast	RA	Annual/Dry
ISPM Southeast	PTX06-1123	RDX	Southeast	RA	Semi-annual
ISPM Southeast	PTX06-1153	RDX	Southeast	RA	Semi-annual
ISPM Southeast	PTX06-1154	RDX	Southeast	RA	Semi-annual
ISPM Zone 11	PTX06-1012	TCE	Southwest	PS, RA	Semi-annual
ISPM Zone 11	PTX06-1155	TCE	Southwest	RA	Semi-annual
ISPM Zone 11	PTX06-1156	PERCHLORATE	Southwest	RA	Semi-annual
Miscellaneous	PTX04-1001	None	North	UM	5 yrs
Miscellaneous	PTX04-1002	None	North	UM	Annual
Miscellaneous	PTX06-1049	4ADNT	North	PS, UM	Annual
Miscellaneous	PTX06-1055	None	North	PS	Dry
Miscellaneous	PTX06-1071	None	North	UM	5 yrs
Miscellaneous	PTX06-1080	None	North	UM	5 yrs
Miscellaneous	PTX06-1081	None	North	UM	Annual
Miscellaneous	PTX06-1082	None	PantexLake	UM	5 yrs
Miscellaneous	PTX06-1083	None	PantexLake	UM	5 yrs
Miscellaneous	PTX06-1085	None	Southwest	UM	Biennial
Miscellaneous	PTX06-1086	None	Southwest	UM	Biennial
Miscellaneous	PTX06-1131	None	Southwest	UM	Annual
Miscellaneous	PTX07-1Q01	None	Southwest	UM	Biennial
Miscellaneous	PTX07-1Q02	None	Southwest	UM	Biennial
Miscellaneous	PTX07-1Q03	None	Southwest	UM	Biennial
Miscellaneous	PTX07-1R03	None	North	UM	5 yrs
Miscellaneous	PTX08-1010	BORON	North	UM	5 yrs
North	OW-WR-38	TOTAL CHROMIUM*	North	UM, RA	Annual
North	PTX06-1048A	None	North	PS, RA	Annual
North	PTX06-1050	RDX	North	UM, RA	Annual
North	PTX06-1136	1,2-DCE	North	PS	Annual
North	PTX07-1O01	RDX	North	PS, UM, RA	Annual
North	PTX07-1O02	1,4-DIOXANE (P-DIOXANE)	North	PS, UM, RA	Annual
North	PTX07-1O03	RDX	North	PS, UM, RA	Annual
North	PTX07-1O06		North	PS, UM, RA	Annual

TABLE 17
SUMMARY MONITORING NETWORK RECOMMENDATIONS

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

IndicatorArea	Well Locations	Primary COC at Well	MAROS Analysis Area	LTM Objectives	Frequency Analysis Result
Southeast	PTX06-1002A	RDX	Southeast	UM, RA	Annual
Southeast	PTX06-1003	RDX	Southeast	UM, RA	Annual
Southeast	PTX06-1005	RDX	Southeast	UM, RA	Annual
Southeast	PTX06-1010	TOTAL CHROMIUM	Southeast	UM	Annual
Southeast	PTX06-1013	BORON	North/Southeast	RA	Annual
Southeast	PTX06-1014	RDX	Southeast	RA	Annual
Southeast	PTX06-1015	RDX	Southeast	RA	Annual
Southeast	PTX06-1023	BORON	North/Southeast	RA	Annual
Southeast	PTX06-1030	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1031	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1034	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1036	RDX	Southwest/Southeast	PS	Annual
Southeast	PTX06-1038	RDX	Southeast	RA	Annual
Southeast	PTX06-1039A	RDX	Southeast	RA	Annual
Southeast	PTX06-1040	RDX	Southeast	RA	Annual
Southeast	PTX06-1041	RDX	Southeast	RA	Annual
Southeast	PTX06-1042	RDX	Southeast	RA	Annual
Southeast	PTX06-1046	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1047A	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1051	None	SSoutheast	PS	Dry
Southeast	PTX06-1052	TOTAL CHROMIUM	Southwest/Southeast	RA	Semi-annual
Southeast	PTX06-1069	None	North/Southeast	PS	Annual
Southeast	PTX06-1088	RDX	Southeast	UM, RA	Annual
Southeast	PTX06-1089	None	Southeast	PS	Dry
Southeast	PTX06-1093	None	Southeast	PS	Dry
Southeast	PTX06-1094	None	Southeast	PS	Dry
Southeast	PTX06-1095A	RDX	Southeast	UM, RA	Semi-annual
Southeast	PTX06-1098	ARSENIC	Southeast	RA	Annual
Southeast	PTX06-1100	None	Southeast	RA	Biennial
Southeast	PTX06-1101	None	Southeast	RA	Biennial
Southeast	PTX06-1102	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1103	RDX	Southeast	RA	Semi-annual
Southeast	PTX06-1120	RDX	Southeast	PS	Semi-annual
Southeast	PTX06-1121	RDX	Southeast	PS	Semi-annual
Southeast	PTX06-1124	None	Southeast	PS	Dry
Southeast	PTX06-1125	None	Southeast	PS	Dry
Southeast	PTX06-1130	RDX	Southeast	RA	Annual
Southeast	PTX06-1133A	None	Southeast	PS	Annual
Southeast	PTX06-1135	2ADNT	Southeast	PS	Annual
Southeast	PTX06-1146	RDX	Southeast	PS	Semi-annual
Southeast	PTX06-1147	RDX	Southeast	PS	Semi-annual
Southeast	PTX08-1002	RDX	North/Southeast	UM, RA	Annual
Southeast	PTX08-1009	4ADNT	Southwest/Southeast	UM, RA	Annual
Southeast, Zone 11	PTX06-1008	TOTAL CHROMIUM	Southwest/Southeast	UM	Annual
Southeast, Zone 11	PTX06-1011	TOTAL CHROMIUM	Southeast	UM	Annual
Southeast, Zone 11	PTX06-1053	4ADNT	Southwest/Southeast	PS, UM	Annual
Southeast, Zone 11	PTX08-1007	TOTAL CHROMIUM	Southwest/Southeast	UM	Annual
Southeast, Zone 11	PTX08-1008	HEXAVALENT CHROMIUM	Southwest/Southeast	UM, RA	Annual
Southeast, Zone 11	PTX10-1014	TCE	Southwest/Southeast	UM	Annual

TABLE 17
SUMMARY MONITORING NETWORK RECOMMENDATIONS

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

IndicatorArea	Well Locations	Primary COC at Well	MAROS Analysis Area	LTM Objectives	Frequency Analysis Result
Zone 11	1114-MW4	TCE	Southwest	UM	Annual
Zone 11	PTX06-1006	TOTAL CHROMIUM	Southwest	PS	Annual
Zone 11	PTX06-1007	TOTAL CHROMIUM	Southwest	UM	Annual
Zone 11	PTX06-1035	4ADNT	Southwest	PS	Annual
Zone 11	PTX06-1073A	TCE	Southwest	PS	Dry
Zone 11	PTX06-1077A	TCE	Southwest	UM	Annual
Zone 11	PTX06-1126	TCE	Southwest	PS, UM	Semi-annual
Zone 11	PTX06-1127	PERCHLORATE	Southwest	PS, UM	Semi-annual
Zone 11	PTX06-1134	4ADNT	Southwest	PS	Semi-annual
Zone 11	PTX06-1148	PERCHLORATE	Southwest/Southeast	PS, RA	Semi-annual
Zone 11	PTX06-1149	PERCHLORATE	Southwest	PS	Semi-annual
Zone 11	PTX06-1150	PERCHLORATE	Southwest	PS, RA	Semi-annual
Zone 11	PTX06-1151	TCE	Southwest	PS	Semi-annual
Zone 11	PTX07-1P02	PERCHLORATE	North/Southwest	UM	Annual
Zone 11	PTX07-1P05	RDX	North/Southwest	UM	Annual
Zone 11	PTX08-1001	RDX	North/Southwest	UM, RA	Annual
Zone 11	PTX08-1003	TOTAL CHROMIUM	Southwest	PS	Annual
Zone 11	PTX08-1005	TCE	Southwest	UM	Semi-annual
Zone 11	PTX08-1006	RDX	Southwest	UM	Semi-annual
Four New Wells					
Southeast	Southeast West of ISB		Southeast	PS	Semi-annual
Southeast	Southeast far extent of perched groundwater		Southeast	PS	Annual
Zone 11	Southwest, upgradient from PTX06-1035		Southwest	PS	Annual
Zone 11	West of PTX06-1151		Southwest	PS, RA	Semi-annual

Notes:

1. Indicator area from Pantex Database 2012.
2. Priority COC from Table 1.
3. LTM Monitoring Objectives: PS = Plume Stability; UM = Uncertainty Management; RA = Response Action Effectiveness.
4. * Chromium detections most likely related to corrosion in wells constructed with stainless steel.
5. Monitoring frequency recommendation from MAROS analysis and qualitative review.

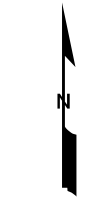
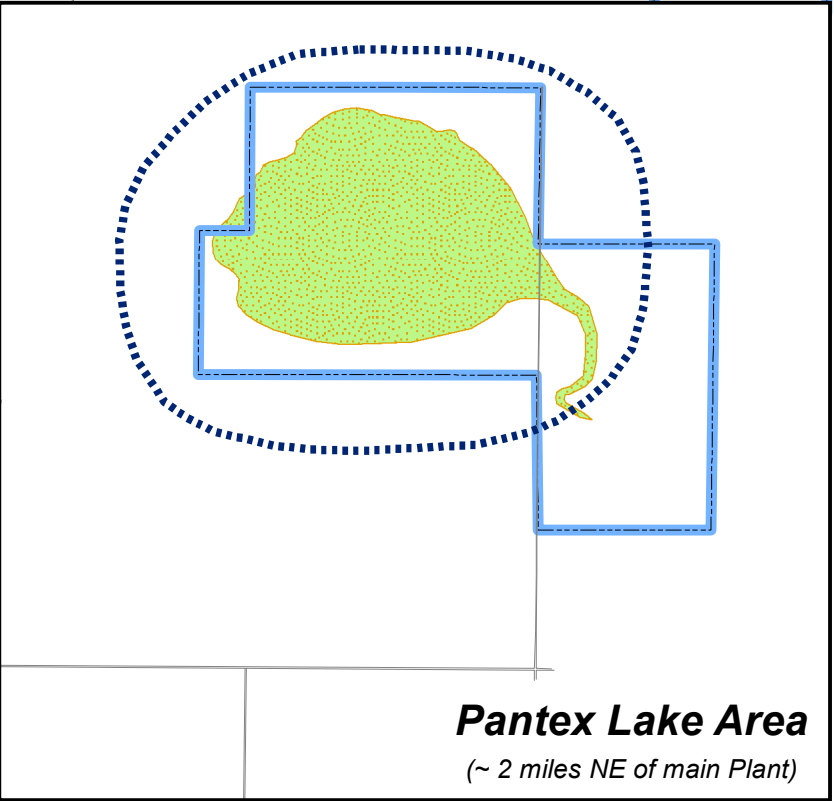
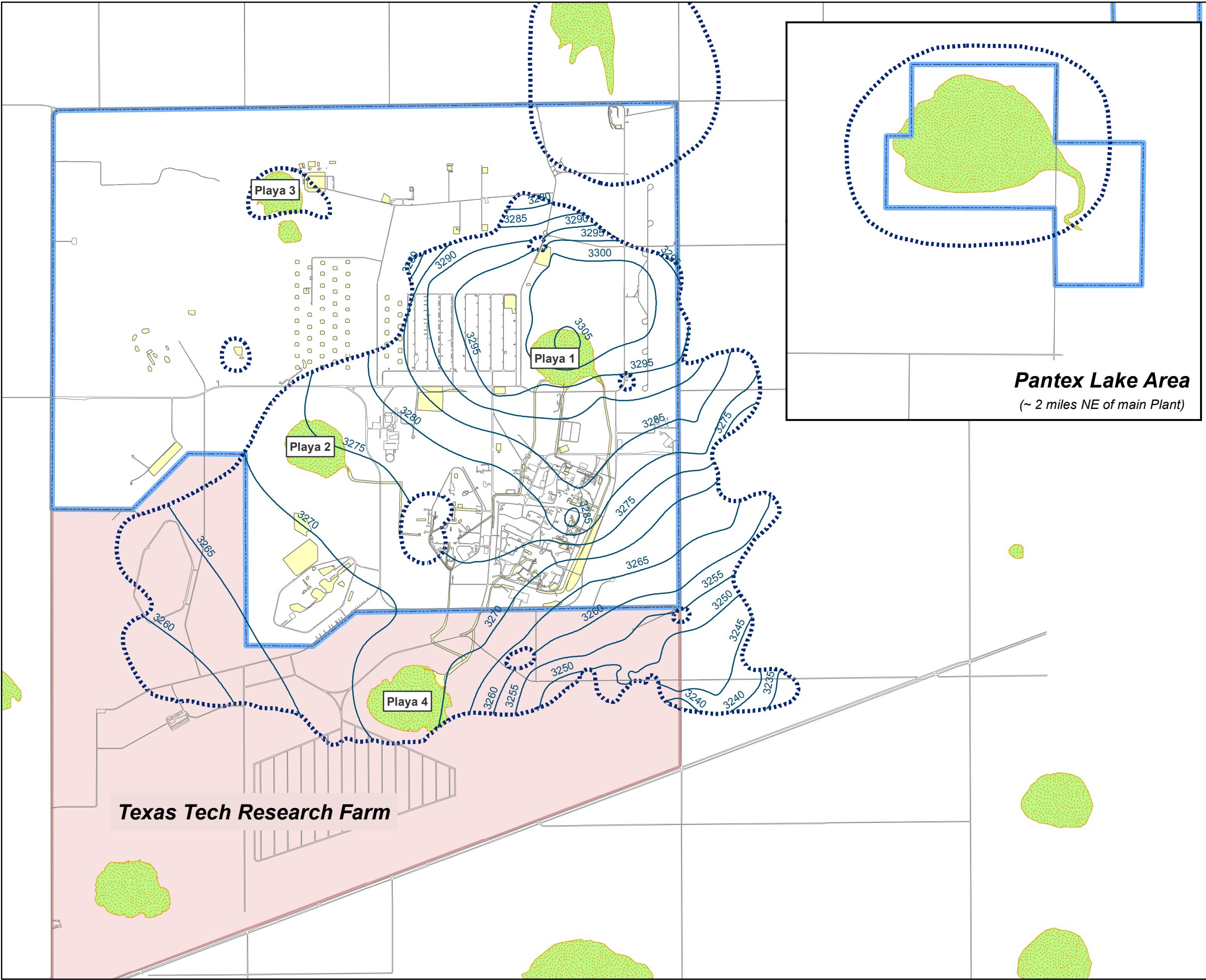
August 2012

**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

FIGURES

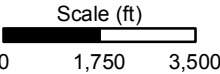
- | | |
|----------|---|
| Figure 1 | Pantex Plant Vicinity |
| Figure 2 | Pantex Perched Groundwater Investigation Well Locations |
| Figure 3 | Pantex Perched Groundwater Remedy Well Locations |
| Figure 4 | Pantex Southeast Sector Perched Groundwater: RDX Average Concentrations and Mann-Kendall Trends |
| Figure 5 | Pantex Perched Groundwater Southeast Sector RDX and 4ADNT First Moments and Mann-Kendall Trends |
| Figure 6 | Southeast Sector RDX Spatial Analysis |
| Figure 7 | Pantex Southwest Sector TCE and Perchlorate Average Concentrations and Mann-Kendall Trends |
| Figure 8 | Pantex North Sector Perched Groundwater RDX Average Concentrations and Mann-Kendall Trends |
| Figure 9 | Pantex Perched Groundwater Recommended Monitoring Network |



LEGEND

- Water Table Elevation 2011 Perched Groundwater
- Extent of Perched Water
- Pantex Roads
- USDOE Property
- Playa Lakes
- SWMU
- Texas Tech University Property

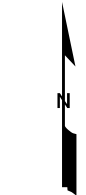
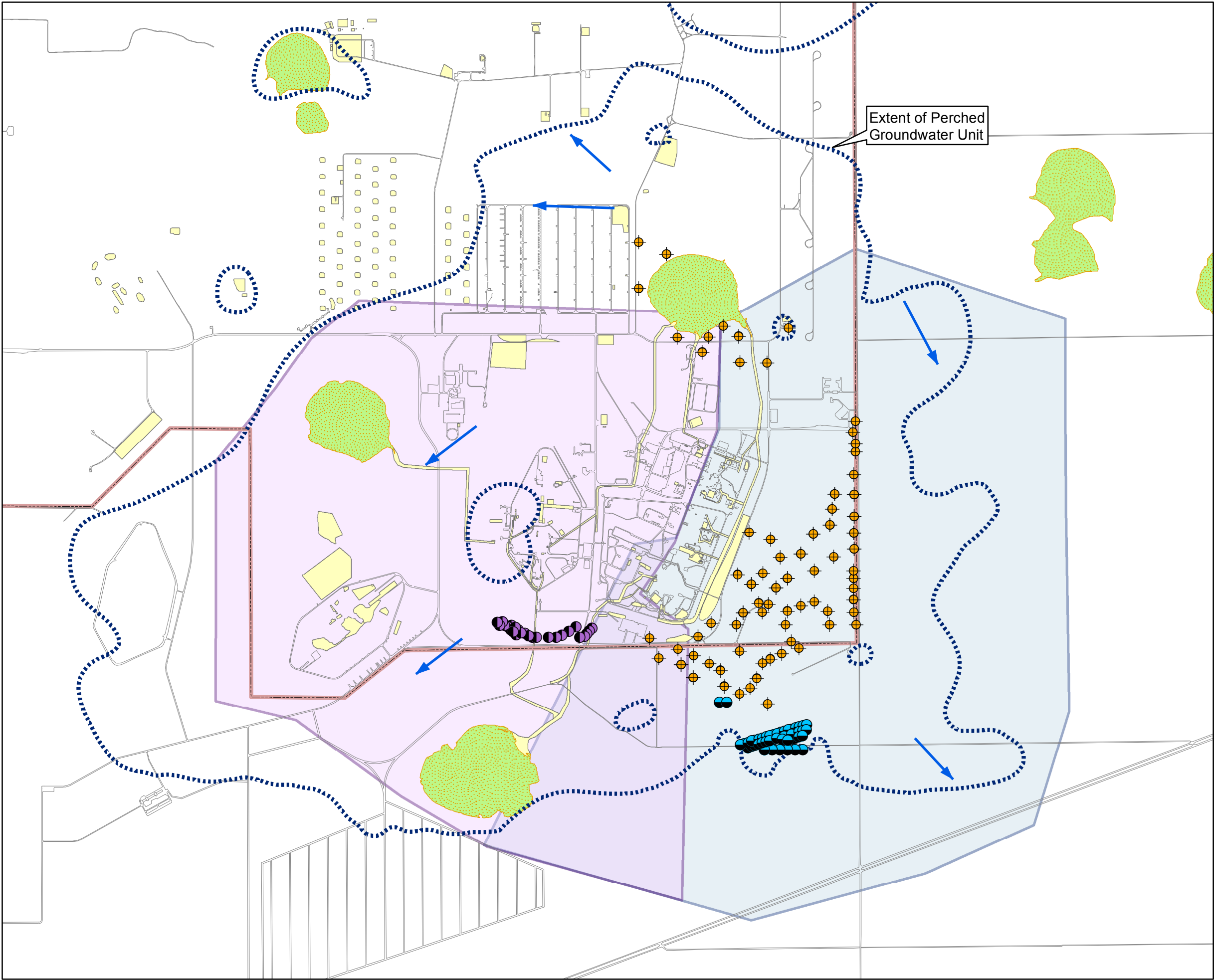
- Notes:**
- Geographic data from BWXT Pantex April 2012.
 - Perched groundwater extent and groundwater elevations from December 2011 data BWXT Pantex.
 - The Pantex Lake area is approximately 2 miles northeast of the main Plant.
 - Groundwater elevations for main plant indicated in ft. amsl.



PANTEX PLANT VICINITY

Carson County, Texas

GIS Job No.	G-3780	Issued:	30-AUG-2012
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	001_01
Appv'd By:	MV		FIGURE 1



LEGEND

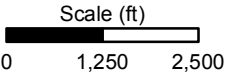
Well Groups

- Extraction Wells
- Southeast ISB
- Southwest ISB
- Investigation Wells

- Extent of Perched Water
- USDOE Property
- Playa Lakes
- SWMU
- Southwest Sector
- Southeast Sector
- Approximate Groundwater Flow Direction

Notes:

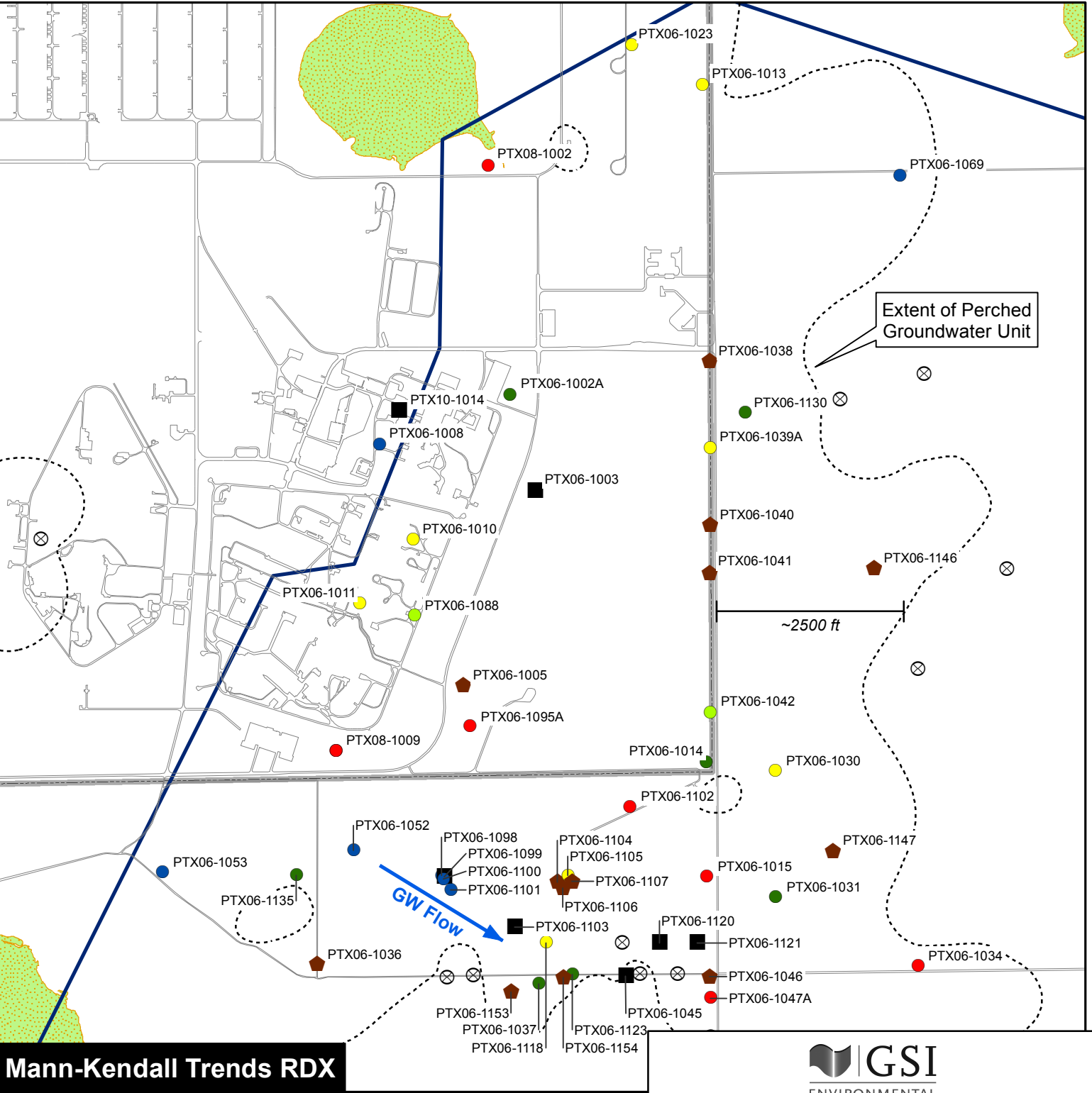
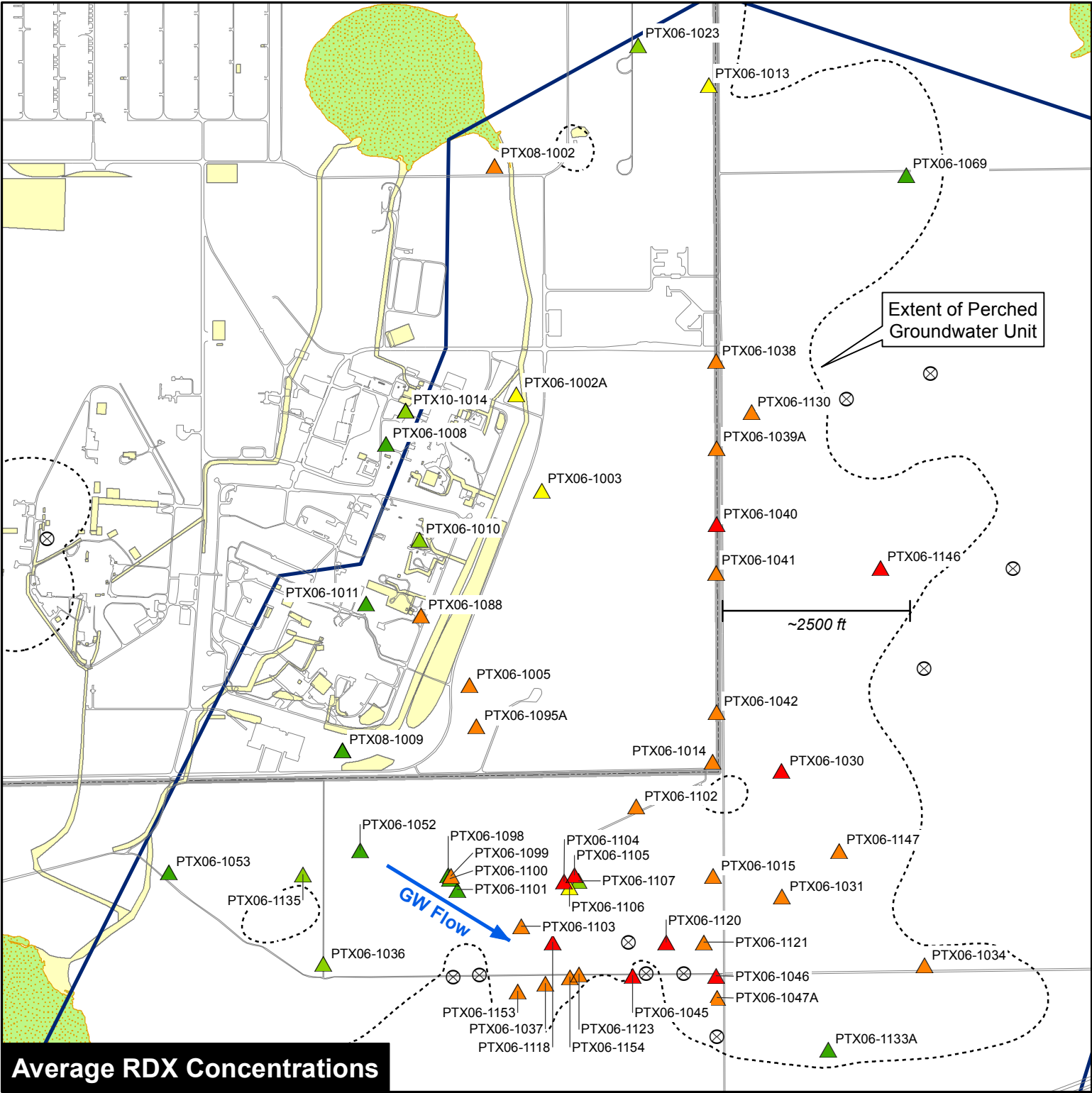
- Only investigation well locations are indicated. Well ID's for perched groundwater wells are shown.
- Approximate groundwater flow directions from 2011 potentiometric measurements.



**PANTEX PERCHED GROUNDWATER
Remedy Well Locations**

Pantex Plant
Carson County, Texas

GIS Job No.	G-3780	Issued:	30-AUG-2012
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	001_03
Appv'd By:	MV	FIGURE 3	



LEGEND

Average RDX Concentration [mg/L]

- ▲ ND - 0.001
- ▲ 0.001 - 0.007
- ▲ 0.007 - 0.05
- ▲ 0.05 - 1.0
- ▲ > 1.0

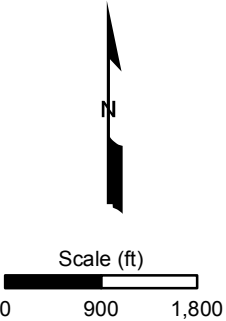
Mann-Kendall Trend RDX

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2008-2011)
- No Trend
- Insufficient Data
- ⊗ Dry Wells

Notes:

1. Average RDX concentrations calculated using lowest detection limit substituted for ND values. Data 2008-2011.
2. Mann-Kendall trends were determined for RDX 2008-2011.
3. Investigation wells are labeled with their well ID. Extraction wells are not labeled.
4. See Pantex Vicinity legend for description of site features.

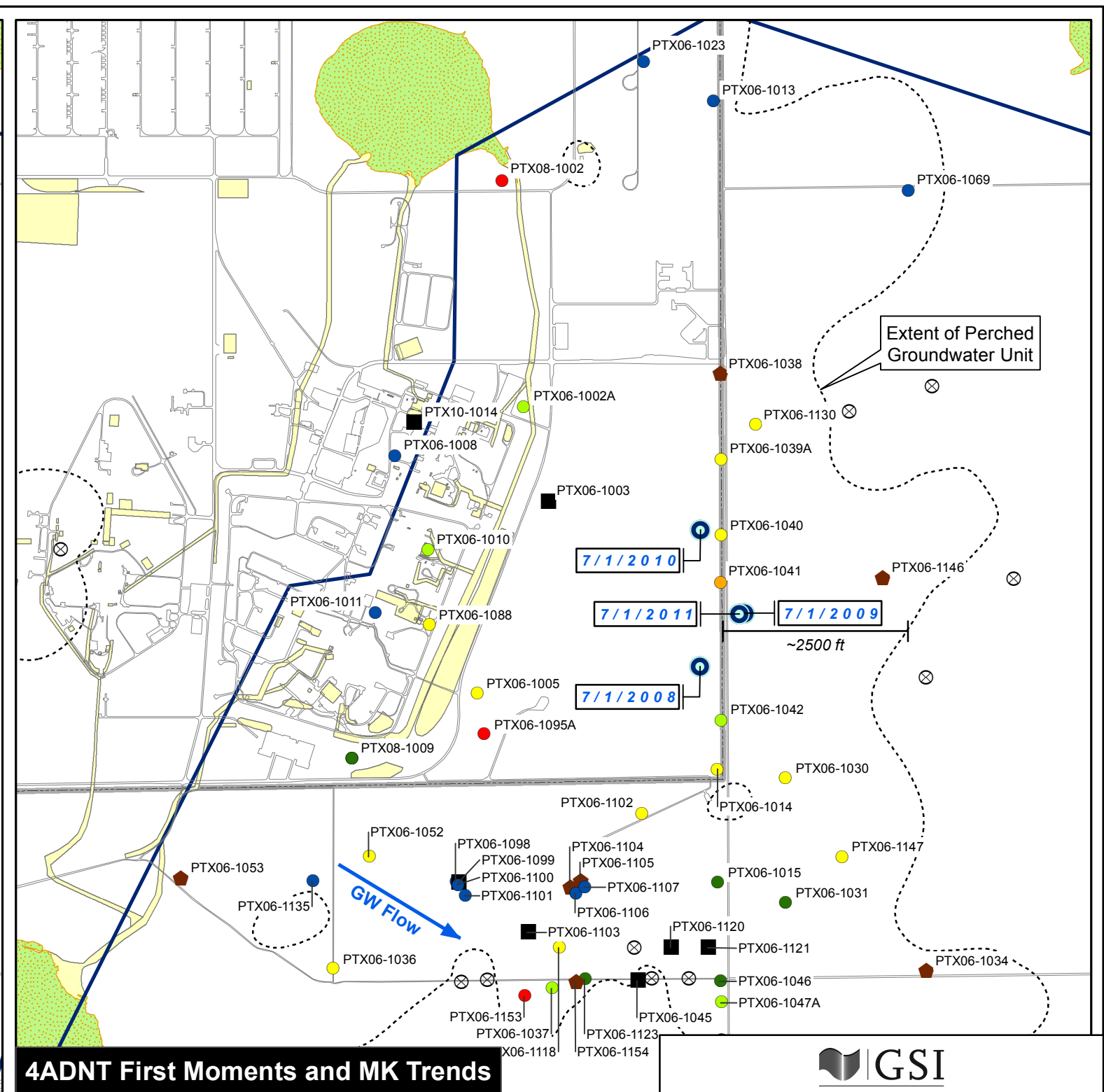
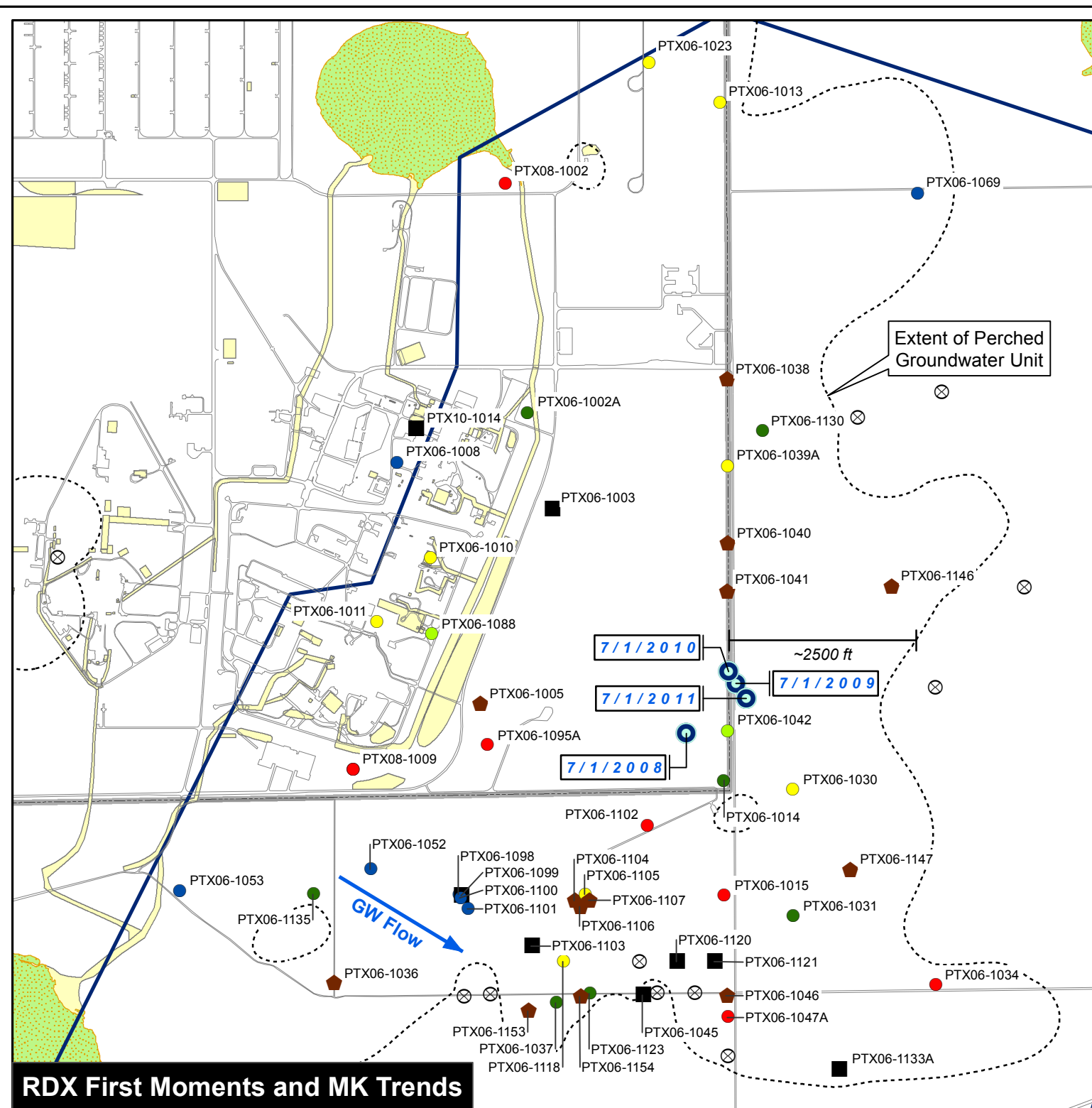
RRS 2 RDX = 0.0077 mg/L



PANTEX SOUTHEAST SECTOR
PERCHED GROUNDWATER:
RDX Average Concentrations and
Mann-Kendall Trends

Pantex Plant
Carson County, Texas

GIS Job No.	G-3780	Issued:	30-AUG-2012
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	001_04
App'd By:	MV		FIGURE 4



LEGEND

- ⊗ Dry Wells Perched Unit
- ⊙ First Moments
(Center of Mass)

Mann-Kendall Trend

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2008-2011)
- No Trend
- Insufficient Data

- Non Detect (2008-2011)
- No Trend
- Insufficient Data

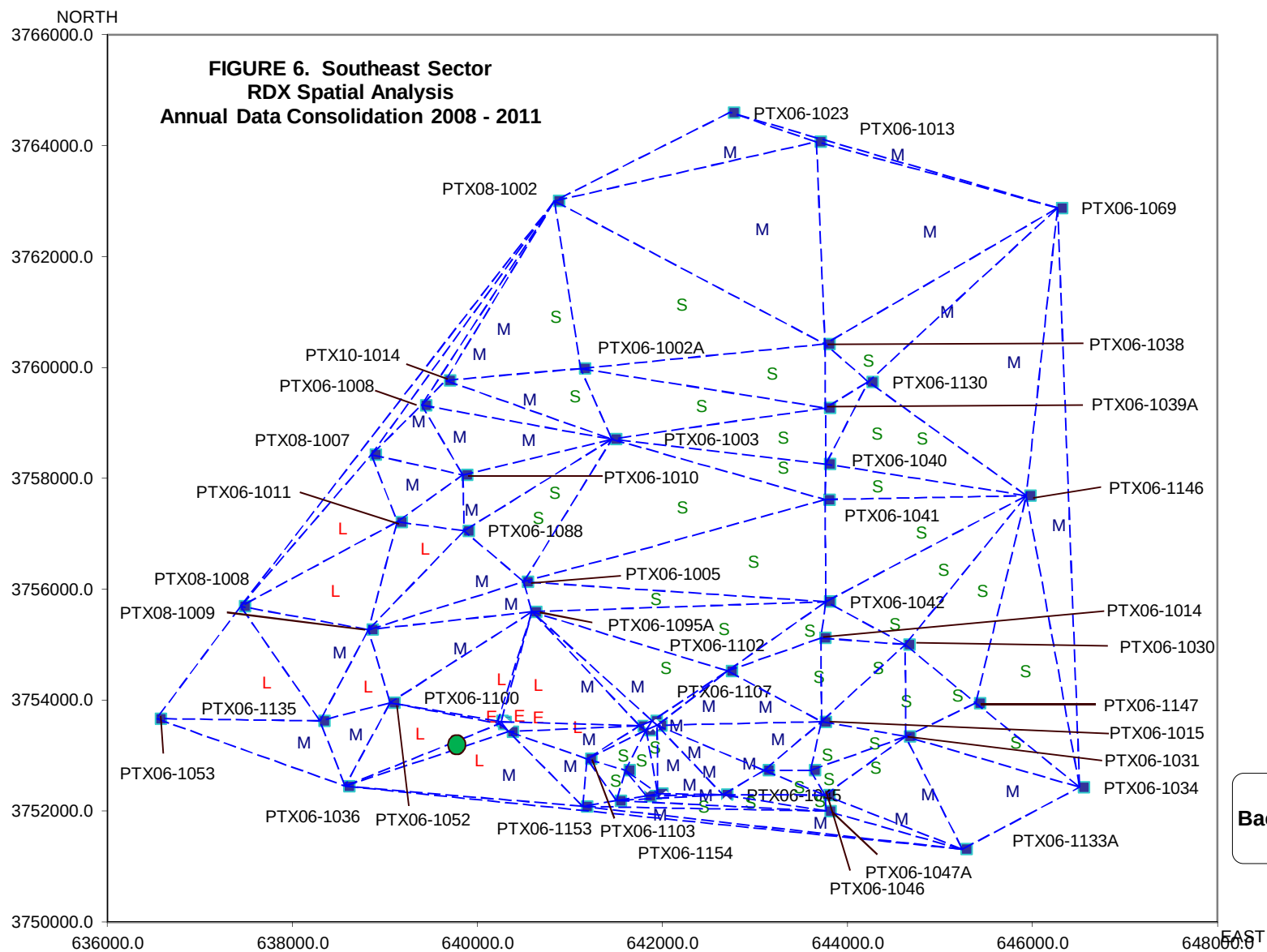
Notes:

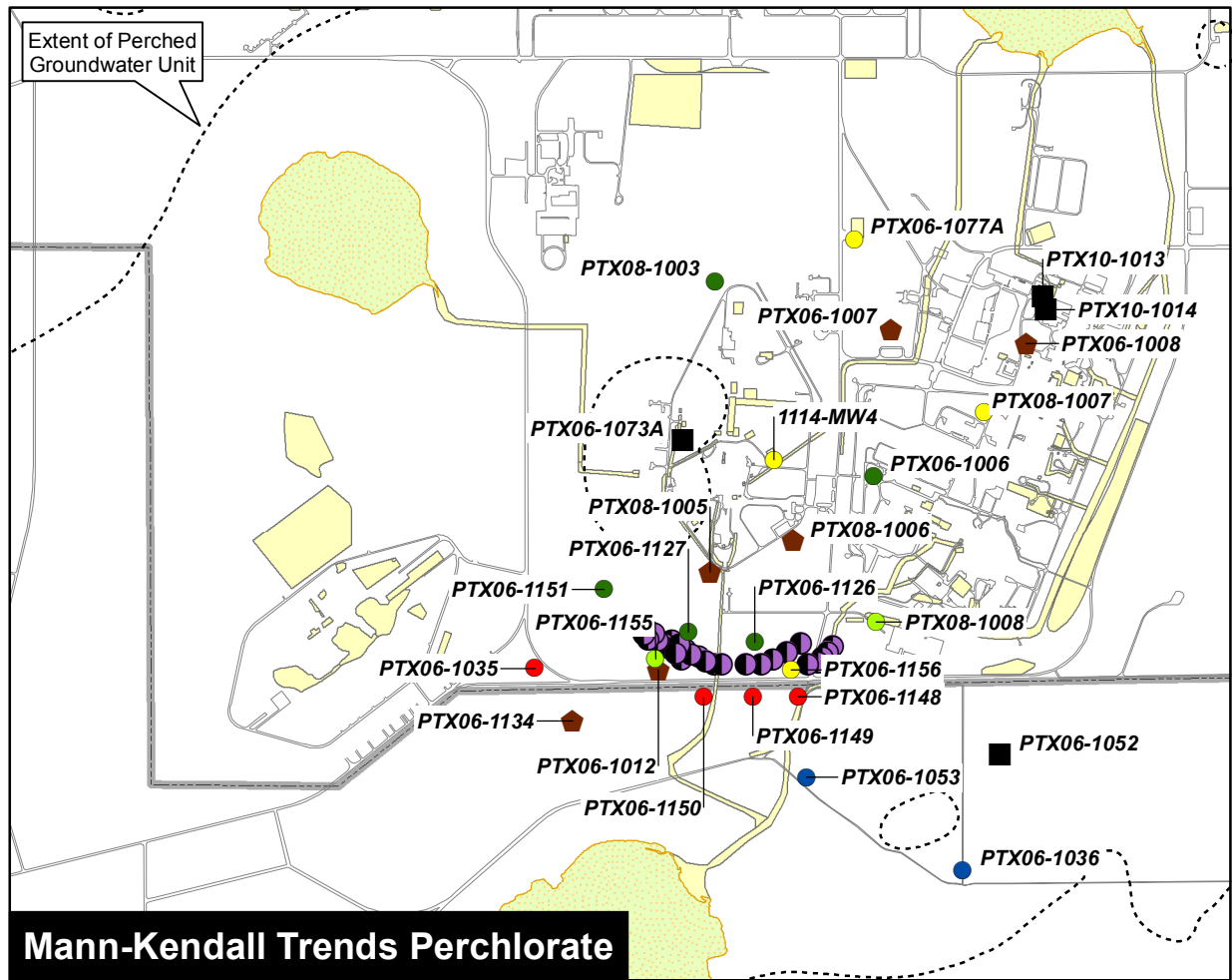
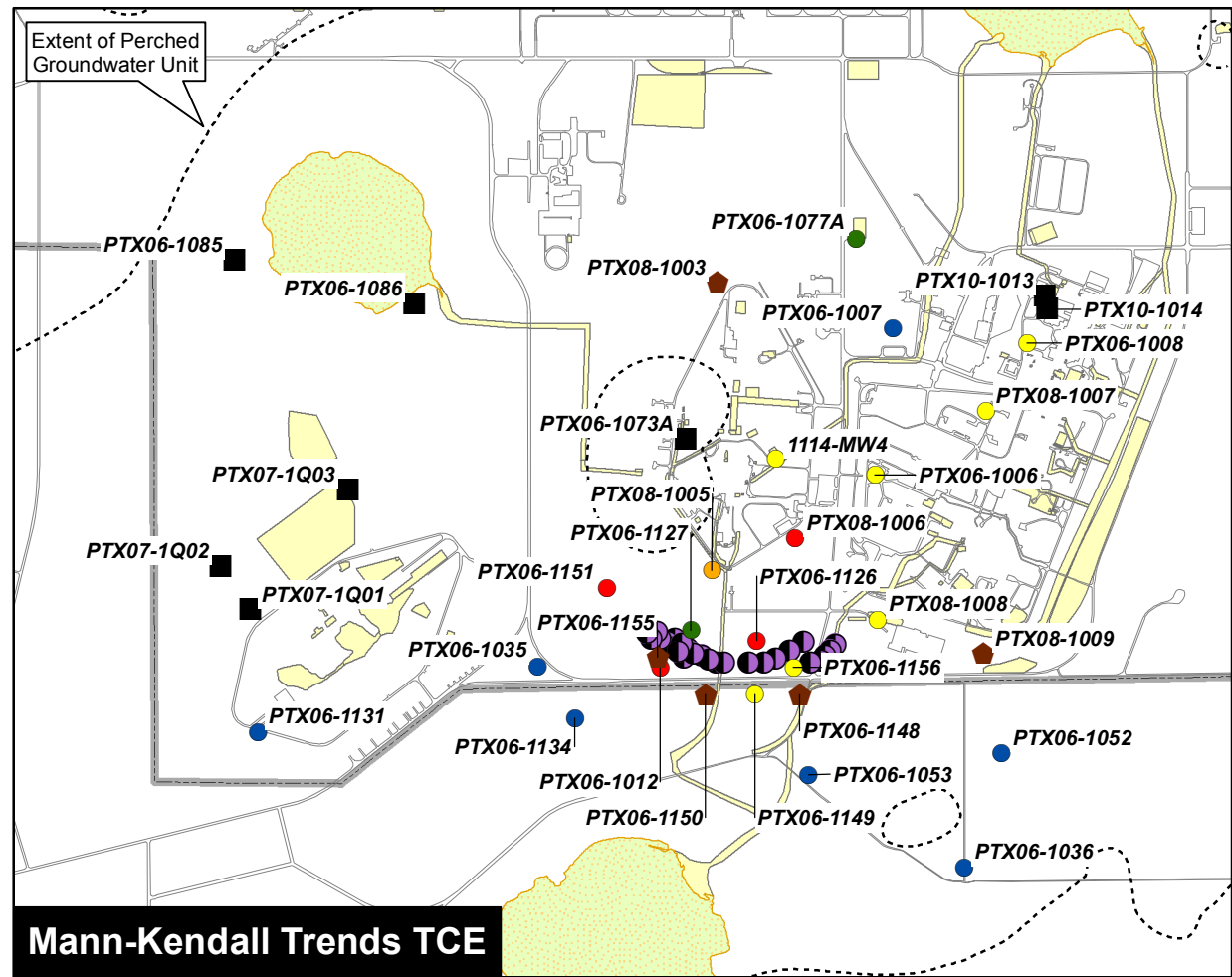
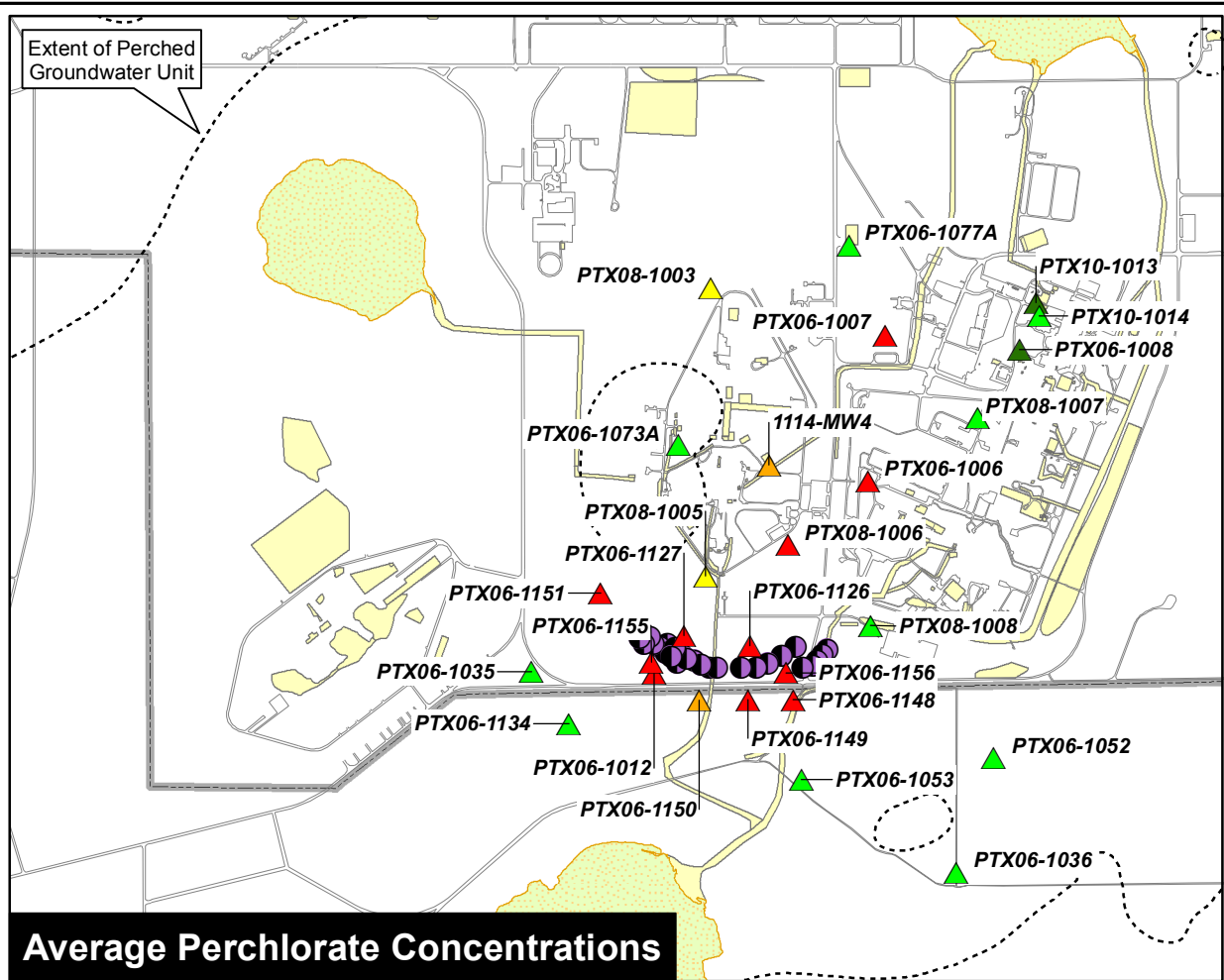
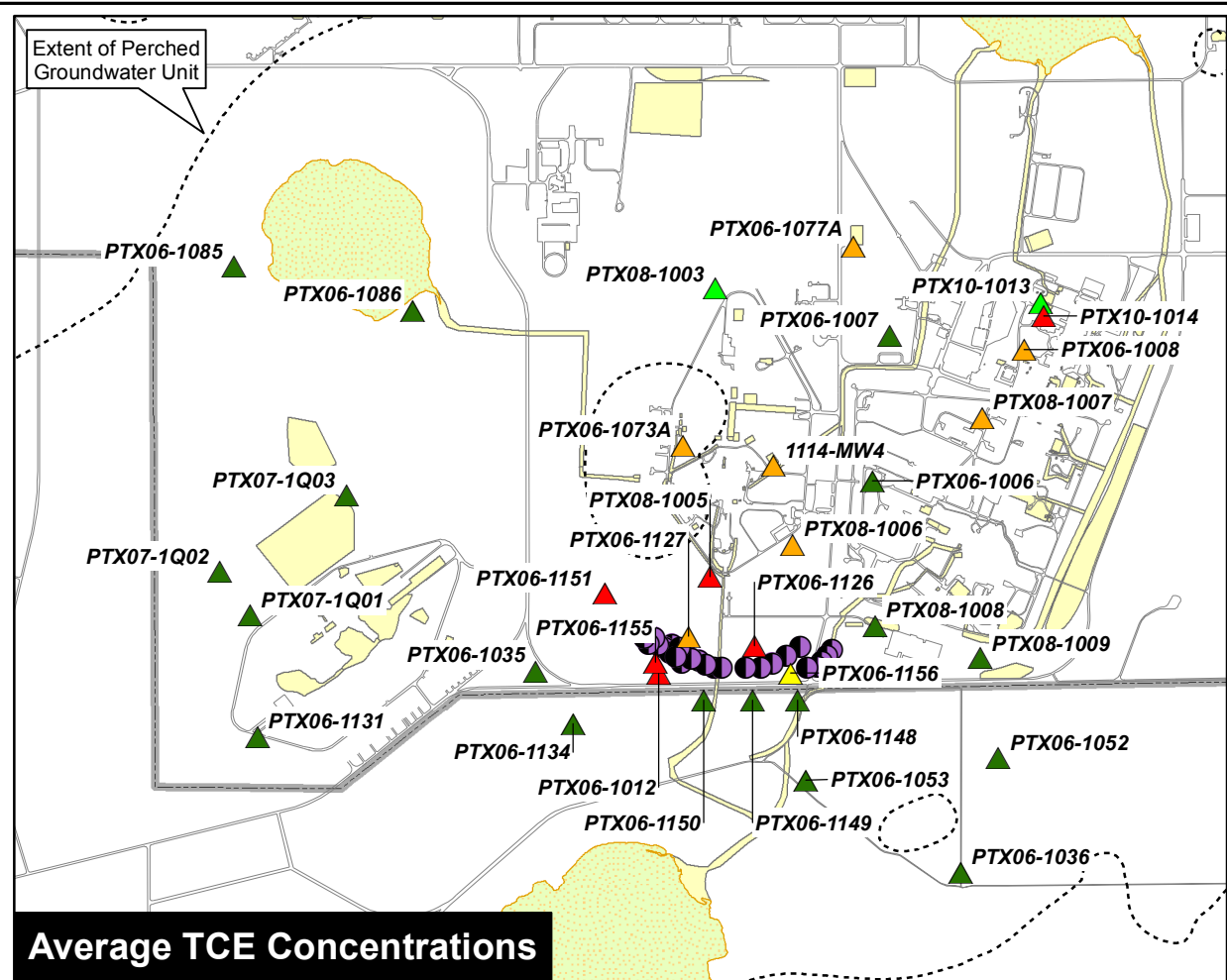
1. First Moments indicate the center of mass estimated based on annually consolidated analytical data from the well network. The effective date of the First Moment estimate is shown.
2. Mann-Kendall trends were determined for RDX and 4ADNT 2008-2011.
3. Only results for investigation wells are shown.



Scale (ft)

0 900 1,800





LEGEND

Average Concentrations [mg/L] 2008-2011

TCE	Perchlorate
▲ ND - 0.001	ND - 0.005
▲ 0.001 - 0.004	0.005 - 0.01
▲ 0.004 - 0.005	0.01 - 0.026
▲ 0.005 - 0.015	0.026 - 0.1
▲ > 0.015	> 0.1

MSC TCE = 0.005 mg/L; Perchlorate = 0.026 mg/L

Well Group

- Southwest ISB

Mann-Kendall Trends 2008-2011

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2008-2011)
- No Trend
- Insufficient Data

Notes:

- Only results for investigation wells are shown.
- Average concentrations calculated using lowest detection limit substituted for ND values.

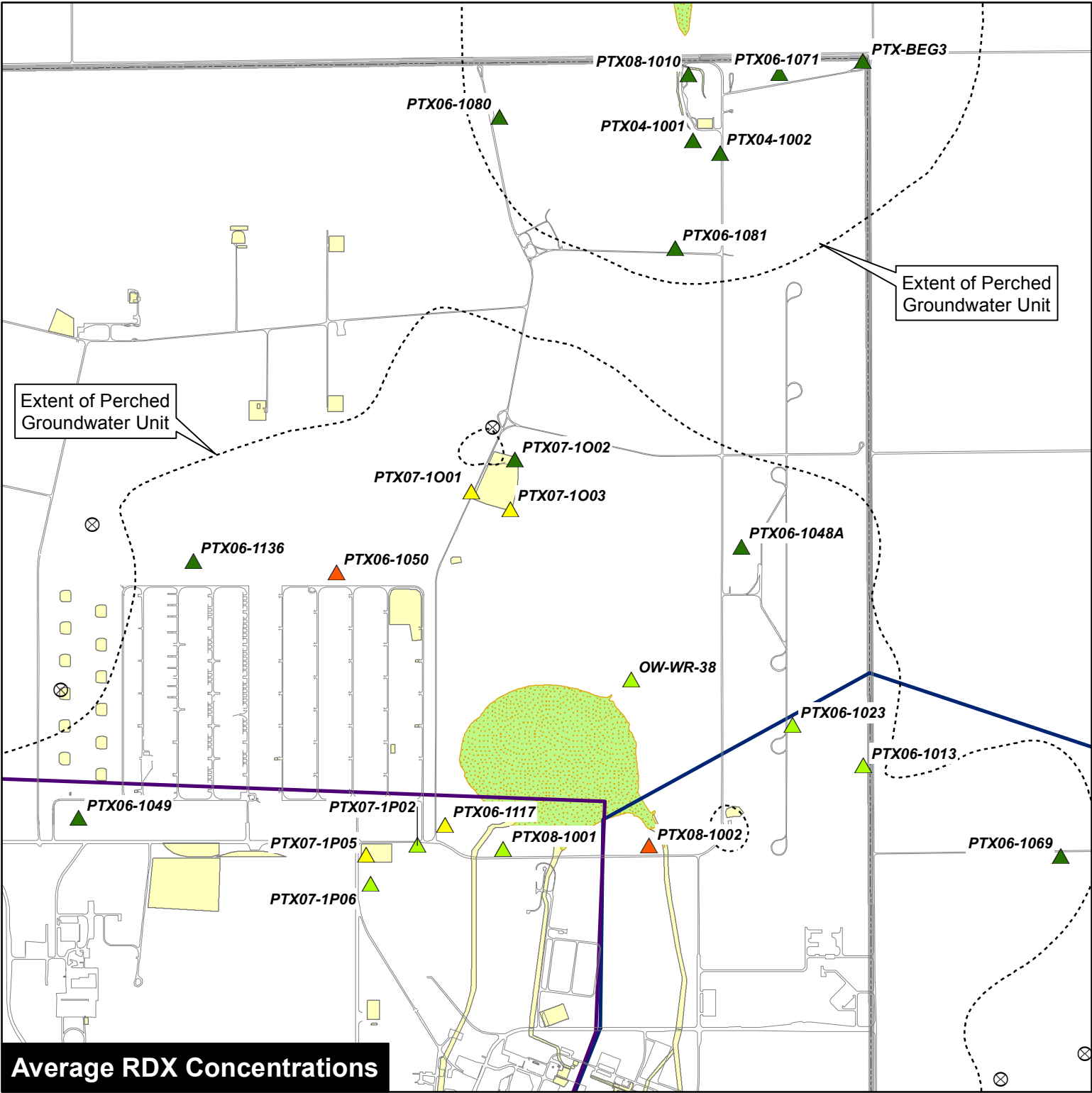
Scale (ft)
0 1,300 2,600

GSI
ENVIRONMENTAL

**PANTEX SOUTHWEST SECTOR
TCE And Perchlorate Average
Concentrations and Mann-Kendall Trends**

Pantex Plant
Carson County, Texas

GIS Job No.	G-3780	Issued:	30-AUG-2012
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	001_06
Appv'd By:	MV	FIGURE 7	



LEGEND

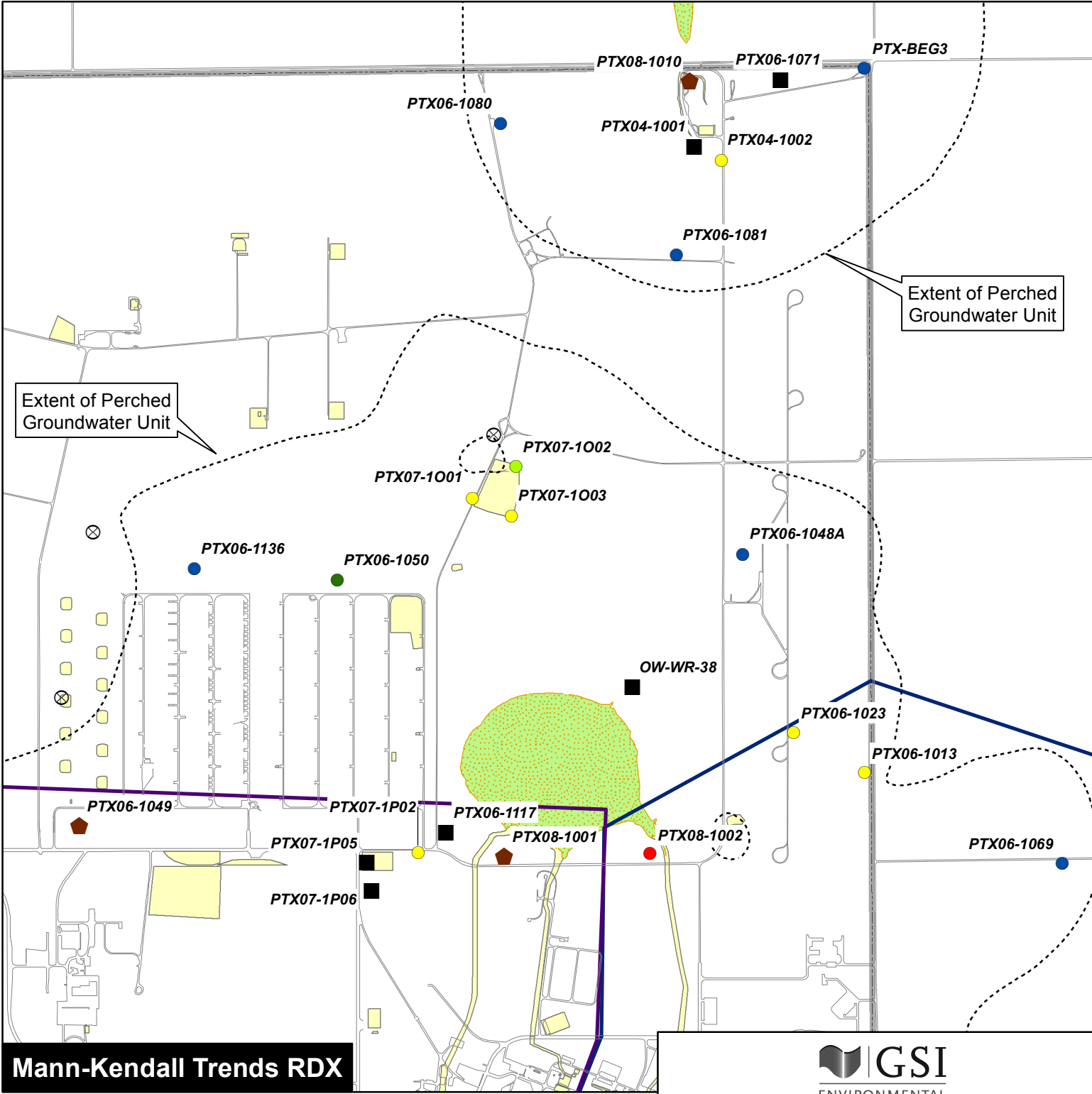
Average RDX Concentration [mg/L]

- ▲ ND - 0.001
- ▲ 0.001 - 0.007
- ▲ 0.007 - 0.05
- ▲ 0.05 - 1.0
- ▲ > 1.0

Mann-Kendall Trend RDX

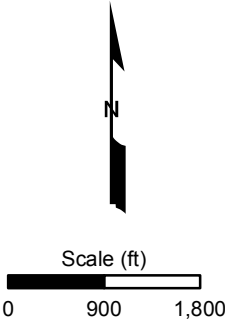
- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2008-2011)
- No Trend
- Insufficient Data

RRS 2 RDX = 0.0077 mg/L



Notes:

1. Average RDX concentrations calculated using lowest detection limit substituted for ND values. Data 2008-2011.
2. Mann Kendall trends were determined for RDX 2008-2011.
3. RDX is not detected in the area of the Burning Ground, Playa 3 and Pantex Lake.



PANTEX NORTH SECTOR
PERCHED GROUNDWATER:
RDX Average Concentrations and
Mann-Kendall Trends

Pantex Plant
Carson County, Texas

GIS Job No.	G-3780	Issued:	30-AUG-2012
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	001_07
App'd By:	MV		FIGURE 8

August 2012

**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

APPENDICES

Appendix A MAROS Spatial Methodology

Appendix B MAROS Reports

Appendix C Electronic Data

August 2012

**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

APPENDIX A:

MAROS Spatial Methodology

MAROS SPATIAL ANALYSIS METHODOLOGY MAROS

This appendix introduces the algorithms used in the MAROS software to identify areas within the monitoring network with too many or too few monitoring wells. The relative importance of each well in the network depends on its ability to provide both unique and important information on plume processes. The software performs an automated evaluation of concentration uncertainty; however, automated results have been reviewed in the context of overall site goals, objectives and hydrogeology to make final well location recommendations.

To determine the relative importance of potential locations in the monitoring network, the software calculates values known as Slope Factor (SF) and Relative Error (RE) for each potential location to measure the information provided by each well. The software also calculates the coefficient of variation (COV) of these metrics to evaluate the level of variability in the historic concentration record. The SF calculation then goes into an iterative process whereby 'less important' wells are removed and the network tested for unacceptable information loss.

The SF of a location is defined as the standardized difference between the logarithmic scales of its measured concentration and its estimated concentration. Since the spatial distribution of groundwater concentration data has often been assumed to follow lognormal distribution, using logarithmic scale of the concentrations smooths the plume surface.

The SF calculation also relies on the Delaunay Triangulation / Voronoi Diagram algorithm which is at the heart of the MAROS spatial analysis approach. Delaunay triangulation is the triangulation of a point set with the property that no point in the point set falls in the interior of the circumcircle of any triangle in the triangulation. (For more information on MAROS Delaunay/Voronoi spatial analysis, consult the MAROS User Manual.)

The following steps are used to calculate SF.

- 1) For a given node (well) N_0 , find its natural neighbors N_i , i.e., the set of nodes that are directly connected to this node by an edge of a Delaunay triangle (Figure A1.1).

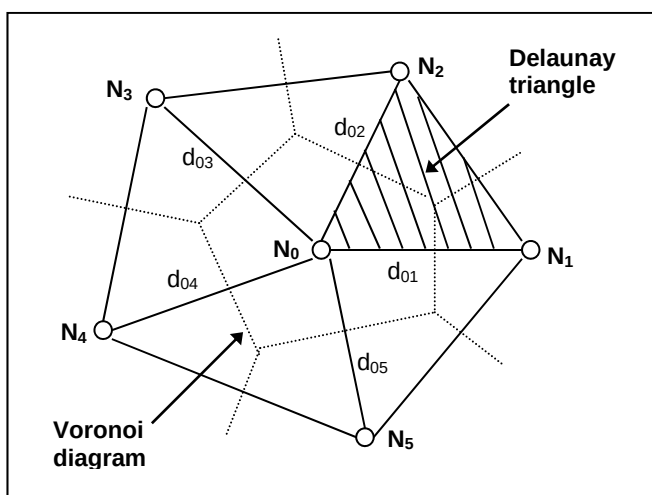


Figure A1.1 Illustration of Natural Neighbors

- 2) The estimated logarithmic concentration EC_0 of node N_0 is computed as the inverse-distance-weighted average of logarithmic concentrations of its natural neighbors:

$$EC_0 = \frac{\sum_{i=1}^n \left(NC_i \cdot \frac{1}{d_{oi}} \right)}{\sum_{i=1}^n \frac{1}{d_{oi}}}$$

where:

n = number of natural neighbors

NC_i = measured concentration in logarithmic scale at node N_i , $i = 1, 2, \dots, n$

d_{oi} = distance between node N_0 and its natural neighbor N_i

- 3) The SF is then calculated as:

$$SF = \left| \frac{EC_0 - NC_0}{\text{Max}(EC_0, NC_0)} \right|$$

where:

EC_0 = estimated logarithmic concentration at node N_0

NC_0 = measured concentration in logarithmic scale at node N_0

The magnitude of SF ranges from 0 to 1 (not including 1). A value of 0 means that the concentration at a location can be exactly estimated by its surrounding locations, thus, sampling at this location provides no extra information to our understanding of the plume. A value larger than 0 indicates the existence of estimation error between points. The larger the estimation error, the larger the discrepancy would be between the estimated concentration and the measured concentration at a location. Consequently, locations with high estimation errors are more important and those with low estimation errors are less important to characterizing the plume. Locations with low SF are candidates for removal while those with high SF may require additional wells.

Because the SF only varies between 0 and 1, choosing one 'low' value, below which a well is determined to be redundant, is fairly straightforward. For this project, SF below 0.3 for interior wells and below 0.1 for hull wells, indicates redundancy. For the well sufficiency determination, MAROS calculates an area-weighted average SF for each Delaunay Triangle. Average SF above 0.6 indicates a fairly high uncertainty between points and the potential need for a new well location.

The SF is a highly smoothed measure of uncertainty in the plume. MAROS 3.0 provides an alternative metric for evaluating uncertainty between points called the Relative Error. The RE uses the nearest neighbor approach but employs the untransformed concentrations at each location. In addition, instead of using the maximum of the estimated or known concentrations, the RE uses only the known concentration in the denominator.

$$RE = \left| \frac{EC_0 - NC_0}{NC_0} \right|$$

where:

EC_0 = estimated logarithmic concentration at node $N0$

NC_0 = measured concentration in logarithmic scale at node $N0$

The RE can vary over several orders of magnitude for various locations within the plume. So, unlike SF, it is difficult to identify single cutoff values for 'low' or 'high' uncertainty. However, the unsmoothed RE can provide a stronger signal of uncertainty than the smoothed SF, so the User is encouraged to review the values and use RE as part of the qualitative analysis of spatial sufficiency.

The COV is a normalized measure of the distribution or variability of data in a dataset calculated by dividing the standard deviation of the dataset by the mean. The COV is identical for SF and RE. The COV of the SF and the RE indicates the level of variability in concentrations within the 'neighborhood' of a well over time. If some wells in the 'neighborhood' have more variable concentrations not reflected in other wells, then the COV will be high (e.g. above 1). While SF and RE indicate general uncertainty in concentrations between points, the COV of RE and SF indicate uncertainty due to variability among neighboring wells over time. Like RE, the COV should be reviewed as part of the qualitative analysis of uncertainty between sampling points.

Our objectives in spatial sampling are to accurately map a contaminant plume and track the change in the plume. It is clear that with more monitoring wells, these objectives can be achieved with a higher degree of accuracy. Unfortunately, there is always a trade-off between degree of accuracy and budget. As part of the algorithm that includes the SF, MAROS extends the spatial analysis to evaluate the 'cost' of the loss of information when a well is removed from the network. To ensure that the elimination of sampling locations from monitoring network will not cause significant information loss, two indicators are developed to measure the information loss. One is Concentration Ratio (CR) and the other is Area Ratio (AR), which are defined as:

$$CR = \frac{C_{avr,Current}}{C_{avr,Original}} \quad AR = \frac{A_{Current}}{A_{Original}}$$

where:

$C_{avr,Current}$ = average plume concentration estimated after elimination of locations in the current step of optimization

$C_{avr,Original}$ = average plume concentration estimated from the potential locations (before elimination of any locations)

$A_{Current}$ = Triangulation area based on locations after elimination of locations in the current step of optimization

$A_{Original}$ = Triangulation area based on potential locations before any optimization (before elimination of any locations)

The average plume concentration is taken as the area-weighted average of the average concentrations of all Delaunay triangles:

$$C_{avr} = \frac{\sum_{i=1}^N TC_i \cdot TA_i}{\sum_{i=1}^N TA_i}$$

where:

N = number of all Delaunay triangles in the triangulation

TA_i = area of each Delaunay triangle, $i = 1, 2, \dots, N$

TC_i = average concentration of each Delaunay triangle, $i = 1, 2, \dots, N$

TC_i is computed as (refer to Figure A.3.3):

$$TC_i = \frac{NC_1 \cdot A_1 + NC_2 \cdot A_2 + NC_3 \cdot A_3}{A_1 + A_2 + A_3}$$

where:

NC_1 = logarithmic concentration at vertex N_1

NC_2 = logarithmic concentration at vertex N_2

NC_3 = logarithmic concentration at vertex N_3

A_1 = Area of sub-part A_1

A_2 = Area of sub-part A_2

A_3 = Area of sub-part A_3

Sampling Location Elimination Status		
Interpretation	SF $\rightarrow$ 0 (Perfect estimation)	SF $\rightarrow$ 1 (High estimation error)
CR or AR far from 1 (significant information loss)	Keep	Keep
CR $\rightarrow$ 1 and AR $\rightarrow$ 1 (less Information loss)	Eliminate	Keep

Figure A.1.2 Decision Process of the Elimination of a Location

After elimination of "unimportant" locations (those with smallest SF values), the estimation of average plume concentration and triangulation area might be affected. By judging the values of

CR and AR, information loss can be evaluated. CR and AR values close to 1 indicate that the information about the plume after elimination of locations is still adequate to track the mass and footprint of contamination. CR and AR values close to 0 represent a large estimation discrepancy and thus indicate greater information loss. By setting the acceptable level of information loss, we can judge when to stop eliminating locations. Those eliminated locations are called "redundant" locations and the rest of potential locations are non-redundant ones and should be kept. An interpretation of the above decision process is given in Figure A.1.2.

The optimization process is iterative. It starts by eliminating the location(s) with smallest SF value(s), then followed by a check of information loss. If information loss is not significant (within the acceptable range), repeat the process until significant information loss happens.

Two kinds of thresholds are defined to judge whether or not to 1) eliminate a location or 2) to terminate the optimization. For this project, the SF threshold for interior nodes was set to 0.30. Those nodes with SF values less than 0.30 were potential nodes to be eliminated. CR and AR thresholds were defined for the second purpose. The CR and AR thresholds were set to 0.85. Elimination of locations is valid, for example, if the CR value was greater than 0.85. In this case, the acceptable level of information loss is $1 - 0.85 = 0.15$, that is, 15%. If the CR value was less than 0.85, the optimization should be terminated and the locations eliminated at this step should be re-instated. The same is true for AR.

August 2012

**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

APPENDIX B:

Southeast Sector MAROS Reports

COC Assessment

Mann-Kendall Reports Select Individual Wells

MAROS Moment Reports Southeast Sector

Zeroth Moments

First Moments

Second Moments

Southeast Percent Mass by Well

MAROS COC Assessment

Project: Pantex SE

User Name: mv

Location: Southeast

State: Texas

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIA	5.1E-01	7.7E-03	6531.8%
TNX	3.9E-02	2.0E-03	1844.5%
MANGANESE	2.3E-01	5.0E-02	350.9%
4-AMINO-2,6-DINITROTOLUENE	4.9E-03	1.2E-03	306.3%
BORON	6.4E-01	1.9E-01	230.1%
CHROMIUM, TOTAL	3.1E-01	1.0E-01	205.7%
2-AMINO-4,6-DINITROTOLUENE	2.6E-03	1.2E-03	115.2%
ARSENIC	1.8E-02	1.0E-02	76.5%
CHROMIUM, HEXAVALENT	1.5E-01	1.0E-01	51.1%
MNX	2.7E-03	2.0E-03	35.5%
DNX	2.3E-03	2.0E-03	15.2%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
BORON	MET	54	42	77.8%	54
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE	ORG	54	35	64.8%	45
TNX	ORG	54	34	63.0%	43
4-AMINO-2,6-DINITROTOLUENE	ORG	54	31	57.4%	39
2-AMINO-4,6-DINITROTOLUENE	ORG	54	20	37.0%	30
ARSENIC	MET	25	8	32.0%	19
MANGANESE	MET	54	17	31.5%	53
DNX	ORG	54	14	25.9%	35
CHROMIUM, TOTAL	MET	54	14	25.9%	50
MNX	ORG	54	10	18.5%	31
CHROMIUM, HEXAVALENT	MET	54	7	13.0%	35

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
TNX	
MNX	
DNX	
CHROMIUM, TOTAL	
BORON	

Project: Pantex SE

User Name: mv

Location: Southeast

State: Texas

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZI	0.00741
4-AMINO-2,6-DINITROTOLUENE	0.0985
2-AMINO-4,6-DINITROTOLUENE	0.0985
CHROMIUM, HEXAVALENT	14
ARSENIC	25
MANGANESE	50.1

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZIN

TNX

4-AMINO-2,6-DINITROTOLUENE

BORON

CHROMIUM, HEXAVALENT

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1037

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

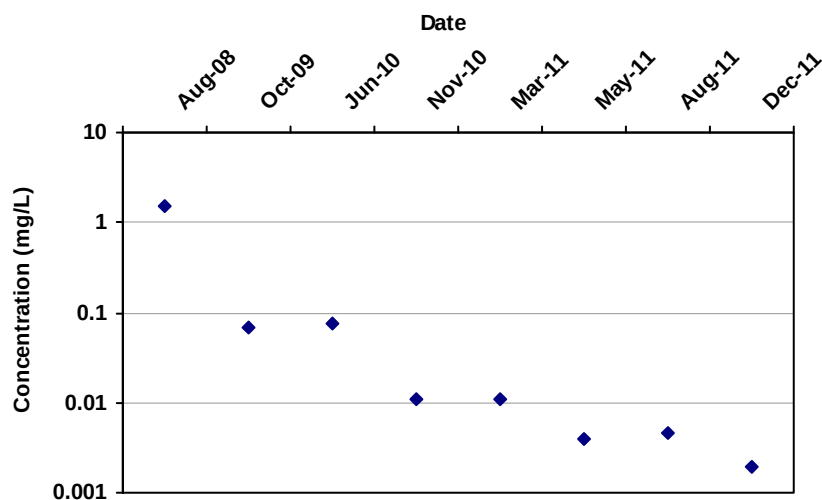
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-23

Confidence in Trend:

99.9%

Coefficient of Variation:

2.50

Mann Kendall Concentration Trend:
(See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1037	T	8/28/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.5E+00		2	2
PTX06-1037	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	6.8E-02		2	2
PTX06-1037	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	7.4E-02		1	1
PTX06-1037	T	11/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.1E-02		1	1
PTX06-1037	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.1E-02		1	1
PTX06-1037	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	3.9E-03		1	1
PTX06-1037	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	4.5E-03		1	1
PTX06-1037	T	12/15/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.9E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1034

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

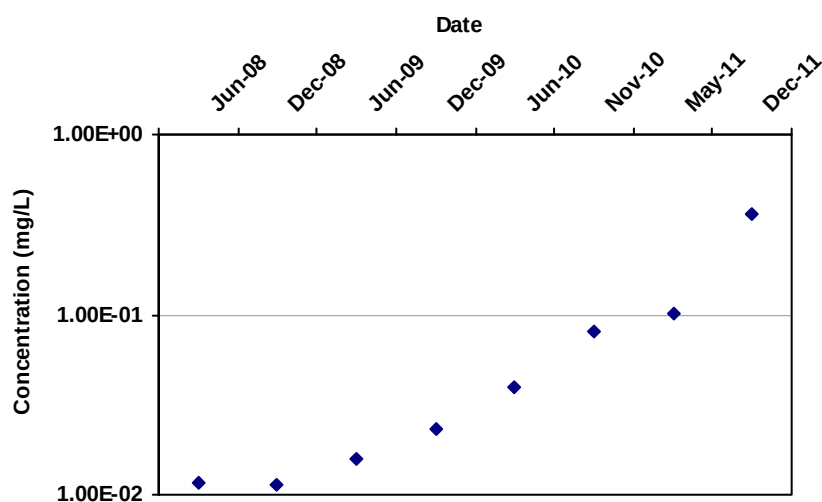
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

26

Confidence in Trend:

100.0%

Coefficient of Variation:

1.46

Mann Kendall Concentration Trend:
(See Note)

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1034	T	6/5/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.2E-02		3	3
PTX06-1034	T	12/18/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.2E-02		1	1
PTX06-1034	T	6/10/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.6E-02		1	1
PTX06-1034	T	12/16/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	2.3E-02		2	2
PTX06-1034	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	4.0E-02		1	1
PTX06-1034	T	11/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	8.0E-02		2	2
PTX06-1034	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.0E-01		1	1
PTX06-1034	T	12/15/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	3.6E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1031

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

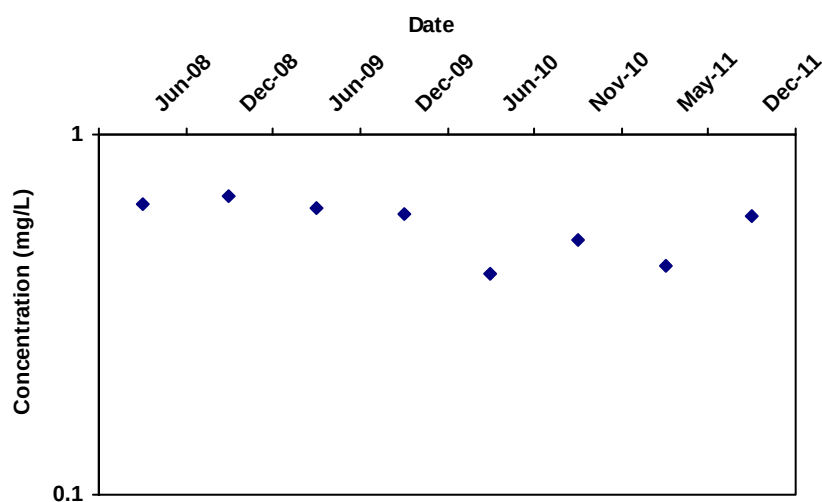
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-16

Confidence in Trend:

96.9%

Coefficient of Variation:

0.18

Mann Kendall Concentration Trend:
(See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1031	T	6/5/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	6.4E-01		2	2
PTX06-1031	T	12/18/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	6.7E-01		2	2
PTX06-1031	T	6/10/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	6.3E-01		2	2
PTX06-1031	T	12/16/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	6.0E-01		1	1
PTX06-1031	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	4.1E-01		1	1
PTX06-1031	T	11/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	5.1E-01		1	1
PTX06-1031	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	4.3E-01		1	1
PTX06-1031	T	12/15/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	5.9E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX08-1009

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/8/2011

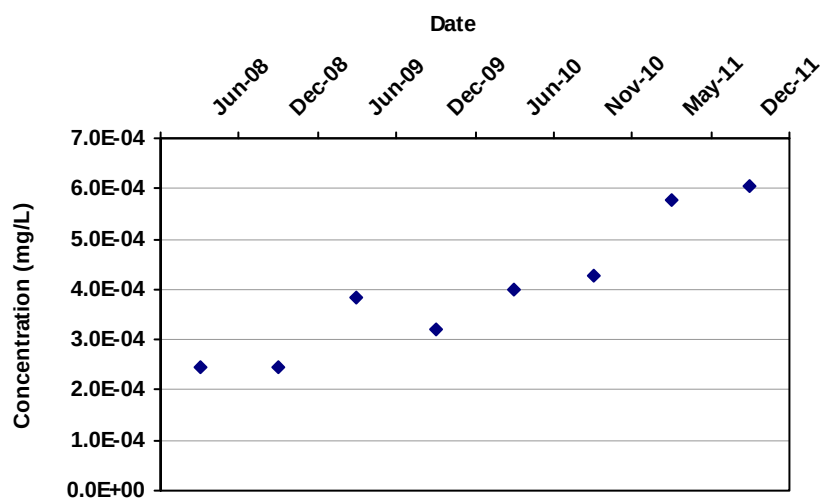
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

25

Confidence in Trend:

100.0%

Coefficient of Variation:

0.34

Mann Kendall Concentration Trend:
(See Note)

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX08-1009	T	6/5/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-04	ND	1	0
PTX08-1009	T	12/18/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-04	ND	1	0
PTX08-1009	T	6/10/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	3.8E-04		1	1
PTX08-1009	T	12/16/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	3.2E-04		1	1
PTX08-1009	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	4.0E-04		1	1
PTX08-1009	T	11/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	4.3E-04		1	1
PTX08-1009	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	5.8E-04		1	1
PTX08-1009	T	12/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	6.1E-04		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1154

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

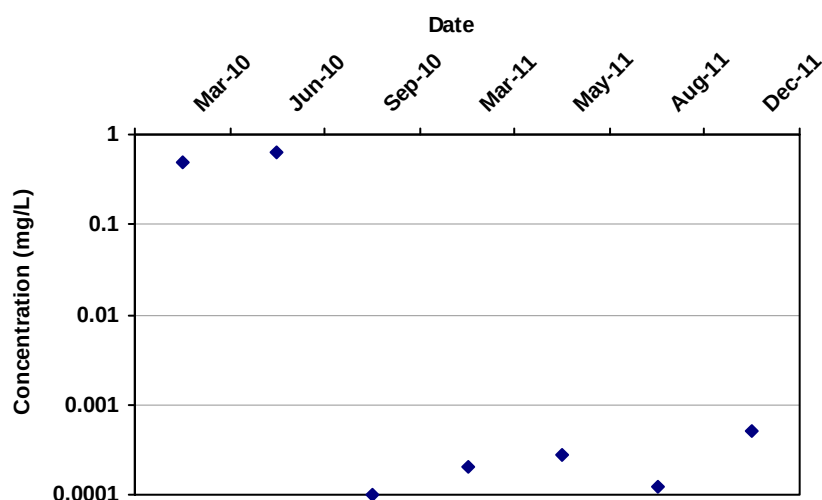
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-3

Confidence in Trend:

61.4%

Coefficient of Variation:

1.72

Mann Kendall Concentration Trend:
(See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1154	T	3/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	4.9E-01		1	1
PTX06-1154	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	6.3E-01		1	1
PTX06-1154	T	9/20/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.0E-04	ND	1	0
PTX06-1154	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.0E-04		1	1
PTX06-1154	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.7E-04		1	1
PTX06-1154	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.2E-04		1	1
PTX06-1154	T	12/15/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	5.0E-04	ND	1	0

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1153

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

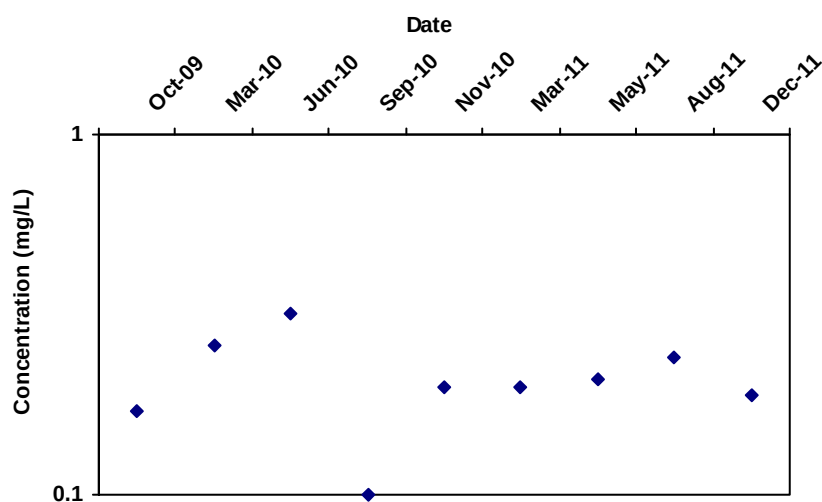
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

1

Confidence in Trend:

50.0%

Coefficient of Variation:

0.29

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1153	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.7E-01		2	2
PTX06-1153	T	3/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	2.6E-01		1	1
PTX06-1153	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	3.2E-01		1	1
PTX06-1153	T	9/20/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.0E-01		1	1
PTX06-1153	T	11/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	2.0E-01		1	1
PTX06-1153	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.0E-01		1	1
PTX06-1153	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.1E-01		1	1
PTX06-1153	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-01		1	1
PTX06-1153	T	12/15/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.9E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1123

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

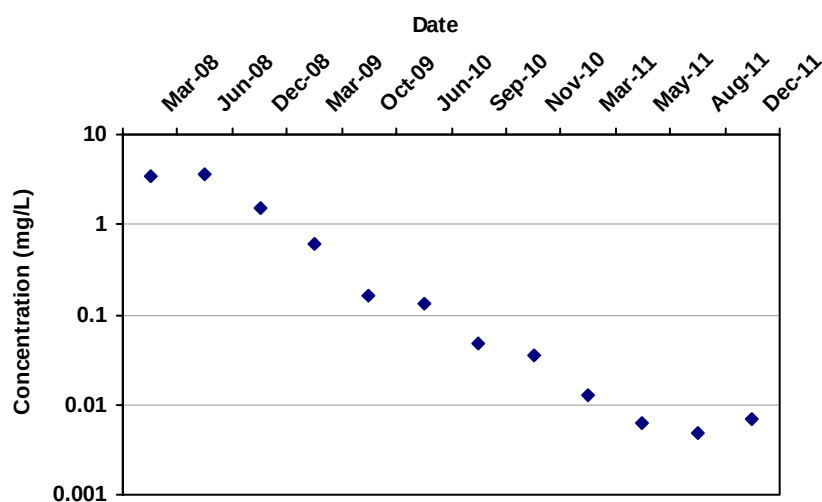
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-60

Confidence in Trend:

100.0%

Coefficient of Variation:

1.70

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1123	T	3/20/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	3.4E+00		3	3
PTX06-1123	T	6/5/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	3.7E+00		2	2
PTX06-1123	T	12/18/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.5E+00		2	2
PTX06-1123	T	3/31/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	6.1E-01		2	2
PTX06-1123	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.6E-01		2	2
PTX06-1123	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.3E-01		1	1
PTX06-1123	T	9/20/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	4.7E-02		1	1
PTX06-1123	T	11/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	3.5E-02		1	1
PTX06-1123	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.3E-02		1	1
PTX06-1123	T	5/31/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	6.1E-03		1	1
PTX06-1123	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	4.9E-03		1	1
PTX06-1123	T	12/15/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	7.0E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1118

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

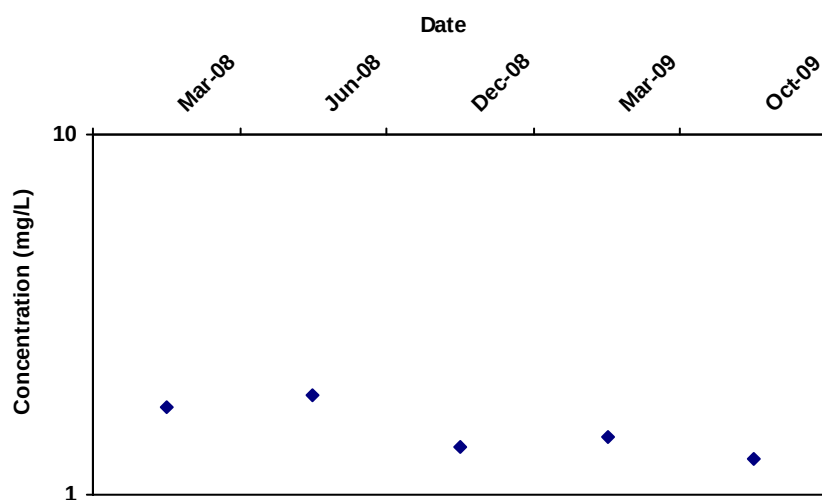
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-6

Confidence in Trend:

88.3%

Coefficient of Variation:

0.18

Mann Kendall Concentration Trend:
(See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1118	T	3/20/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.7E+00		3	3
PTX06-1118	T	6/5/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.9E+00		2	2
PTX06-1118	T	12/18/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.4E+00		2	2
PTX06-1118	T	3/31/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.5E+00		2	2
PTX06-1118	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.3E+00		2	2

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1046

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

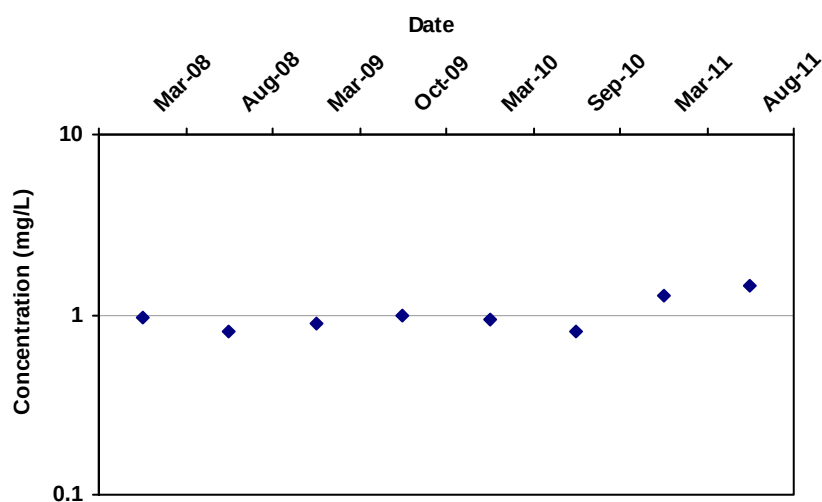
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

10

Confidence in Trend:

86.2%

Coefficient of Variation:

0.23

Mann Kendall Concentration Trend:
(See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1046	T	3/20/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	9.7E-01		2	2
PTX06-1046	T	8/28/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	8.0E-01		2	2
PTX06-1046	T	3/31/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	9.0E-01		2	2
PTX06-1046	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	9.8E-01		1	1
PTX06-1046	T	3/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	9.4E-01		1	1
PTX06-1046	T	9/20/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	8.0E-01		1	1
PTX06-1046	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.3E+00		1	1
PTX06-1046	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.5E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1045

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

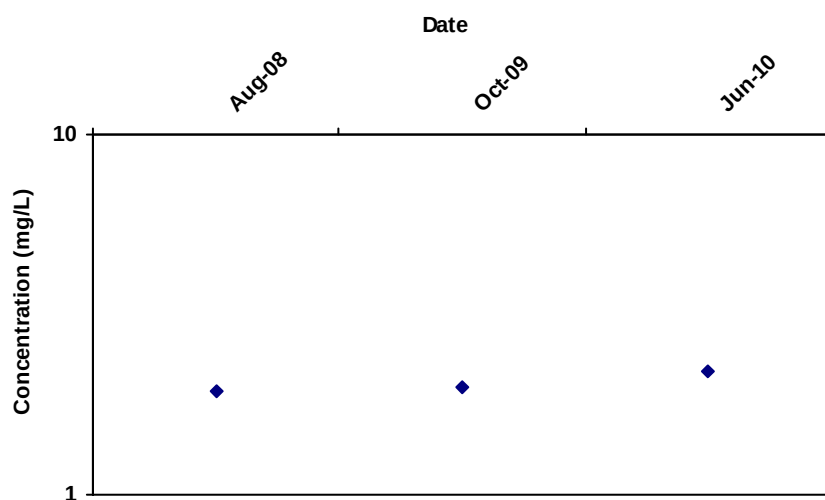
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

0

Confidence in Trend:

0.0%

Coefficient of Variation:

0.00

Mann Kendall Concentration Trend:
(See Note)

N/A

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1045	T	8/28/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	1.9E+00		2	2
PTX06-1045	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	2.0E+00		2	2
PTX06-1045	T	6/3/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	2.2E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1042

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/15/2011

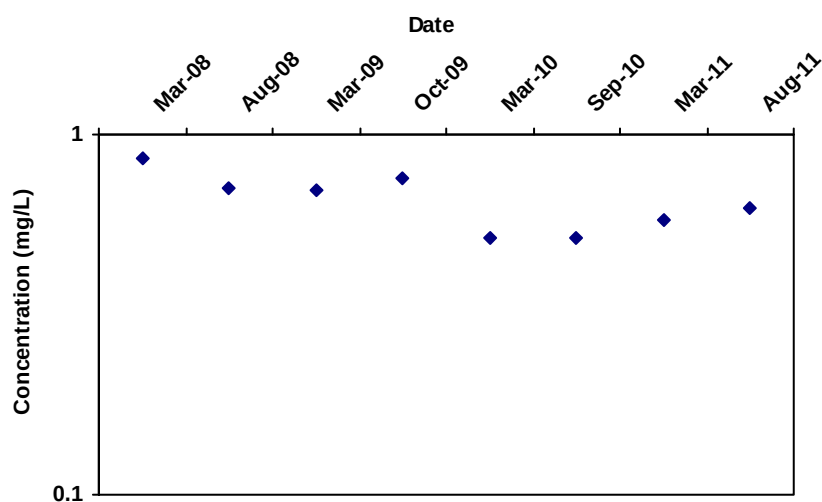
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-12

Confidence in Trend:

91.1%

Coefficient of Variation:

0.18

Mann Kendall Concentration Trend:
(See Note)

PD

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1042	T	3/20/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	8.6E-01		2	2
PTX06-1042	T	8/28/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	7.1E-01		2	2
PTX06-1042	T	3/31/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	7.0E-01		2	2
PTX06-1042	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	7.6E-01		1	1
PTX06-1042	T	3/29/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	5.2E-01		1	1
PTX06-1042	T	9/20/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	5.2E-01		1	1
PTX06-1042	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	5.8E-01		1	1
PTX06-1042	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	6.3E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1038

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 3/20/2008 to 12/8/2011

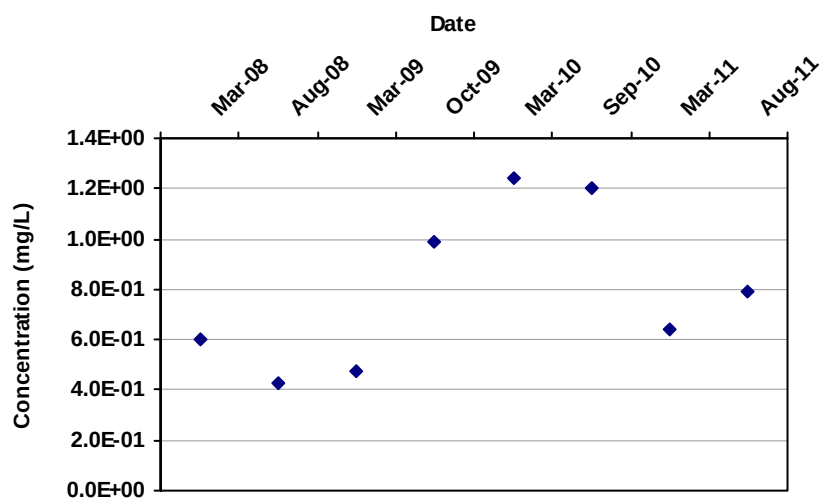
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

10

Confidence in Trend:

86.2%

Coefficient of Variation:

0.40

Mann Kendall Concentration Trend:
(See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1038	T	3/20/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	6.0E-01		2	2
PTX06-1038	T	8/28/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	4.2E-01		2	2
PTX06-1038	T	3/31/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	4.8E-01		2	2
PTX06-1038	T	10/27/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	9.9E-01		1	1
PTX06-1038	T	3/30/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.2E+00		1	1
PTX06-1038	T	9/20/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.2E+00		1	1
PTX06-1038	T	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	6.4E-01		1	1
PTX06-1038	T	8/24/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	7.9E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Zeroth Moment Analysis

Project: Pantex

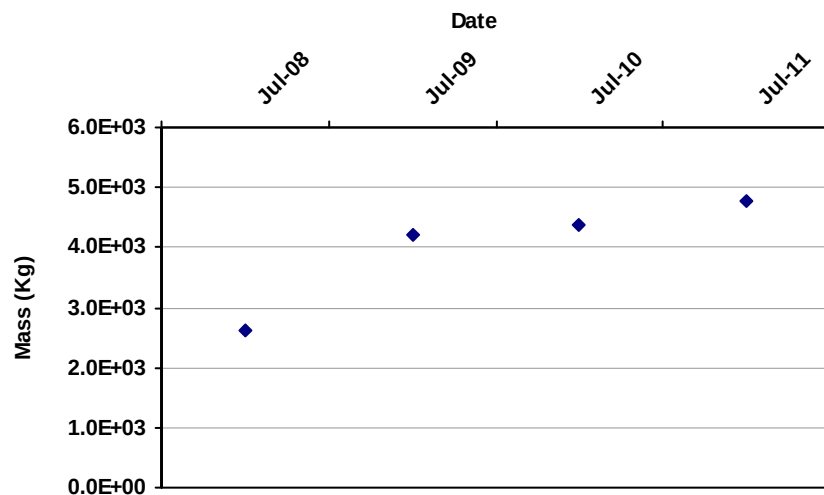
User Name: MV

Location: Southeast

State: Texas

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

6

Confidence in Trend:

95.8%

Coefficient of Variation:

0.24

Zeroth Moment Trend:

1

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2008	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	2.6E+03	43
7/1/2009	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.2E+03	48
7/1/2010	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.4E+03	50
7/1/2011	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.8E+03	45

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex

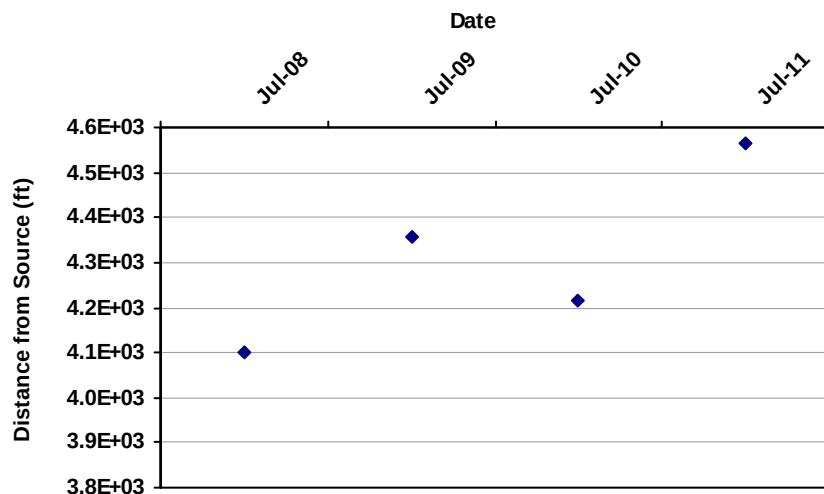
User Name: MV

Location: Southeast

State: Texas

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Distance from Source to Center of Mass



Mann Kendall S Statistic:

4

Confidence in Trend:

83.3%

Coefficient of Variation:

0.05

First Moment Trend:

NT

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2008	HEXAHYDRO-1,3,5-TRINITRO	643,264	3,755,744	4,099	43
7/1/2009	HEXAHYDRO-1,3,5-TRINITRO	643,918	3,756,408	4,359	48
7/1/2010	HEXAHYDRO-1,3,5-TRINITRO	643,824	3,756,560	4,216	50
7/1/2011	HEXAHYDRO-1,3,5-TRINITRO	644,055	3,756,209	4,563	45

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex

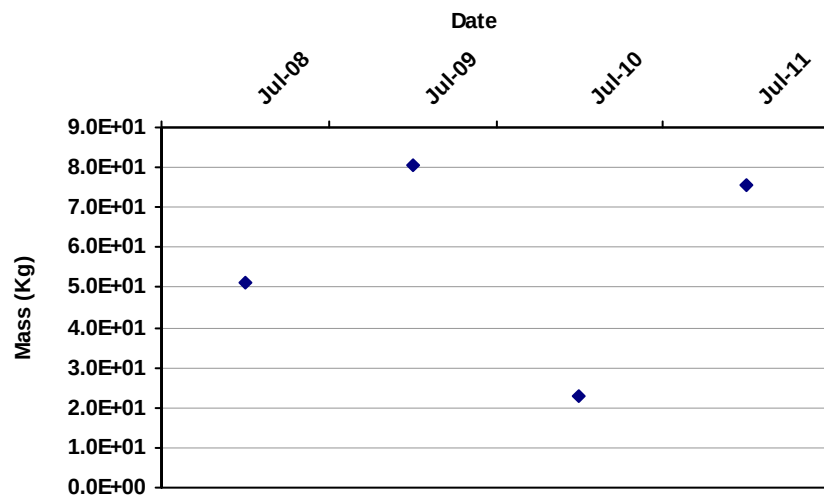
User Name: MV

Location: Southeast

State: Texas

COC: 4-AMINO-2,6-DINITROTOLUENE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

0

Confidence in Trend:

37.5%

Coefficient of Variation:

0.46

Zeroth Moment Trend:

S

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2008	4-AMINO-2,6-DINITROTOLUENE	5.1E+01	43
7/1/2009	4-AMINO-2,6-DINITROTOLUENE	8.1E+01	47
7/1/2010	4-AMINO-2,6-DINITROTOLUENE	2.3E+01	50
7/1/2011	4-AMINO-2,6-DINITROTOLUENE	7.5E+01	45

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Percent of Mass by Well

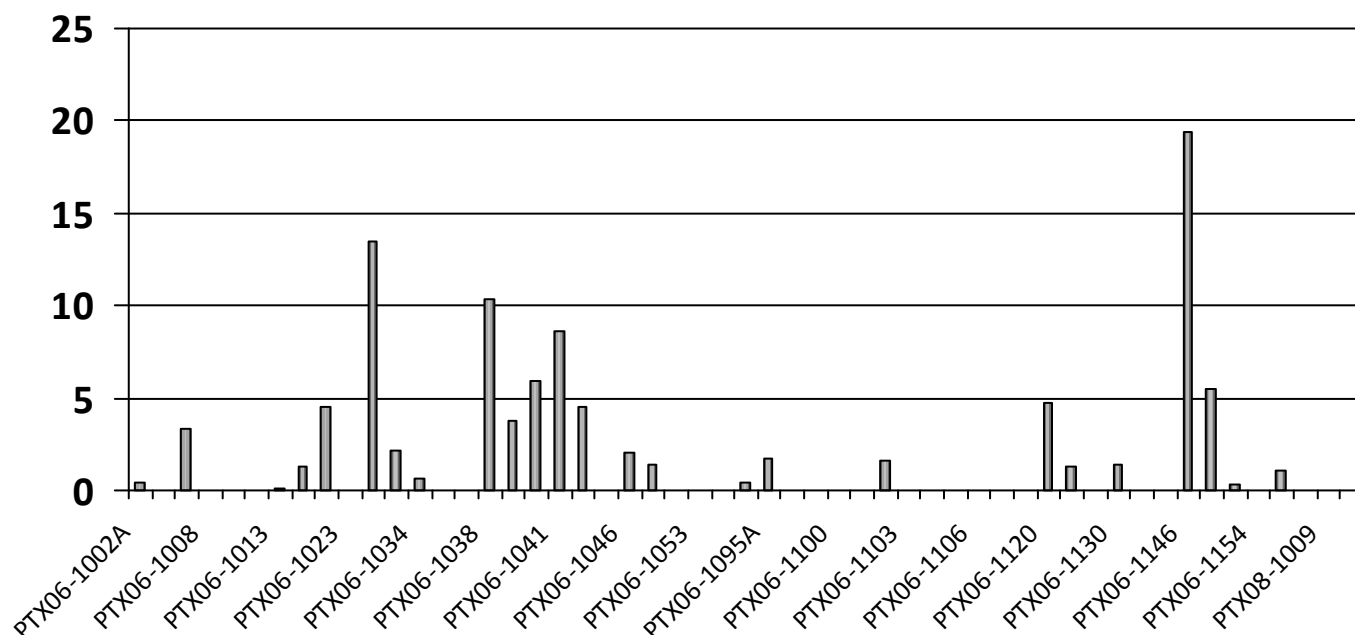
Project: Pantex

User Name: MV

Location: Southeast

State: Texas

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE 7/1/2011



Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area
PTX06-1002A	4,402,558.94	45,244.55	0.44	4.84
PTX06-1003	3,918,856.72	1,028.70	0.01	4.30
PTX06-1005	2,548,949.86	349,938.97	3.37	2.80
PTX06-1008	987,593.05	42.13	0.00	1.08
PTX06-1010	1,967,856.17	1,552.27	0.01	2.16
PTX06-1011	2,149,107.03	91.67	0.00	2.36
PTX06-1013	3,617,684.36	6,927.64	0.07	3.97
PTX06-1014	1,093,970.16	136,117.24	1.31	1.20
PTX06-1015	1,327,174.18	465,962.58	4.49	1.46
PTX06-1023	947,066.62	396.03	0.00	1.04
PTX06-1030	2,946,964.04	1,396,308.47	13.45	3.24
PTX06-1031	1,671,851.06	224,257.93	2.16	1.84
PTX06-1034	1,127,754.27	67,644.11	0.65	1.24
PTX06-1036	1,004,583.71	611.79	0.01	1.10



MAROS Percent of Mass by Well

Project: Pantex

User Name: MV

Location: Southeast

State: Texas

Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area	
PTX06-1037	202,153.31	282.57	0.00	0.22	
PTX06-1038	5,713,842.65	1,073,916.78	10.34	6.28	
PTX06-1039A	1,790,297.45	387,006.38	3.73	1.97	
PTX06-1040	1,935,106.06	614,638.09	5.92	2.13	
PTX06-1041	3,247,020.61	892,403.07	8.59	3.57	
PTX06-1042	2,977,062.19	470,059.54	4.53	3.27	
PTX06-1045	778,331.31	204.31	0.00	0.85	
PTX06-1046	587,683.41	211,345.66	2.04	0.65	
PTX06-1047A	865,158.46	140,577.44	1.35	0.95	
PTX06-1052	1,579,601.49	67.38	0.00	1.73	
PTX06-1053	1,147,674.53	48.96	0.00	1.26	
PTX06-1069	3,266,131.76	139.32	0.00	3.59	
PTX06-1088	1,519,539.11	48,443.86	0.47	1.67	
PTX06-1095A	2,641,828.61	180,998.29	1.74	2.90	
PTX06-1098	846,627.40	22.22	0.00	0.93	
PTX06-1099	485,737.67	127.51	0.00	0.53	
PTX06-1100	200,062.24	5.25	0.00	0.22	
PTX06-1101	1,121,499.59	29.44	0.00	1.23	
PTX06-1102	2,455,161.41	168,209.25	1.62	2.70	
PTX06-1103	722,264.25	189.59	0.00	0.79	
PTX06-1104	598,769.67	157.18	0.00	0.66	
PTX06-1105	674,708.49	177.11	0.00	0.74	
PTX06-1106	211,955.58	55.64	0.00	0.23	
PTX06-1107	531,748.49	139.58	0.00	0.58	
PTX06-1118	384,955.51	101.05	0.00	0.42	
PTX06-1120	758,636.31	497,855.10	4.79	0.83	
PTX06-1121	517,017.60	134,767.11	1.30	0.57	
PTX06-1123	375,357.81	763.62	0.01	0.41	
PTX06-1130	3,767,179.55	146,354.93	1.41	4.14	
PTX06-1133A	959,090.33	40.91	0.00	1.05	
PTX06-1135	1,943,784.15	427.33	0.00	2.13	

MAROS Percent of Mass by Well

Project: Pantex

User Name: MV

Location: Southeast

State: Texas

Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area	
PTX06-1146	4,504,954.34	2,010,335.97	19.36	4.95	
PTX06-1147	2,706,999.07	566,693.36	5.46	2.97	
PTX06-1153	531,364.39	29,291.46	0.28	0.58	
PTX06-1154	152,348.62	10.90	0.00	0.17	
PTX08-1002	3,494,447.28	111,405.17	1.07	3.84	
PTX08-1008	1,183,750.62	50.49	0.00	1.30	
PTX08-1009	2,528,484.34	392.93	0.00	2.78	
PTX10-1014	1,424,843.63	684.46	0.01	1.56	
	91,045,149.5	10,384,543.3	100	100	

August 2012

**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

APPENDIX B:

Southwest Sector MAROS Reports

COC Assessment

Mann-Kendall Reports Select Individual Wells

MAROS Moment Reports Southeast Sector

Zeroth Moments

First Moments

Second Moments

Southeast Percent Mass by Well

MAROS COC Assessment

Project: Pantex

User Name: MV

Location: Southwest Area

State: Texas

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
TRICHLOROETHYLENE (TCE)	3.6E-02	5.0E-03	615.8%
PERCHLORATE	1.4E-01	2.6E-02	450.4%
CARBON TETRACHLORIDE	5.5E-04	1.7E-04	222.5%
MANGANESE	1.4E-01	5.0E-02	181.0%
CHROMIUM, HEXAVALENT	2.7E-01	1.0E-01	173.3%
4-AMINO-2,6-DINITROTOLUENE	2.0E-03	1.2E-03	62.6%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
PERCHLORATE	INO	35	15	42.9%	26
TRICHLOROETHYLENE (TCE)	ORG	36	14	38.9%	24
MANGANESE	MET	34	11	32.4%	33
4-AMINO-2,6-DINITROTOLUENE	ORG	36	10	27.8%	19
CARBON TETRACHLORIDE	ORG	18	2	11.1%	2
CHROMIUM, HEXAVALENT	MET	32	3	9.4%	26

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
PERCHLORATE	
4-AMINO-2,6-DINITROTOLUENE	0.0985
CARBON TETRACHLORIDE	0.277
TRICHLOROETHYLENE (TCE)	0.297
CHROMIUM, HEXAVALENT	14
MANGANESE	50.1

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

TRICHLOROETHYLENE (TCE)
PERCHLORATE
4-AMINO-2,6-DINITROTOLUENE

Project: Pantex

User Name: MV

Location: Southwest Area

State: Texas

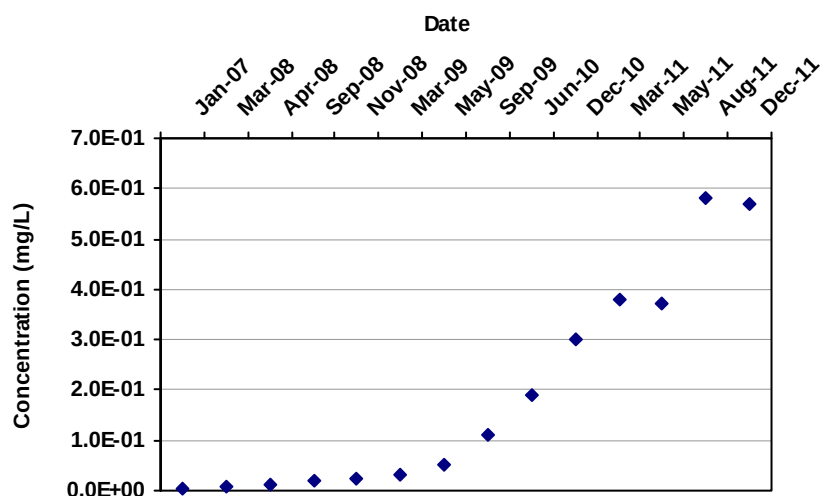
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZIN

CHROMIUM, HEXAVALENT

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1012
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/2007 to 12/30/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

87

Confidence in Trend:

100.0%

Coefficient of Variation:

1.13

Mann Kendall Concentration Trend:
 (See Note)

Data Table:

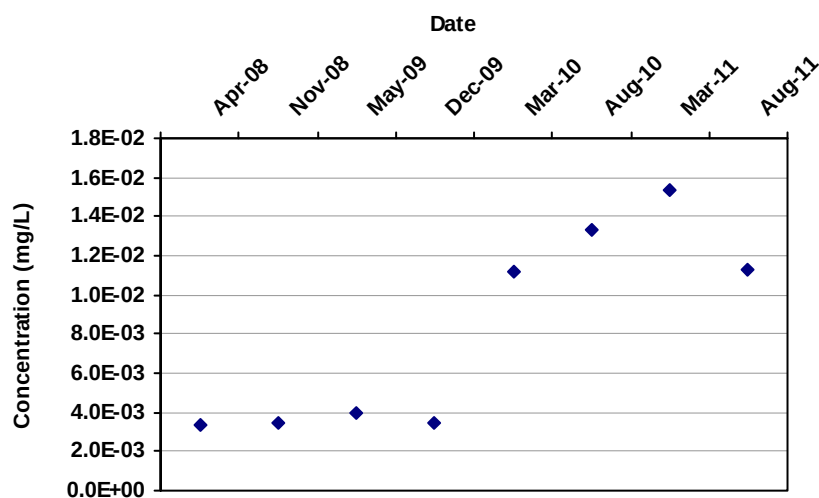
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1012	T	1/15/2007	TRICHLOROETHYLENE (TCE)	2.3E-03		1	1
PTX06-1012	T	3/10/2008	TRICHLOROETHYLENE (TCE)	6.6E-03		1	1
PTX06-1012	T	4/30/2008	TRICHLOROETHYLENE (TCE)	1.0E-02		1	1
PTX06-1012	T	9/10/2008	TRICHLOROETHYLENE (TCE)	2.1E-02		1	1
PTX06-1012	T	11/11/2008	TRICHLOROETHYLENE (TCE)	2.2E-02		1	1
PTX06-1012	T	3/31/2009	TRICHLOROETHYLENE (TCE)	3.0E-02		1	1
PTX06-1012	T	5/20/2009	TRICHLOROETHYLENE (TCE)	5.1E-02		2	2
PTX06-1012	T	9/15/2009	TRICHLOROETHYLENE (TCE)	1.1E-01		2	2
PTX06-1012	T	6/17/2010	TRICHLOROETHYLENE (TCE)	1.9E-01		1	1
PTX06-1012	T	12/6/2010	TRICHLOROETHYLENE (TCE)	3.0E-01		1	1
PTX06-1012	T	3/9/2011	TRICHLOROETHYLENE (TCE)	3.8E-01		1	1
PTX06-1012	T	5/25/2011	TRICHLOROETHYLENE (TCE)	3.7E-01		1	1
PTX06-1012	T	8/15/2011	TRICHLOROETHYLENE (TCE)	5.8E-01		1	1
PTX06-1012	T	12/19/2011	TRICHLOROETHYLENE (TCE)	5.7E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX08-1006
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/2008 to 12/30/2011
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

20

Confidence in Trend:

99.3%

Coefficient of Variation:

0.62

Mann Kendall Concentration Trend: (See Note)

Data Table:

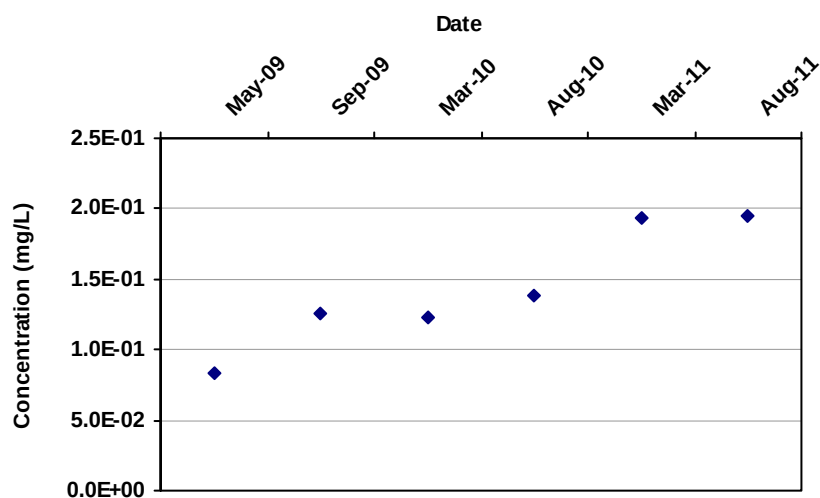
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX08-1006	S	4/30/2008	TRICHLOROETHYLENE (TCE)	3.4E-03		2	2
PTX08-1006	S	11/11/2008	TRICHLOROETHYLENE (TCE)	3.5E-03		2	2
PTX08-1006	S	5/20/2009	TRICHLOROETHYLENE (TCE)	4.0E-03		4	4
PTX08-1006	S	12/3/2009	TRICHLOROETHYLENE (TCE)	3.5E-03		2	2
PTX08-1006	S	3/30/2010	TRICHLOROETHYLENE (TCE)	1.1E-02		2	2
PTX08-1006	S	8/30/2010	TRICHLOROETHYLENE (TCE)	1.3E-02		2	2
PTX08-1006	S	3/9/2011	TRICHLOROETHYLENE (TCE)	1.5E-02		2	2
PTX08-1006	S	8/15/2011	TRICHLOROETHYLENE (TCE)	1.1E-02		2	2

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1151
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/2008 to 12/30/2011
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

13

Confidence in Trend:

99.2%

Coefficient of Variation:

0.30

Mann Kendall Concentration Trend: (See Note)

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1151	T	5/20/2009	TRICHLOROETHYLENE (TCE)	8.3E-02		6	6
PTX06-1151	T	9/15/2009	TRICHLOROETHYLENE (TCE)	1.3E-01		4	4
PTX06-1151	T	3/30/2010	TRICHLOROETHYLENE (TCE)	1.2E-01		4	4
PTX06-1151	T	8/30/2010	TRICHLOROETHYLENE (TCE)	1.4E-01		2	2
PTX06-1151	T	3/9/2011	TRICHLOROETHYLENE (TCE)	1.9E-01		2	2
PTX06-1151	T	8/15/2011	TRICHLOROETHYLENE (TCE)	2.0E-01		2	2

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Zeroth Moment Analysis

Project: Pantex SW

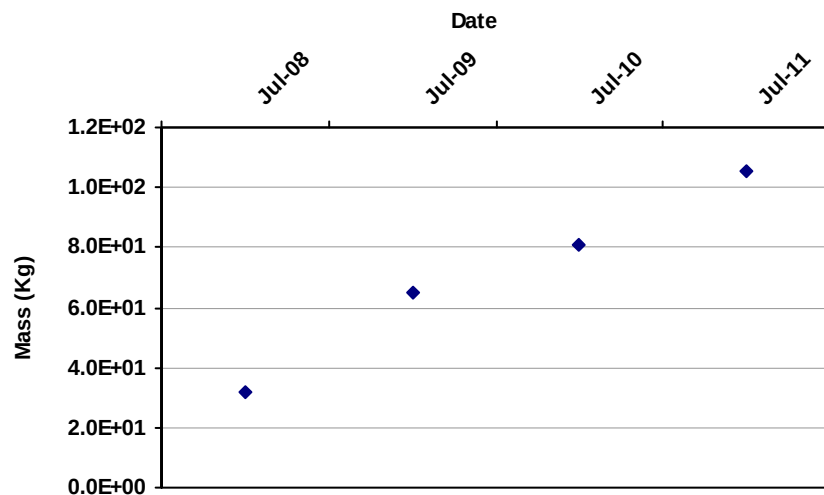
User Name: MV

Location: Southwest Area

State: Texas

COC: TRICHLOROETHYLENE (TCE)

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

6

Confidence in Trend:

95.8%

Coefficient of Variation:

0.43

Zeroth Moment Trend:

1

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2008	TRICHLOROETHYLENE (TCE)	3.2E+01	23
7/1/2009	TRICHLOROETHYLENE (TCE)	6.5E+01	32
7/1/2010	TRICHLOROETHYLENE (TCE)	8.1E+01	32
7/1/2011	TRICHLOROETHYLENE (TCE)	1.1E+02	32

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SW

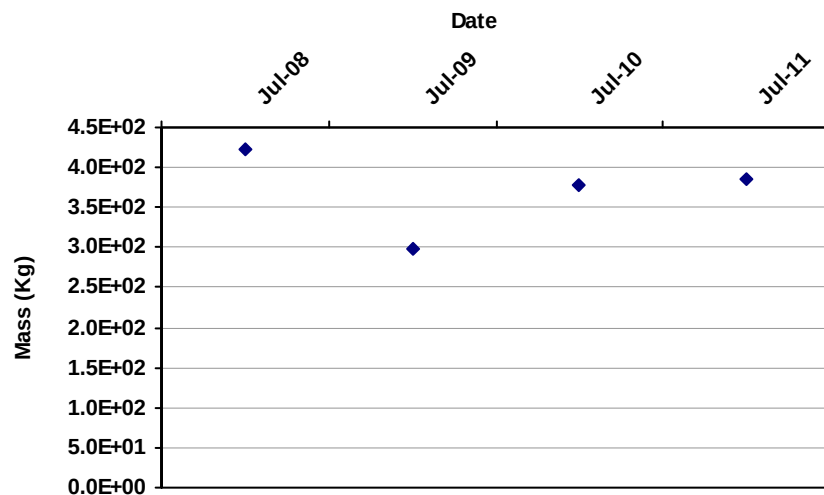
User Name: MV

Location: Southwest Area

State: Texas

COC: CHROMIUM, HEXAVALENT

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

0

Confidence in Trend:

37.5%

Coefficient of Variation:

0.14

Zeroth Moment Trend:

S

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2008	CHROMIUM, HEXAVALENT	4.2E+02	14
7/1/2009	CHROMIUM, HEXAVALENT	3.0E+02	11
7/1/2010	CHROMIUM, HEXAVALENT	3.8E+02	9
7/1/2011	CHROMIUM, HEXAVALENT	3.9E+02	21

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SW

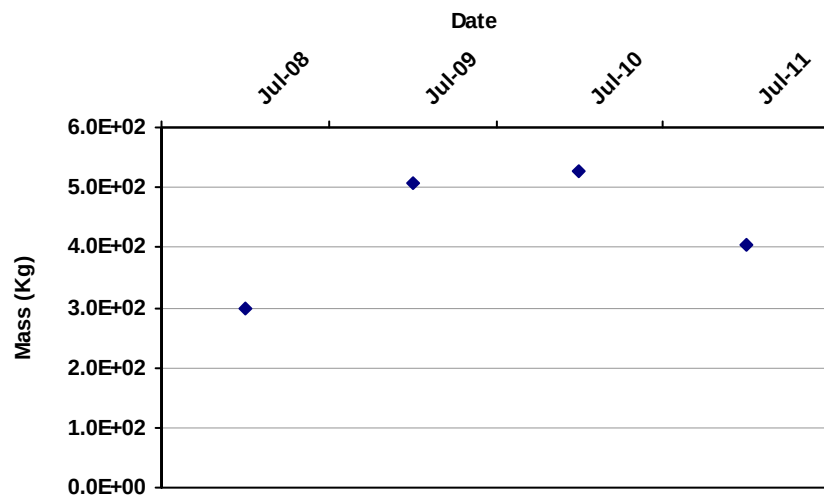
User Name: MV

Location: Southwest Area

State: Texas

COC: PERCHLORATE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

2

Confidence in Trend:

62.5%

Coefficient of Variation:

0.24

Zeroth Moment Trend:

NT

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2008	PERCHLORATE	3.0E+02	22
7/1/2009	PERCHLORATE	5.1E+02	25
7/1/2010	PERCHLORATE	5.3E+02	24
7/1/2011	PERCHLORATE	4.0E+02	23

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex SW

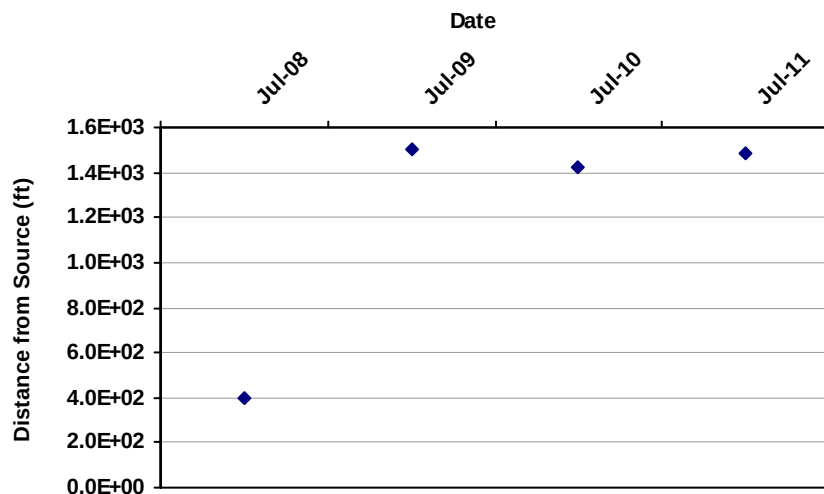
User Name: MV

Location: Southwest Area

State: Texas

COC: TRICHLOROETHYLENE (TCE)

Distance from Source to Center of Mass



Mann Kendall S Statistic:

2

Confidence in Trend:

62.5%

Coefficient of Variation:

0.45

First Moment Trend:

NT

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2008	TRICHLOROETHYLENE (TCE	636,006	3,756,703	398	23
7/1/2009	TRICHLOROETHYLENE (TCE	634,897	3,756,713	1,504	32
7/1/2010	TRICHLOROETHYLENE (TCE	634,976	3,756,763	1,424	32
7/1/2011	TRICHLOROETHYLENE (TCE	634,916	3,756,778	1,484	32

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex SW

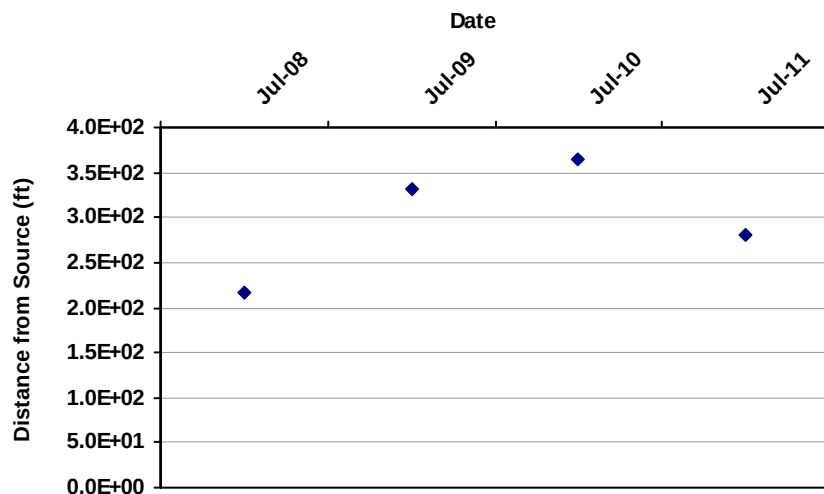
User Name: MV

Location: Southwest Area

State: Texas

COC: PERCHLORATE

Distance from Source to Center of Mass



Mann Kendall S Statistic:

2

Confidence in Trend:

62.5%

Coefficient of Variation:

0.22

First Moment Trend:

NT

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2008	PERCHLORATE	636,438	3,756,975	217	22
7/1/2009	PERCHLORATE	636,135	3,756,563	331	25
7/1/2010	PERCHLORATE	636,098	3,756,558	364	24
7/1/2011	PERCHLORATE	636,124	3,756,714	280	23

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex SW

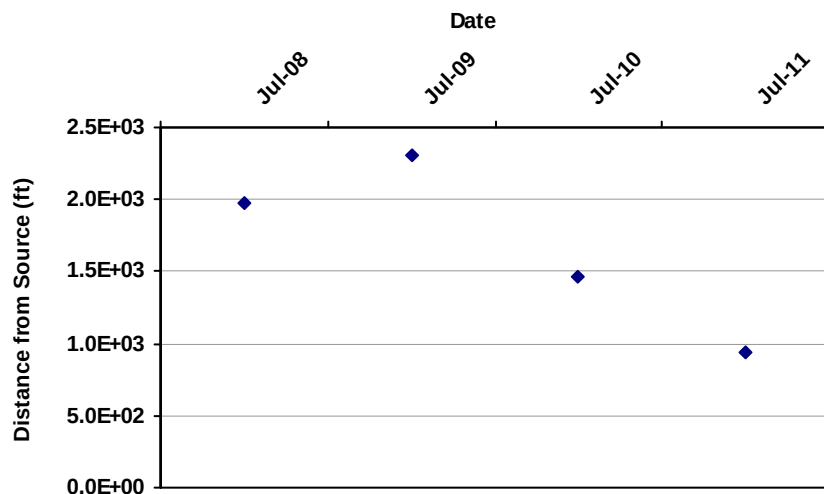
User Name: MV

Location: Southwest Area

State: Texas

COC: CHROMIUM, HEXAVALENT

Distance from Source to Center of Mass



Mann Kendall S Statistic:

-4

Confidence in Trend:

83.3%

Coefficient of Variation:

0.36

First Moment Trend:

S

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2008	CHROMIUM, HEXAVALENT	637,657	3,755,238	1,976	14
7/1/2009	CHROMIUM, HEXAVALENT	637,896	3,754,999	2,312	11
7/1/2010	CHROMIUM, HEXAVALENT	637,532	3,755,827	1,468	9
7/1/2011	CHROMIUM, HEXAVALENT	636,552	3,755,836	938	21

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS Percent of Mass by Well

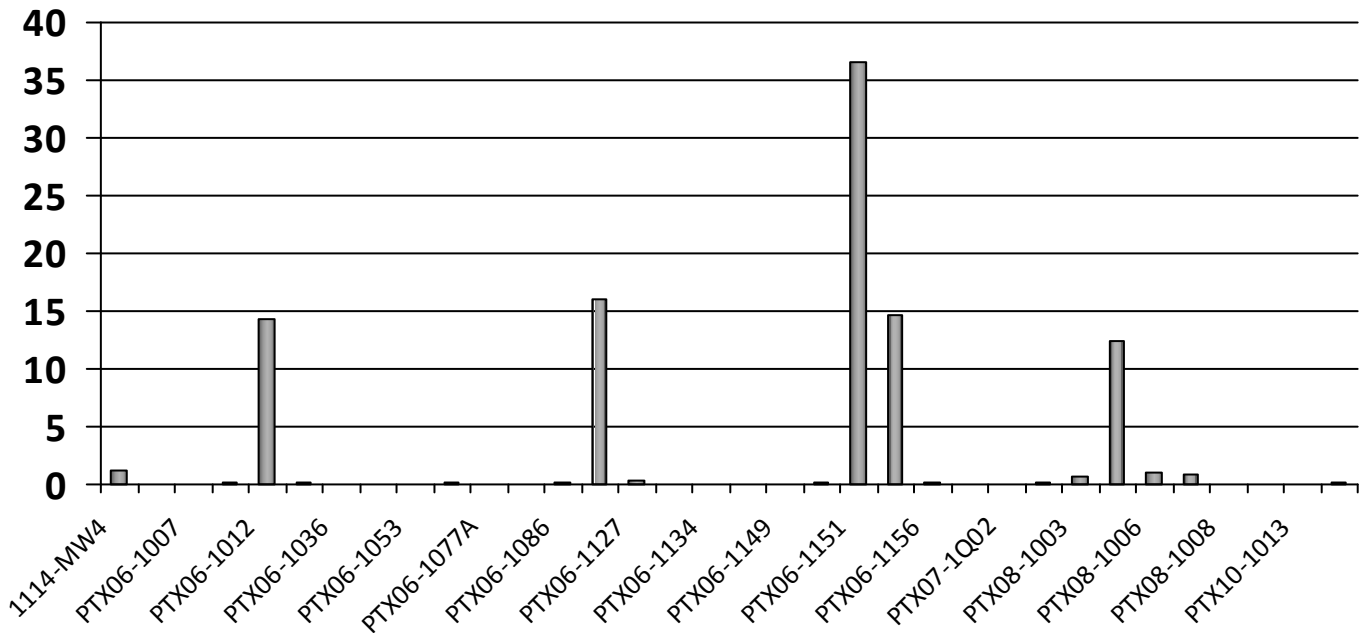
Project: Pantex SW

User Name: MV

Location: Southwest Area

State: Texas

TRICHLOROETHYLENE (TCE) 7/1/2011



Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area
1114-MW4	2,187,613.01	6,230.60	1.19	2.99
PTX06-1006	2,794,778.02	359.48	0.07	3.82
PTX06-1007	2,905,458.18	381.34	0.07	3.97
PTX06-1008	900,486.86	810.78	0.15	1.23
PTX06-1012	603,863.67	75,294.26	14.38	0.83
PTX06-1035	4,680,031.01	614.25	0.12	6.40
PTX06-1036	1,069,347.98	140.35	0.03	1.46
PTX06-1052	1,442,269.16	189.30	0.04	1.97
PTX06-1053	3,024,698.98	396.99	0.08	4.14
PTX06-1073A	4,919,904.15	1,291.47	0.25	6.73
PTX06-1077A	1,034,525.75	135.78	0.03	1.41
PTX06-1085	2,120,492.01	278.31	0.05	2.90
PTX06-1086	6,512,090.93	854.71	0.16	8.90
PTX06-1126	811,729.86	83,527.01	15.95	1.11

MAROS Percent of Mass by Well

Project: Pantex SW

User Name: MV

Location: Southwest Area

State: Texas

Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area	
PTX06-1127	653,953.23	1,840.22	0.35	0.89	
PTX06-1131	1,529,074.53	200.69	0.04	2.09	
PTX06-1134	2,620,474.97	343.94	0.07	3.58	
PTX06-1148	983,574.27	271.10	0.05	1.34	
PTX06-1149	669,908.34	74.74	0.01	0.92	
PTX06-1150	1,631,135.77	479.55	0.09	2.23	
PTX06-1151	3,764,924.56	191,728.79	36.62	5.15	
PTX06-1155	524,940.44	76,477.26	14.61	0.72	
PTX06-1156	598,334.56	608.62	0.12	0.82	
PTX07-1Q01	2,392,536.82	314.02	0.06	3.27	
PTX07-1Q02	277,970.92	36.48	0.01	0.38	
PTX07-1Q03	7,342,274.74	963.67	0.18	10.04	
PTX08-1003	4,240,681.87	3,606.70	0.69	5.80	
PTX08-1005	1,512,612.73	64,919.45	12.40	2.07	
PTX08-1006	1,562,699.46	5,476.29	1.05	2.14	
PTX08-1007	2,555,772.44	4,280.28	0.82	3.49	
PTX08-1008	2,505,918.23	328.90	0.06	3.43	
PTX08-1009	2,389,939.26	313.68	0.06	3.27	
PTX10-1013	286,672.58	75.25	0.01	0.39	
PTX10-1014	89,793.37	725.98	0.14	0.12	
	73,140,482.7	523,570.3	100	100	

MAROS Percent of Mass by Well

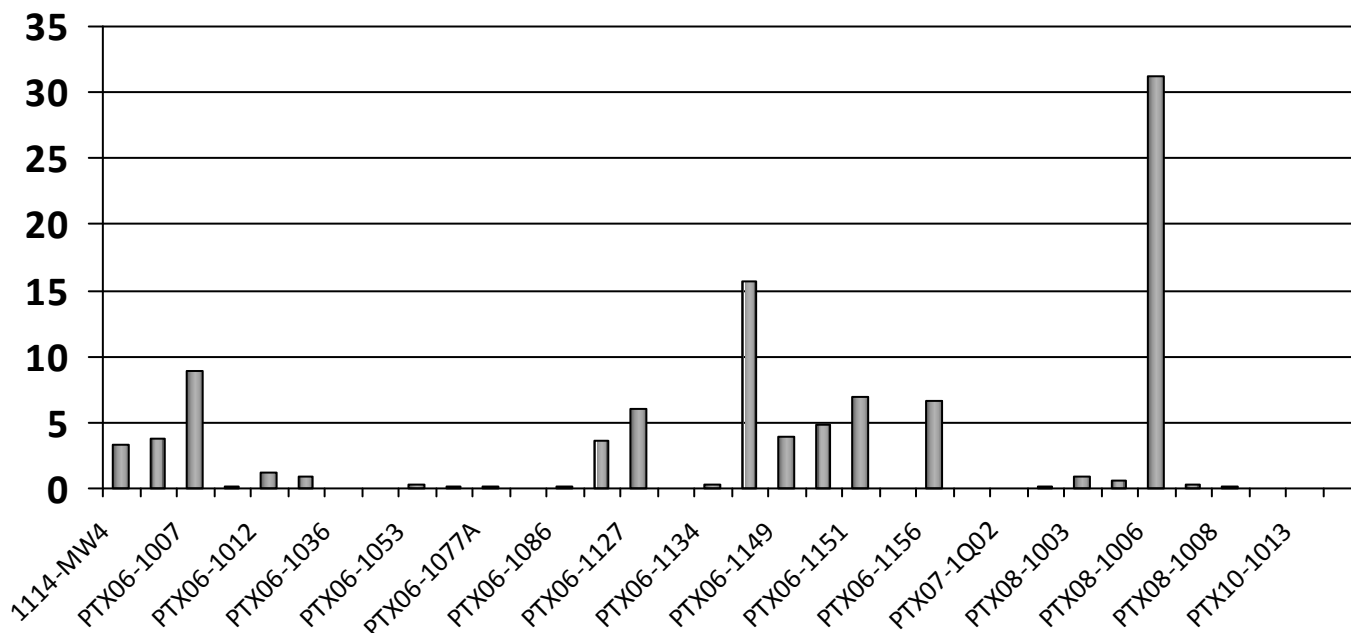
Project: Pantex SW

User Name: MV

Location: Southwest Area

State: Texas

PERCHLORATE 7/1/2011



Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area
1114-MW4	2,187,613.01	50,131.89	3.35	2.99
PTX06-1006	2,794,778.02	57,149.72	3.82	3.82
PTX06-1007	2,905,458.18	132,706.81	8.86	3.97
PTX06-1008	900,486.86	1,418.27	0.09	1.23
PTX06-1012	603,863.67	17,040.28	1.14	0.83
PTX06-1035	4,680,031.01	13,280.17	0.89	6.40
PTX06-1036	1,069,347.98	280.70	0.02	1.46
PTX06-1052	1,442,269.16	378.60	0.03	1.97
PTX06-1053	3,024,698.98	4,763.90	0.32	4.14
PTX06-1073A	4,919,904.15	1,291.47	0.09	6.73
PTX06-1077A	1,034,525.75	1,428.42	0.10	1.41
PTX06-1085	2,120,492.01	556.63	0.04	2.90
PTX06-1086	6,512,090.93	1,709.42	0.11	8.90
PTX06-1126	811,729.86	53,482.85	3.57	1.11



MAROS Percent of Mass by Well

Project: Pantex SW

User Name: MV

Location: Southwest Area

State: Texas

Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area	
PTX06-1127	653,953.23	90,122.93	6.02	0.89	
PTX06-1131	1,529,074.53	401.38	0.03	2.09	
PTX06-1134	2,620,474.97	4,354.25	0.29	3.58	
PTX06-1148	983,574.27	233,918.56	15.62	1.34	
PTX06-1149	669,908.34	58,382.51	3.90	0.92	
PTX06-1150	1,631,135.77	71,719.00	4.79	2.23	
PTX06-1151	3,764,924.56	103,474.25	6.91	5.15	
PTX06-1155	524,940.44	1,009.36	0.07	0.72	
PTX06-1156	598,334.56	98,439.13	6.57	0.82	
PTX07-1Q01	2,392,536.82	628.04	0.04	3.27	
PTX07-1Q02	277,970.92	72.97	0.00	0.38	
PTX07-1Q03	7,342,274.74	1,927.35	0.13	10.04	
PTX08-1003	4,240,681.87	14,248.69	0.95	5.80	
PTX08-1005	1,512,612.73	8,397.84	0.56	2.07	
PTX08-1006	1,562,699.46	466,612.31	31.16	2.14	
PTX08-1007	2,555,772.44	4,025.34	0.27	3.49	
PTX08-1008	2,505,918.23	3,216.66	0.21	3.43	
PTX08-1009	2,389,939.26	627.36	0.04	3.27	
PTX10-1013	286,672.58	75.25	0.01	0.39	
PTX10-1014	89,793.37	129.17	0.01	0.12	
	73,140,482.7	1,497,401.5	100	100	

August 2012

**GROUNDWATER MONITORING NETWORK OPTIMIZATION 2012
Pantex Plant**

Carson County, Texas

APPENDIX B:

North Sector MAROS Reports

COC Assessment

Mann-Kendall Reports Select Individual Wells

North Sector Percent Mass by Well

MAROS COC Assessment

Project: Pantex

User Name: MV

Location: North/Playa 1

State: Texas

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIA	1.6E-02	7.7E-03	111.7%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE	ORG	31	9	29.0%	22

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZI	0.00741

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZIN
4-AMINO-2,6-DINITROTOLUENE
PERCHLORATE
TRICHLOROETHYLENE (TCE)
2,6-DINITROTOLUENE

MAROS Mann-Kendall Statistics Summary

Well: PTX07-100

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 1/1/2007 to 12/30/2012

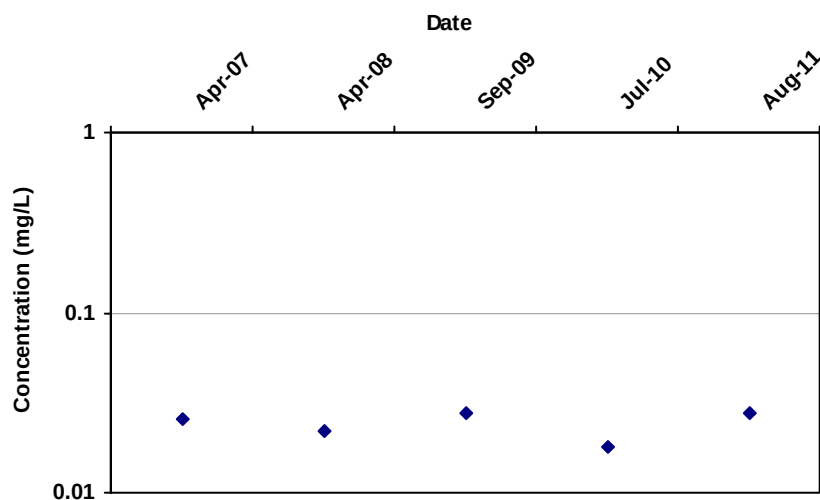
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

0

Confidence in Trend:

40.8%

Coefficient of Variation:

0.17

Mann Kendall Concentration Trend:
(See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX07-1003	T	4/15/2007	HEXAHYDRO-1,3,5-TRINITRO-1,	2.6E-02		1	1
PTX07-1003	T	4/17/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.2E-02		1	1
PTX07-1003	T	9/21/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	2.8E-02		1	1
PTX07-1003	T	7/27/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.8E-02		1	1
PTX07-1003	T	8/11/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.8E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX01-1001

Well Type: T

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 1/1/2007 to 12/30/2012

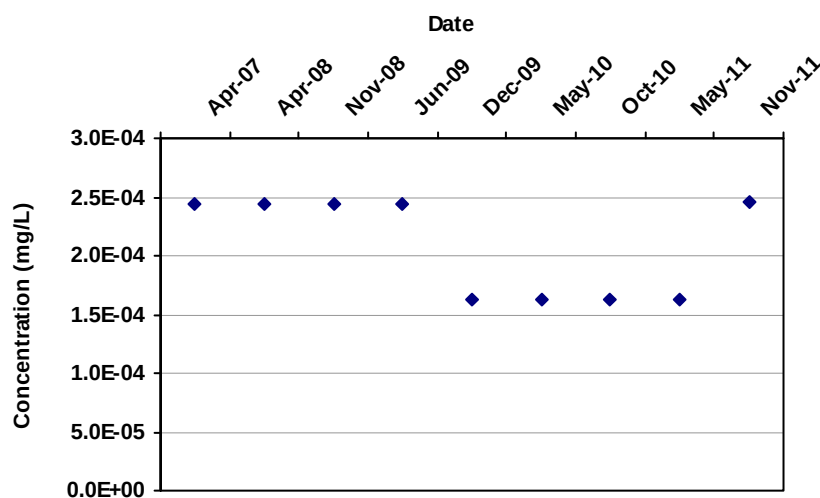
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-8

Confidence in Trend:

76.2%

Coefficient of Variation:

0.21

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX01-1001	T	4/15/2007	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-04	ND	1	0
PTX01-1001	T	4/17/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-04	ND	1	0
PTX01-1001	T	11/13/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-04	ND	1	0
PTX01-1001	T	6/22/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	2.4E-04	ND	1	0
PTX01-1001	T	12/15/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.6E-04	ND	1	0
PTX01-1001	T	5/12/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.6E-04	ND	1	0
PTX01-1001	T	10/25/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.6E-04	ND	1	0
PTX01-1001	T	5/10/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.6E-04	ND	1	0
PTX01-1001	T	11/3/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	2.5E-04		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX08-1002

Well Type: S

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 1/1/2007 to 12/30/2012

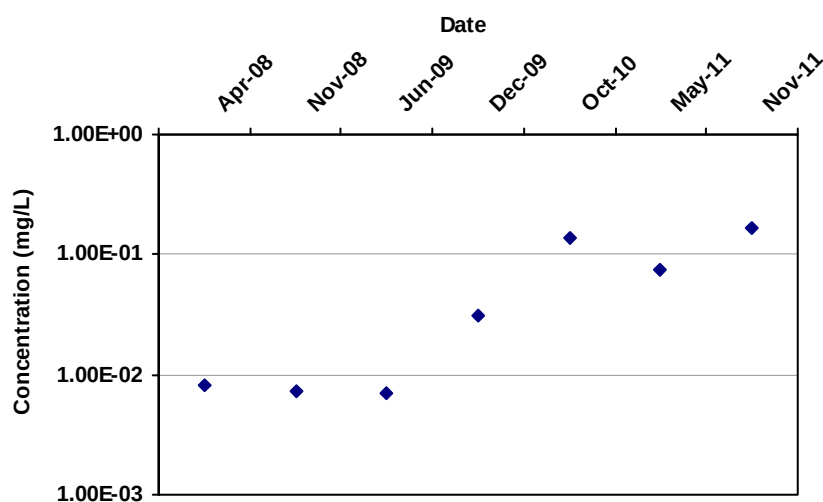
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

13

Confidence in Trend:

96.5%

Coefficient of Variation:

1.08

Mann Kendall Concentration Trend:
(See Note)

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX08-1002	S	4/17/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	8.3E-03		1	1
PTX08-1002	S	11/13/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	7.2E-03		1	1
PTX08-1002	S	6/22/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	6.9E-03		1	1
PTX08-1002	S	12/15/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	3.1E-02		1	1
PTX08-1002	S	10/25/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.4E-01		1	1
PTX08-1002	S	5/10/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	7.5E-02		1	1
PTX08-1002	S	11/3/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.7E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: PTX06-1050

Well Type: S

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Time Period: 1/1/2007 to 12/30/2012

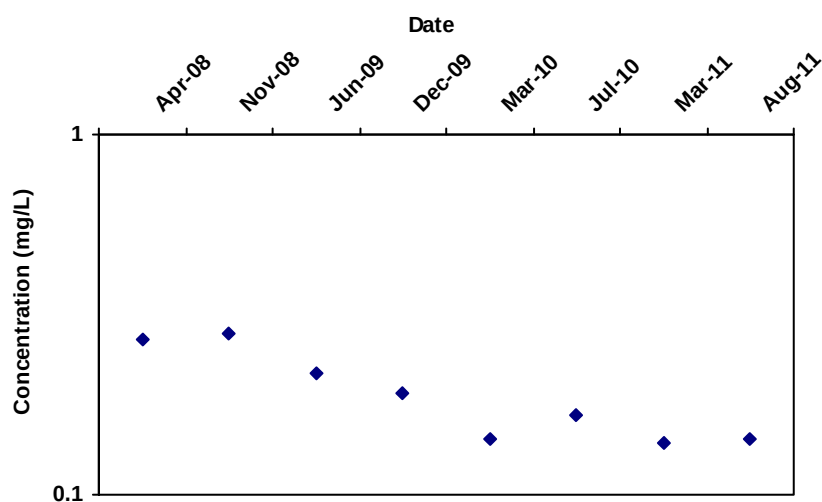
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-21

Confidence in Trend:

99.6%

Coefficient of Variation:

0.30

Mann Kendall Concentration Trend:
(See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
PTX06-1050	S	4/17/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.7E-01		2	2
PTX06-1050	S	11/13/2008	HEXAHYDRO-1,3,5-TRINITRO-1,	2.8E-01		2	2
PTX06-1050	S	6/22/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	2.2E-01		2	2
PTX06-1050	S	12/15/2009	HEXAHYDRO-1,3,5-TRINITRO-1,	1.9E-01		1	1
PTX06-1050	S	3/30/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.4E-01		1	1
PTX06-1050	S	7/27/2010	HEXAHYDRO-1,3,5-TRINITRO-1,	1.7E-01		1	1
PTX06-1050	S	3/8/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.4E-01		1	1
PTX06-1050	S	8/11/2011	HEXAHYDRO-1,3,5-TRINITRO-1,	1.4E-01		2	2

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Percent of Mass by Well

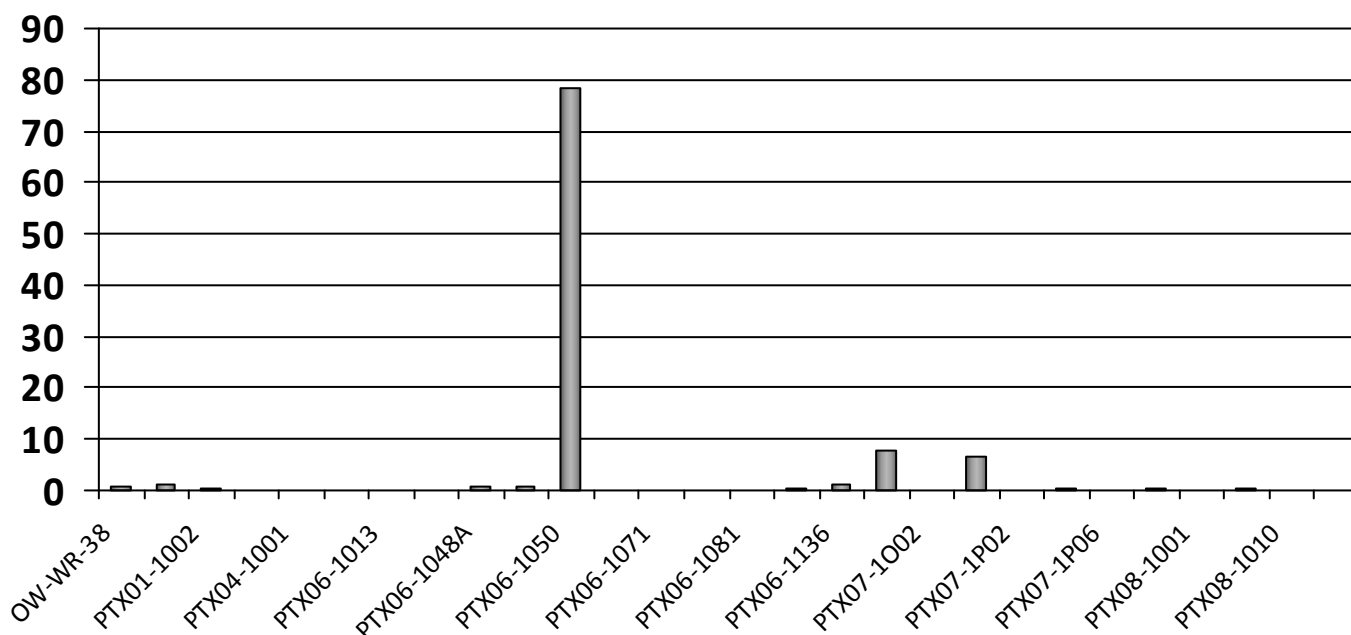
Project: Pantex

User Name: MV

Location: North/Playa 1

State: Texas

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE 8/11/2011



Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area
OW-WR-38	5,918,258.09	3,277.98	0.87	4.03
PTX01-1001	16,228,309.66	4,259.93	1.13	11.04
PTX01-1002	3,802,743.20	998.22	0.26	2.59
PTX01-1008	1,185,797.82	311.27	0.08	0.81
PTX04-1001	1,513,671.05	64.57	0.02	1.03
PTX04-1002	3,040,224.13	150.43	0.04	2.07
PTX06-1013	2,620,865.74	687.98	0.18	1.78
PTX06-1023	4,362,334.45	190.09	0.05	2.97
PTX06-1048A	13,230,049.71	3,472.89	0.92	9.00
PTX06-1049	9,813,689.82	2,576.09	0.68	6.68
PTX06-1050	7,941,351.32	296,013.88	78.28	5.40
PTX06-1069	1,809,621.96	77.19	0.02	1.23
PTX06-1071	1,146,193.20	48.89	0.01	0.78
PTX06-1080	9,467,080.08	403.83	0.11	6.44



MAROS Percent of Mass by Well

Project: Pantex

User Name: MV

Location: North/Playa 1

State: Texas

Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area	
PTX06-1081	9,741,065.29	415.52	0.11	6.63	
PTX06-1117	3,105,543.92	815.21	0.22	2.11	
PTX06-1136	17,532,814.15	4,602.36	1.22	11.93	
PTX07-1O01	4,955,924.50	29,140.84	7.71	3.37	
PTX07-1O02	6,341,563.83	374.55	0.10	4.32	
PTX07-1O03	3,458,957.03	25,150.94	6.65	2.35	
PTX07-1P02	723,122.98	189.82	0.05	0.49	
PTX07-1P05	3,877,555.32	1,017.86	0.27	2.64	
PTX07-1P06	139,495.23	36.62	0.01	0.09	
PTX07-1R03	7,393,422.00	1,940.77	0.51	5.03	
PTX08-1001	2,075,257.53	544.76	0.14	1.41	
PTX08-1002	3,208,630.86	842.27	0.22	2.18	
PTX08-1010	679,468.72	130.02	0.03	0.46	
PTX-BEG3	1,637,746.41	429.91	0.11	1.11	
	146,950,758.0	378,164.7	100	100	

Appendix C

Sampling Evaluation for High Plains Aquifer Monitoring Wells (RPS Espey, 2012)

Sampling Evaluation for High Plains Aquifer Monitoring Wells



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License # F-293

Executive Summary

The objective of this study is to evaluate existing High Plains Aquifer monitoring wells and sampling methods at the Pantex Plant. Pantex currently uses a modified low-flow purging and sampling procedure to collect samples from these wells. However, recent data and discussions with regulators have prompted questions regarding the representativeness of the sampling results using low-flow methods. To address these concerns, this project was commissioned by B&W Pantex to review state-of-the-industry sampling methods, evaluate well construction details of the High Plains Aquifer wells, and develop recommendations for changes to the sampling program, if warranted.

The purpose of groundwater monitoring wells in the High Plains Aquifer at Pantex Plant is for detection of constituents potentially migrating to the High Plains Aquifer from historical releases. To achieve this objective, the well network must provide broad coverage of the aquifer downgradient of potential source areas in overlying perched groundwater or the unsaturated zone. The wells must monitor this area laterally such that a contaminant plume cannot escape undetected between two wells and vertically so that contaminants do not pass above or below the screened interval of a monitoring well. The wells must monitor for a broad range of constituents (high explosives, metals, inorganics, and volatile organics) with very low limits of detection.

The High Plains Aquifer comprises a relatively thick sequence of sand and gravel layers with some clayey layers present throughout the aquifer's thickness. The USGS flow study revealed that little to no vertical flow occurs in the High Plains Aquifer wells under ambient conditions except in the far northern portions of the Plant where some downward flow occurs as a result of pumping from irrigation and municipal water supply wells. The most transmissive zones of the aquifer, where present, were found in the upper portions of the well screens.

Newer wells were constructed using multiple screened intervals separated by blank casing sections that allow complete isolation of the screened intervals through the placement of diverters or packers. Older wells were typically completed with continuous well screen across the entire saturated interval and do not allow for zone isolation.

The existing High Plains Aquifer monitoring network is acceptable for detection monitoring. The data obtained from a recent vertical flow study indicate that monitoring wells in good hydraulic communication with the aquifer should meet the assumptions of sustained horizontal flow through with little or no ambient vertical flow between aquifer strata. Under these conditions, ambient concentrations in wells would be expected to represent flow-weighted averages of concentrations in the aquifer. Because all potential contaminant sources are located above the Ogallala Aquifer water table, the highest concentrations of potential contaminants would be found in the upper portion of the aquifer. Ambient in-well concentrations would be most similar to concentrations in the upper portion of

the aquifer because zones of higher transmissivity were observed in the upper portions of well screens and vertical ambient flows, where observed, are downward. Therefore, samples obtained from these wells are representative of conditions in the upper zone of saturation where potential contaminants are expected. Wells with multiple screened intervals that can be isolated can also provide representative data of conditions lower in the aquifer. However, in the event of contaminant detection, these wells may facilitate spreading of contamination to deeper layers of the aquifer.

Because the assumptions of thorough mixing and horizontal through-flow appear to be valid for these wells, use of low-flow or passive sampling methods should be equally appropriate for most wells. The existing sampling protocol is equivalent to the low-flow “micropurge” method described in the literature (Kearl et al. 1994; Shanklin et al. 1995) and is an acceptable method for sampling these wells.

Recommendations for improving the sampling program include:

- Conducting well-specific evaluations of natural flow through;
- Developing well-specific purge criteria based on achieving a minimum two-volume purge of the sample tubing and pump;
- Installation of packers in additional wells where appropriate to reduce the effective screen length for sampling and increase the sensitivity of detection monitoring;
- Testing of the passive Snap Sampler in combination with zone isolation baffles; and
- Continued use of the well construction design specified in the Long-Term Monitoring System Design Report (Stovall and Jarrett 2009) for future detection monitoring wells in the High Plains Aquifer.

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Introduction

The objective of this study is to evaluate existing High Plains Aquifer monitoring wells (also known as Ogallala wells) and sampling methods at the Pantex Plant. Pantex currently uses a modified low-flow purging and sampling procedure to collect samples from these wells. However, recent data and discussions with regulators have prompted questions regarding the representativeness of the sampling results using low-flow methods. To address these concerns, this project was commissioned by B&W Pantex to review state-of-the-industry sampling methods, evaluate well construction details of the High Plains Aquifer wells, and develop recommendations for changes to the sampling program, if warranted.

Because this project primarily consisted of an extensive review of peer-reviewed literature on groundwater purging and sampling methods and monitoring well design and construction, the complete collection of works cited in this report has been provided in digital format accompanying this document. Many of the reference articles provide in-depth analysis and excellent discussion of the relevant issues; the reader is therefore referred to the original articles for further information. In particular, the following articles greatly enhanced the reviewers understanding of the complexities of well flow and sampling processes: Britt 2005; Britt, Parker, & Cherry, 2010; Martin-Hayden 2000; and Martin-Hayden & Britt 2006.

Site Background

History

The Pantex Plant (Pantex) is a Department of Energy (DOE) owned, contractor-operated facility, managed by B&W Pantex, LLC. The Pantex Plant was originally constructed by the U.S. Army for production of conventional ordnance during World War II. Pantex was deactivated after the war and the property reverted to the War Assets Administration. Texas Technological College purchased the installation in 1949. The Army Ordnance Corps reclaimed the site in 1951 for use by the Atomic Energy Commission as a nuclear weapons facility. Today the Plant's mission is to assemble nuclear weapons for the nation's stockpile; disassemble nuclear weapons being retired from the stockpile; evaluate repair and retrofit nuclear weapons in the stockpile; sanitize components from dismantled nuclear weapons; provide interim storage for plutonium pits from dismantled nuclear weapons; and develop, fabricate, and test chemical explosives and explosive components for nuclear weapons to support DOE initiatives. The Pantex Plant is located in Carson County, approximately 17 miles northeast of Amarillo, Texas. DOE owns approximately 11,700 acres at Pantex Plant.

Regulatory Background

Pantex implemented its remedial actions in accordance with the Compliance Plan for Industrial Solid Waste Management Sites, issued on October 21, 2003, and updated on September 16, 2010 to include final remedial actions, under the provisions of Texas Health and Safety Code Annotated, Chapter 361 and Chapter 26 of the Texas Water Code. The Compliance Plan (CP-50284) is a Texas Commission on Environmental Quality (TCEQ) permit, which delineates the requirements for conduct of corrective actions and groundwater monitoring programs according to the Resource Conservation and Recovery Act (RCRA). Pantex was listed on the National Priorities List in 1994, requiring Pantex to also investigate and cleanup according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Pantex meets the requirements of CERCLA through the Interagency Agreement (IAG), effective February 22, 2008. The IAG is issued through the US Environmental Protection Agency (EPA).

Geology and Hydrology

The primary subsurface geologic units in the vicinity of the Pantex Plant are the Blackwater Draw Formation (clayey silts), the Ogallala Formation (sand to silty sand), and the Triassic Dockum Group (sand to clay). The first of two water-bearing units below the Pantex Plant in the Ogallala Formation is the perched aquifer located at depths of approximately 200 to 300 feet. This aquifer is supported by a relatively low permeability zone, referred to as the 'Fine-Grained Zone' (FGZ), which consists of silts and clays that retard the downward migration of the perched groundwater. The perched aquifer flows

radially and away from a playa lake designated as Playa 1 and ranges in thickness from less than one foot to over 50 feet.

The second water-bearing zone below the FGZ is the Ogallala formation or the High Plains Aquifer. The High Plains Aquifer is a primary drinking and irrigation water source for most of the High Plains. The groundwater surface is approximately 400 feet below ground surface and is approximately 1 to 100 feet thick in the southern regions of the Plant and approximately 250 to 400 feet thick in the northern regions. The base of the Ogallala formation in the southeastern area is deposited directly on the Permian basement rocks (Dockum Group). The primary flow direction in the Ogallala Aquifer is north to northeast.

High Plains Aquifer Monitoring Objectives

Monitoring wells in the High Plains Aquifer are used for both early detection and uncertainty management. Specific wells in the High Plains Aquifer serve as point of exposure wells to also satisfy requirements in the Compliance Plan. Uncertainty management wells were used to satisfy requirements in the Compliance Plan for periodic evaluation of the closest water bearing unit near sources of contamination.

The purpose of early detection wells is to identify potential breakthrough of constituents to the High Plains Aquifer from overlying perched groundwater, if present, or potential source areas in the unsaturated zone before potential points of exposure have been impacted. Early detection wells are located downgradient of potential source areas, such as impacted areas of perched groundwater, along the edge of the known extent of impacted perched groundwater, and upgradient of potential points of exposure (i.e., the Pantex property boundary). Wells downgradient of potential source areas are located as close to the source area as possible; in some cases these wells must be moved further downgradient because of the risk of creating a migration pathway to the Ogallala Aquifer by drilling through impacted perched groundwater. The focus of monitoring in early detection wells is on indicator constituents (Table 1), defined as COCs and degradation products in overlying or upgradient perched groundwater that will most likely be detected following potential breakthrough to the aquifer.

Because of the cleanup actions that have been implemented to protect the High Plains Aquifer, the expected conditions for the early detection wells are that constituents are not detected above background, the practical quantitation limit (PQL), or groundwater protection standards (GWPSs) and that constituents do not reach potential points of exposure above GWPSs.

The purpose of uncertainty management wells in the High Plains Aquifer is to confirm expected conditions identified in the RCRA Facility Investigations and ensure there are not any deviations, fill potential data gaps, and fulfill long-term monitoring requirements for soil units closed to Risk Reduction Standard (RRS) 3. Uncertainty management wells are located downgradient of RRS 3 units, using a Zone or Waste Management Group approach, in areas where perched groundwater is not present, or

downgradient of potential source areas, such as impacted areas of perched groundwater and along the edge of the known extent of impacted perched groundwater.

The uncertainty management wells were also used to satisfy requirements in the Compliance Plan for periodic evaluation of wells near sources of contamination to ensure that new contamination is not found over time. This sampling is conducted every five years to correspond to the CERCLA 5-year review and focuses on wells near the source areas.

Current High Plains Aquifer Monitoring Program

The current monitoring program is detailed in the Field Sampling Plan for USDOE/NNSA Pantex Plant Groundwater Remedial Action Projects (November 2011 Update to the Sampling and Analysis Plan Dated April 2009). Groundwater samples are collected from 26 High Plains Aquifer monitoring wells as shown in Figure 1. The analyte list is dependent on spatial location of the well on the Pantex Plant (Northwest and Southeast areas). General chemistry parameters such as standard cations and anions are collected for all High Plains Aquifer monitoring wells. Water quality samples are collected semi-annually with the exception of three wells which are sampled annually. Multi-depth wells are sampled semi-annually at one depth with samples taken from the additional multiple depths every five years.

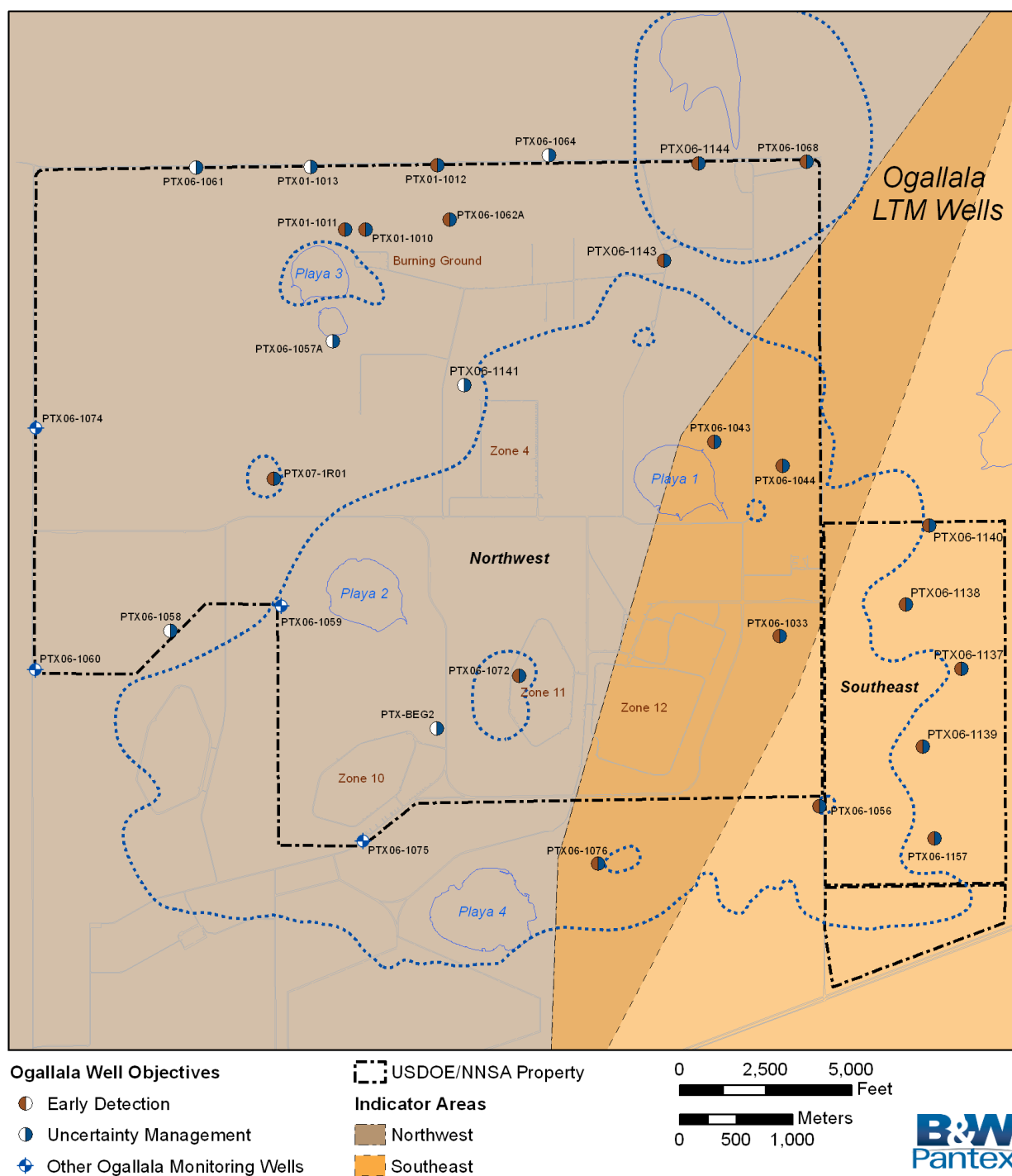


Figure 1 Ogallala Aquifer Monitoring Network

Sampling Methods

Sample procedures include pre-sampling activities such as acquisition of appropriate documentation paperwork, condition of the well head and casing, etc. Water-level measurements are made in 0.1 ft increments using a non-dedicated electronic probe. The High Plains wells have dedicated Bennett pumps. Well total depth measurements are taken at any time the pump is removed but at a minimum every five years. Well depth measurements are measured with a non-dedicated weighted probe attached to a graduated 1 ft cable. Measurements are taken and rounded to the nearest 0.5 ft.

Sample collection is convened with low-flow purge procedures with flow rates set at 0.3 to 0.8 L/min. The wells are purged for a set amount of time for stabilization. Three minutes of flow are collected prior to the first water quality measurement. Purge times are ten minutes for High Plains Aquifer wells. Purge water is routed through a flow through cell to monitor field parameters. Field parameters are measured using a YSI multi-parameter water quality meter and are electronically recorded. Turbidity measurements are also made using a turbidity meter. Purge water from the High Plains Aquifer wells is disposed of in accordance with the Pantex Multi-sector Stormwater permit, TXR050000. Although not currently applicable to the High Plains Aquifer wells, the procedure includes additional steps to address dry wells and/or wells not having a sufficient amount of groundwater available.

Sample collection priority is volatile organic compounds (VOCs), high explosives, perchlorate, metals, filtered metals, general chemistry, and samples for radiochemistry analyses. Samples are preserved and stored for transportation to a laboratory for analysis. Chain of custody forms are completed as well as all logbooks.

Eight High Plains Aquifer wells are multi-depth screened wells. These eight wells are equipped with dedicated pumps set at one of their screened intervals with diverters set in the blank casing below the screen for routine annual sampling. However, every five years the multiple depths are to be sampled. The multiple depths are sampled according to the low-flow sampling procedure using portable Bennett pumps equipped with baffles placed within the blank screen intervals. The procedure for sampling is the same as for those wells with dedicated pumps for pre-sampling activities and water and bottom depth measurements. The portable Bennett pump is lowered from the surface to a specified depth for each multi-depth well with baffles on each side of the pump set by well construction details to locate the blank screen depths. Once the pump and baffles are in place, sampling is continued in the same manner as those wells with dedicated pumps with the exception of a 13 minute purge time. The pump is rinsed in distilled water only between depths and potentially other wells. Purge water is disposed of in accordance with the Pantex Multi-sector Stormwater permit, TXR050000. Samples are preserved, stored, and delivered to the laboratory for analysis in the same pattern as all other High Plains Aquifer wells.

Summary of Relevant Groundwater Purging/Sampling Methodologies

This section provides a brief overview of state-of-the-art groundwater purging and sampling methodologies. The purpose of this overview is to provide general information about each of the methodologies relevant to the sampling objectives at Pantex including pros and cons of each method and arguments for sample representativeness.

The collection of “representative” samples which reflect in situ groundwater conditions at the time and location of sampling is a key objective of groundwater quality monitoring. This implies that the chemical and microbiological properties of the groundwater sample reflect those in the aquifer adjacent to the sampling point. The term “representative” involves recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives (CL:AIRE 2008, Puls and Barcelona 1996).

Traditional Fixed Well-Volume Purging

Methodology Description: Removal of a fixed number of well volumes from the casing using a pump or bailer prior to sample collection. The 3-5 well volume “rule of thumb” originated from early research on groundwater sampling that failed to recognize that this volume of purging was required to remove excessive turbidity caused by mixing of the water column by insertion and use of the sampling device.

Pros:

- Comparatively simple implementation.
- Does not require any specialized equipment, only a bailer or portable sample pump is needed.

Cons:

- No consideration of well-specific hydraulics or site-specific hydrogeology of geochemistry.
- Because no purging rate is specified, or related to well-specific response, the well may be hydraulically over-purged and dewatered, causing aeration of the formation and increased sample turbidity.
- No standardized definition of “well volume;” may lead to inconsistent application.
- Does not provide independent chemically-based confirmation of when fresh formation water enters the well.

- Commonly results in removal of more water than is necessary leading to decreased sampling efficiency and increased costs associated with labor and disposal of purge water.
- Allows use of grab sampling devices that agitate the water column and increase turbidity.
- Potential for damage to the well filter pack caused by turbulent flow.

Sample Representativeness: When carefully implemented, this method can provide a volume-averaged concentration of the water-bearing zone. However, high flow-rate (i.e., turbulent) pumping (or bailing) degrades sample quality by mixing water from the screened zone of the formation with water from above and below the screened interval; mobilization of fine-grained solids from the formation, filter pack, and well sump; and possible dewatering of a portion of the screen causing agitation, aeration, and oxidation of the sample and precipitation of solids (Nielsen and Nielsen 2007). Note: “high flow-rate” refers to the velocity imparted during pumping to the formation pore water adjacent to the well screen, not the rate of pumping.

Variations of this approach include purging to stabilization of indicator parameters and use of a packer above the well screen to reduce purge volume. In many cases, these variations are affected by the same problems as defined volume purging. Packers can reduce purge volume and associated management costs for wells in which the static water level is significantly above the top of the well screen. When purge flow rate, stabilization of indicator parameters and drawdown, and sample collection method are specifically defined, purging to stabilization of indicator parameters is the same as low-flow purging and sampling, described below.

Low-Flow Purging and Sampling

Low-flow purging and sampling techniques have been developed to eliminate some of the potential problems associated with traditional sampling methods including: reduction in the amount of purge water generated, directly resulting in a reduction in disposal costs associated with purging a well, reduction in sample turbidity eliminating the need for filtration, attainment of better quality samples, and sample collection in a manner that minimizes disruption to the monitoring well (Puls and Barcelona 1997). Low-flow purging is based on the assumption that water in the screened interval is representative of water in the formation surrounding the screen, depending upon well construction and site hydrogeology. Samples collected using the low-flow methodology represent a transmissivity-weighted average of the concentrations of water in the screened interval of the well (Nielsen and Nielsen 2007).

Methodology Description: Water is removed directly from the screened interval of the well without disturbing the stagnant water above the screen through the use of a dedicated low-flow pump permanently installed in the well or by carefully installing a portable low flow pump. Typically flow rates on the order of 0.1 -0.5 L/min are used, but flow rates as high as 1 L/min may be acceptable in coarse formations. The objective is to pump in a manner that minimizes stress or disturbance on formation

hydraulics to the extent practical, as indicated by water level drawdown. Minimizing drawdown in the well minimizes the velocity of pore water in the formation outside the well, avoids turbulent flow through the well screen, and effectively isolates stagnant water above the screen. A stabilized water level indicates that water pumped from the well is derived directly from the formation. Stabilization, rather than the actual amount, of drawdown should be the primary focus to collect high quality samples. In low hydraulic conductivity formations, the screen entrance velocities can be kept low despite significant drawdown as long as drawdown is stabilized (Barcelona et al 2005, Nielsen and Nielsen 2007).

Measurements of water levels and water-quality indicator parameters (e.g., temperature, dissolved oxygen, specific conductance, pH, and redox potential) are repeated every 5-10 minutes during purging. Visual observations of the clarity and color of the pump discharge water are also recorded. These successive field parameter measurements are used to determine when purging is sufficient and sample collection may proceed. In general, purging will continue until all field parameters and visual observations show no significant fluctuations or trends (increasing or decreasing over time). Generally, purging at a rate that minimizes drawdown reduces the time required for indicator parameters to stabilize. Stabilization of water quality parameters is determined according to pre-defined criteria, such as changes among three consecutive readings made several minutes apart of no more than:

- ± 0.2 unit for pH,
- $\pm 3\%$ for specific conductance,
- ± 20 mV for redox potential,
- $\pm 0.2^\circ\text{C}$ for temperature, and
- $\pm 10\%$ for turbidity, and
- $\pm 10\%$ or ± 0.2 mg/L (whichever is greater) for dissolved oxygen (Nielsen and Nielsen 2007).

The total volume purged varies with well diameter, but is typically less than one-third to one-half the well volume. Specific conductance and dissolved oxygen, along with drawdown, are often cited as the most suitable analytes for judging stability of purge water (Hart et al. 2000, Barcelona et al. 2005). Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured (Puls and Barcelona 1996).

For long-screen wells, purging of one-third to one-half of a well volume is impractical because purging of these volumes would require several hours at typical low-flow purge rates. Some researchers have demonstrated that samples taken directly from the screened interval are representative of groundwater in the surrounding formation and that purging to stabilization is unnecessary (Kearl et al. 1994; Shanklin

et al. 1995). This technique, known as “micropurge” sampling, is an adaptation of the low-flow sampling procedure and requires only sufficient flushing of the pump and discharge tubing (suggested two calculated pump/tubing volumes) before a representative sample can be collected. Under this protocol, field parameter information is collected as part of the routine sampling procedure to determine and confirm baseline site conditions and monitor hydrogeologic changes within the aquifer.

Pros:

- Improved sample quality through minimized disturbance of the well and formation thereby minimizing artifacts of turbidity;
- Improved accuracy, precision, and repeatability, and reduced sample variability because of minimized disturbance and mixing;
- Samples are representative of the mobile load of contaminants present (dissolved and colloid-associated);
- Less operator variability, greater operator control;
- Increased well life through reduced stress on the well and formation; and
- Smaller purging volume which decreases waste disposal costs and sampling time.

Cons:

- Not suitable for very low-yield wells;
- Need to transport additional equipment to and from the site; and
- Requires properly trained and experienced field technicians to monitor drawdown and regulate flow to minimize drawdown.

Sample Representativeness: Low-flow purging and sampling techniques in many cases rely on flow through in wells because the method commonly removes only a portion of the water within the screened interval. In all cases, samples collected using the low-flow methodology represent a transmissivity-weighted average of the concentrations of water in the screened interval of the well. While isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques, it is sometimes unclear if the sample obtained represents formation water or well-mixed water from within the wellbore. Micropurge, like low-flow, sampling provides representative samples because it relies on natural flow through the screened interval of a well and in-well mixing processes.

Passive (No Purge) Sampling

Methodology Description: A passive sampler is defined as one that is able to acquire a sample from a discrete location or interval in a well without the active transport associated with a pump or purge technique (ITRC, 2005). In wells, all passive methods rely on the well water being in equilibrium with the formation water. Passive sampling technologies include devices that recover a grab sample (e.g., HydraSleeve or Snap Sampler), devices that rely on diffusion of the analytes to reach equilibrium between the sampler and the well water (e.g., Regenerated-Cellulose Dialysis Membrane Samplers or Polyethylene Diffusion Bag Samplers), and devices that rely on diffusion and sorption to accumulate analytes in the sampler (e.g., Semi-Permeable Membrane Devices or GORE™ Sorbers). Information on grab and diffusion-based passive samplers is presented separately below. Additional information on diffusion/sorption-based samplers is not presented because these types of samplers are only suitable for organic analytes.

Sample Representativeness: Groundwater sampling is performed to collect a sample of formation-quality water from the screened or open portion of a well. Research shows that many if not most wells exhibit ambient flow-through under natural groundwater gradients. The screened sections of these wells may be considered in equilibrium with the formation water without pumping; however, ambient flow, temperature inversions, and density effects can induce mixing within wells, resulting in a flow-weighted averaging effect in many wells without purging. Over the past decade, a number of research studies have included side-by-side comparison tests with a site's current sampling method (e.g., well volume purge sampling or low-flow purge sampling) to determine whether passive samplers are appropriate at a particular well. These tests have shown that contaminant concentrations from passive samplers adequately represent local ambient conditions within the screened interval despite whether the contaminant concentrations are higher or lower than a conventional sampling method. Disagreement in the data does not necessarily invalidate either sampling method because there are differences between active and passive sampling approaches and a one-to-one correlation may not occur (ITRC 2007).

Devices That Recover a Grab Sample (e.g., HydraSleeve, Snap Sampler)

Methodology Description: Samples are an instantaneous representation of conditions in the well at the sampling point at the moment of sample collection. Sample collection devices are deployed in a well from a few hours (HydraSleeve) or one day (Snap Sampler) to several months prior to the date of sample collection. The sample is collected instantaneously when the device is activated without causing drawdown or agitation of the water column in the well.

The In Situ Sealed, or “Snap”, Sampler is a double-end opening bottle deployed down the well on a holder attached to a trigger mechanism. The bottle is allowed to passively equilibrate in the well, and then the Snap Sampler is triggered from the surface, closing both ends of the bottle and capturing a

groundwater sample in the well from the defined depth. Once recovered, the sample is shipped to the laboratory. The Snap Sampler technology continues to evolve, and current implementations include the ability to collect much larger sample volumes and an improved pneumatic trigger for deeper installations that has been successfully tested up to 2,000 ft.

The HydraSleeve is a disposable polyethylene bag equipped with a self-sealing valve at the top and a reusable stainless steel weight at the bottom. The sampler is deployed by attaching a suspension cord to the top and lowering the empty sampler into the well. During installation, hydrostatic pressure causes the sampler to retain its flat and empty profile for an indefinite period prior to sample collection. After lowering the sampler to the desired sample depth, the water column is allowed to equilibrate. To initiate sample collection the HydraSleeve is pulled upward through the sample zone at one foot per second or faster. As it moves upward, the valve at the top opens and the sleeve expands to contain the sample. Once the sample sleeve is full, the self-sealing valve closes, preventing loss of the sample or the entry of extraneous, non-representative fluid during recovery. At the surface, the HydraSleeve is punctured with the pointed discharge straw and the sample transferred to suitable containers for transport to the laboratory.

Pros:

- Can sample all groundwater analytes as long as an adequate volume of sample is recovered for analysis. Maximum sample volumes range from 2 liters for the Snap Sampler to 4 liters for the HydraSleeve.
- Effective in low yield wells.
- Samples a discrete interval in well.
- Multiple samplers can be deployed to provide a vertical contaminant profile.
- Reduced sampling time. Grab samplers can be re-deployed immediately following sample collection so that only one well visit is required per sample event. In addition, samples collected with the Snap Sampler can be packaged and shipped to the lab in the Snap container eliminating time required to prepare sample bottles and transfer the samples to the bottles.
- Reduced reliance on operator experience for collection of high quality samples.
- Minimal decontamination of sampling equipment between sampling events or wells.
- Improved safety because of reduced handling of contaminated groundwater and fewer equipment needs.

Cons:

- May be difficult to collect adequate sample volume although the minimum required sample volume to conduct most standard analyses may be much less than the typically requested

volume, depending on the choice of analytical methods and desired detections. Prior coordination with the laboratory could eliminate this minimum volume limitation as a concern.

- Use of the Snap Sampler requires dedicated bottle holders, trigger line, and wellhead dock. Bottle holders and wellhead docks can be moved from well to well, but trigger lines are typically dedicated to a specific well based on the desired depth of sample collection.

Sample Representativeness: Like all passive sampling methods, the equilibrium-grab method relies on flow-through and ambient mixing within the well to transfer formation water into the well and into the sampler at the time of collection (Britt et al. 2010). However, low-flow sampling is based on this same requirement, so the use of passive samplers should be appropriate in any well that is suitable for low-flow sampling.

The Snap Sampler and HydraSleeve have been included in a number of recent Environmental Security Technology Certification Program (ESTCP) research programs and comparison studies at several Department of Defense (DoD) facilities. The general conclusions of these studies are that both types of samplers exhibit excellent agreement between analyte concentrations in the no-purge sampler and low-flow sampling with no statistically significant differences between analyte concentrations for VOCs, dissolved inorganics, total non-metal anions, and total metals and metalloids (Parsons 2005, Parker et al. 2011).

Devices That Rely on Diffusion (e.g., Regenerated-Cellulose Dialysis Membrane Samplers, Polyethylene Diffusion Bag Samplers)

Methodology Description: Diffusion samplers (also called equilibrium samplers) are devices that rely on the analytes to reach equilibrium between the sampler and the groundwater via diffusion. Regenerated-cellulose dialysis membrane (dialysis) samplers were developed to sample groundwater in wells for inorganic and organic constituents using a diffusion-type sampler. Prior to their development, diffusion samplers constructed with polyethylene membrane could sample for only select VOCs. Because of this limitation, polyethylene diffusion bag samplers are not included in this review.

The dialysis sampler consists of a deionized water- filled tube of high-grade regenerated-cellulose dialysis membrane inside an outer protective layer of low-density polyethylene (LDPE) mesh. Typically, the dialysis sampler is deployed in the open interval of a well at a desired sampling depth. Once deployed, the dialysis sampler must be left in the well for sufficient time for the concentrations inside the membrane sampler to equilibrate with the concentrations of chemical constituents present in the groundwater outside the membrane sampler. After the appropriate equilibration time, the dialysis sampler is retrieved from the well, and samples are transferred to conventional sample containers, shipped to a laboratory, and analyzed. The regenerated cellulose diffusion membrane has a pore size of 18 Angstroms and a molecular weight cut-off of 8000 Daltons. The sampler may be constructed using either 1.25-inch or 2.5-inch diameter membranes (ITRC 2005).

Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Laboratory equilibration testing has shown that dialysis samplers equilibrate within 1–3 days for anions, dissolved organic carbon, and VOCs; 3–7 days for most cations and trace elements; and 7–14 days for most explosive compounds (ITRC 2007).

Several other types of diffusion membrane samplers have been described in the literature (e.g., Nylon-Screen Passive Diffusion Samplers, Passive Vapor Diffusion Samplers, Peeper Samplers, Rigid Porous Polyethylene Samplers) and may be appropriate for use at Pantex. However, few are commercially available, and most have limited sample collection volume, are limited to volatile analytes, or lack sufficient field testing (ITRC 2005).

Pros:

- Can sample most groundwater analytes as long as an adequate volume of sample is recovered for analysis. Sample volume is about 1 liter per foot of membrane, so up to 5 liters can easily be obtained.
- Exclude particulates from groundwater samples due to their 0.0018-micron pore size. Therefore, dialysis samplers collect truly “dissolved” analytes, and no field filtration is required
- Minimal decontamination of sampling equipment between sampling events or wells.
- Improved safety because of reduced handling of contaminated groundwater and fewer equipment needs.

Cons:

- May be difficult to collect adequate sample volume although the minimum required sample volume to conduct most standard analyses may be much less than the typically requested volume, depending on the choice of analytical methods and desired detections. Prior coordination with the laboratory could eliminate this minimum volume limitation as a concern.
- Unable to collect sample for total inorganic analyses because of 0.0018-micron pore size.
- Fully constructed dialysis membrane samplers are not currently available from any commercial vendor. The samplers are relatively simple and inexpensive to construct from commercial regenerated-cellulose dialysis membrane.
- Must be constructed within a week of deployment and must be kept wet during this time to preserve the permeability, flexibility, and strength of the membrane.
- Must be allowed to equilibrate for at least the length of time determined in laboratory equilibration tests for the contaminants of concern at a site.

- May begin to biodegrade in some pore-water and groundwater systems; if biodegradation of the membrane occurs, membranes may only be deployed for four to six weeks depending on ambient conditions (e.g., temperature, bacterial populations).

Sample Representativeness: A number of field comparison studies have shown that dialysis samplers can be used to collect samples for analysis of a wide variety of both organic and inorganic chemical constituents in groundwater. Field comparisons have shown that dialysis samplers recover concentrations of VOCs and most inorganic and nonvolatile organic constituents similar to those recovered by low-flow purging and sampling (Imbrigiotta et al. 2007, Parker et al. 2011). Results of analyses for perchlorate and explosives showed excellent agreement between concentrations collected with dialysis samplers and low-flow purging with the exception of two explosive compounds, (2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene). For these two compounds, the researchers recommended that dialysis samplers should only be used to qualitatively identify the presence/absence of these compounds in a well (Imbrigiotta and Trotsky 2011).

Summary Comparison of Passive Sampling Technologies

The following table provides a summary of research articles assessing the performance of the Snap Sampler and Regenerated Cellulose Dialysis membrane samplers in comparison with low flow purging and sampling results with emphasis on VOCs, metals (with chromium and chromium VI notation) and explosives.

Table 1 Summary of Research Studies Comparing Passive and Low Flow Sampling Methods

Report	Sample Device	Analyte Concurrence	Comments	Comments
Parsons, 2005	Snap	VOCs	Did not have volume Snap Sampler for other analytes	
	RCD	Metals	Metals incl. Cr VI	VOCs not studied for RCD
ITRC, March 2006	Snap	Metals	No concurrence for Hg, Ag, Sn, or Sulfide in any samplers, no specific Cr VI	Laboratory studies
		VOCs	Concurrence	
		Explosives	Concurrence	
	RCD	Dissolved Metals	No concurrence for Hg, Ag, Sn, or Sulfide in any samplers, no specific Cr VI	Laboratory studies
		VOCs	Concurrence	
		Explosives	Concurrence	
USGS, 2007	RCD	Dissolved Metals	Incl. trace metals, no specific Cr VI	No concurrence on Hg, Ag, and Sn
		VOCs	BTEX, MTBE	
ESTCP, June 2011	Snap	Metals	Dissolved and total metals, no specific Cr VI	Concurrence issues with Cr, Fe and Mn but with all samplers
		VOCs	Three chlorinated solvents, MTBE	
USACE, August 2007	Snap	VOCs	Concurrence after 3 days equilibrium	
		Explosives	Concurrence after 7 days equilibrium	
USACE, December 2008	Snap	Metals	Includes Cr, but no specific Cr VI	
		Perchlorate	100% Recovery	
USACE, February 2011	Snap	Total and Dissolved Metals	Includes Cr	
		VOCs	MTBE, TCE	When differ slightly, higher in Snap
	RCD	Dissolved Metals	Includes Cr, but no specific Cr VI	
		VOCs	MTBE and Acetone slightly higher than low flow	
USGS, 2008	RCD	Perchlorate	Concurrence	
		Explosives	Concurrence	

Flow Mechanics of Wells

The low-flow method was principally developed from observations in short-screened (~5-ft), small-diameter (<2-inch) wells in relatively high permeability hydrogeologic settings where flow rates on the order of ~1 L/min could be sustained with minimal drawdown. In these situations, the objectives of collecting high-quality samples and minimizing purge volume could be achieved (Barcelona et al. 2005). In low permeability formations, substantial drawdown may occur, but the method can still be applied so long as the drawdown can be stabilized at low flow rates. In very low yield formations where drawdown cannot be stabilized, attempts to purge the well until parameters stabilize typically dewater the well screen, so a minimum purge sampling method is recommended instead (Nielsen and Nielsen 2006). At the opposite end of the well spectrum, long-screen or large-diameter wells installed in high permeability formations, low flow purging and sampling techniques remove only a portion of the water within the screen interval and thus rely on natural flow through the screen under background hydraulic gradients to provide a representative sample.

Under natural gradient conditions, flow through the screened interval is expected to occur in permeable formations (Kearl et al. 1994), principally from the most permeable strata in the screened interval (Marsh and Lloyd 1980). Indeed, natural flow through is a key assumption for low-flow purging and sampling as highlighted by this statement in the American Society of Testing Materials (ASTM) standard practice document for low-flow purging:

Low-flow purging is based on the observations of many researchers that water moving through the formation also moves through the well screen. Thus, the water in the well screen is representative of the formation surrounding the screen (ASTM 2002).

Ambient Wellbore Processes

Additional research has demonstrated that aquifer water in the screened interval of wells is not stagnant because of flow through and in-well mixing processes that occur under ambient conditions. Under background flow conditions, stratified contaminants within an aquifer show a tendency to mix within a monitoring well in proportion to their flow-weighted contribution. If ambient flow through and mixing creates a flow-weighted average concentration in the screen interval of a well, it is arguable that the well is “naturally purged” and a representative sample can be collected directly from the screen interval of the well (Britt 2005). Simple tracer dissipation tests can be used to determine whether individual wells have natural flow through, and passive stratification testing can show whether contaminant concentrations in the well are mixed.

Mixing within open-well casings is of concern because of the potential for redistribution of contaminants in the aquifer, of particular importance for longer screen monitoring wells, and dilution of high-concentration contaminant stringers with surrounding cleaner water. The effect of dilution is especially

relevant for sentinel well detection monitoring. In wells where uncontaminated water preferentially flows into the borehole, composite samples are diluted to artificially low concentrations that may result in failure to detect the contaminant (Church and Granato 1996). Redistribution of contaminants from one vertical zone to another can be caused by vertical flows through the wellbore induced by vertical hydraulic gradients (Martin-Hayden and Britt 2006; Elci et al. 2001; Hutchins and Acree 2000; Church and Granato 1996). Because of these concerns, it is imperative to evaluate the effects of vertical flow and in-well mixing processes for any monitoring system that relies on the use of long-screen wells in addition to ensuring that natural flow through is occurring in the wells. Unacceptable levels of dilution or lack of flow through the screened interval under natural gradient conditions would preclude the use of long-screen wells for detection monitoring.

In-Well Hydraulics During Pumping

The stability of purging parameters is often cited as the most reliable indicator of when pumped water is representative of the groundwater concentrations and when a sample should be collected (Nielsen and Nielsen 2006). However, relatively little focus has been given to ambient through-flow and mixing or to how the water travels from the heterogeneous groundwater environment to the sampling device. Flow and mixing processes control parameter variability and stabilization during purging and are ultimately the link between the groundwater concentration distribution and the sample concentration (Martin-Hayden and Britt 2006).

Numerical modeling by Varljen et al. (2006) demonstrates the vertical distribution of water flowing into a well screen during sampling once steady-state conditions have been achieved (as indicated by stabilization of the pumping water level and water quality indicator parameters). These simulations reveal that (1) the entire well screen is sampled, although preferential flux into the screen occurs if the screen intersects a zone of higher permeability; (2) the location of the pump intake within the screen does not influence the actual zone sampled; and (3) the actual zone monitored is longer than the length of the screen if the monitoring well partially penetrates an aquifer. The illustration in Figure 2 demonstrates these points. The region of highest influx coincides with the layer of increased permeability, and no increase in flux is evident adjacent to the pump intake.

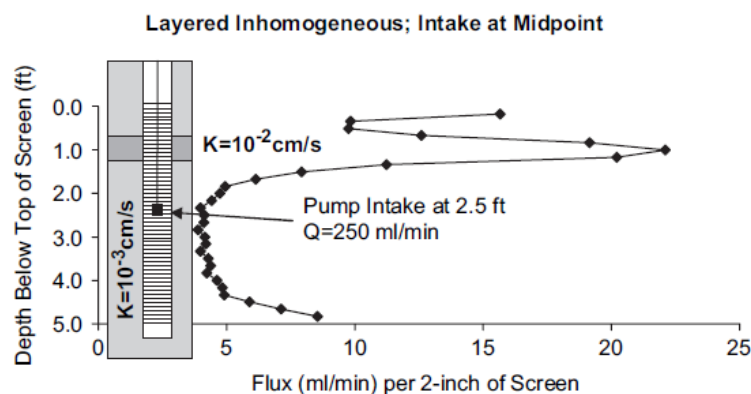


Figure 2 Simulated Well Inflows in a Layered Aquifer

The simulations conducted by Varljen et al. (2006) indicate that aquifer heterogeneities have the most significant influence on the actual monitoring zone, while pump placement and purging rate have little influence on the vertical interval that is sampled. The results further demonstrate that a detection monitoring approach predicated on sampling from the entire well screen is valid when purging at low flow rates because groundwater is sampled from the entire length of the well screen. However, the simulations only evaluated steady state pumping conditions in short-screen wells. Because steady state conditions would not be expected in long-screen wells, these results must be interpreted with caution and a transient evaluation is required.

Martin-Hayden (2000) examined the mechanics of how groundwater moves from a heterogeneous formation into a well, and once inside the well, how it flows and mixes in the wellbore during pumping. Under conditions typical of low-flow purging and sampling, flow within the wellbore is expected to be laminar and not mixed as a result of pumping (although water in the well prior to pumping may be thoroughly mixed). Based on this assumption, Martin-Hayden (2000) developed a model of sample concentration response to laminar wellbore flow.

At the onset of pumping, the water entering the pump intake is entirely prepurge well water (i.e., water derived from ambient through-flow and mixing) as shown in Figure 3a. As a monitoring well is pumped the reduced head within the well is distributed along the screen and groundwater flowing in along the screen begins to flow along a flow tube toward the pump intake. The reduced head will also tend to draw mixed groundwater in from the down-gradient side (shadow) of the screen. During early purging, even though the pumped water is still predominantly prepurge well water, the first fresh groundwater to enter the pump intake is that entering the screen section nearest the pump intake. As pumping proceeds water is transported from positions progressively farther from the pump intake, and the flow of prepurge well water entering the pump intake is progressively replaced by the groundwater reaching the pump intake (Figures 3b through 3d). Eventually (after about 4 to 6 well volumes have been pumped), a flow-weighted average concentration will arrive at the pump intake if pumping overcomes any of the ambient borehole flow and mixing effects discussed previously. In most cases the

concentration is changing most rapidly during early purging and may appear to stabilize at concentrations that are not representative of the flow-weighted average concentration (Martin-Hayden and Britt 2006).

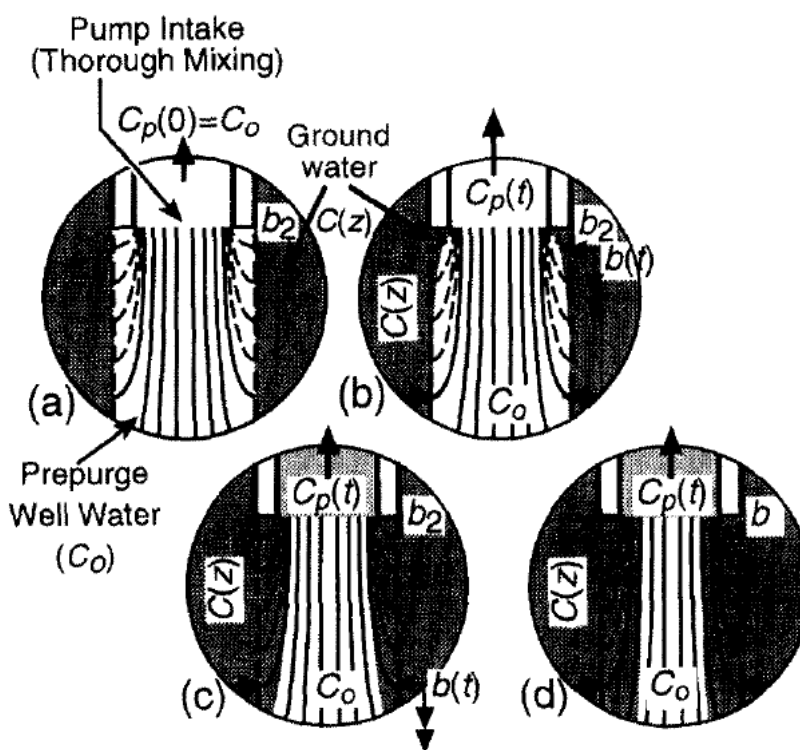


Figure 3 Details of the Pump Intake Showing Flow Regimes and the Replacement of Well Water by Groundwater (Martin-Hayden 2000)

The rate at which well water at the pump intake is replaced by groundwater is determined from the time that a parcel of water takes to travel to the intake from each position of inflow progressively further along the well screen. Because the total flow at any position in the well is the sum of inflows below that point, the rate of inflow along the screen varies according to the permeability of the aquifer outside the well at that location (Martin-Hayden 2000).

Limitations for Sampling Long-Screen Wells

Over the past two decades, groundwater researchers have studied sample biases and the potential for cross-contamination caused by conventional, single-interval monitoring wells. The studies show that conventional monitoring wells yield blended or composite samples that mask the true vertical distribution of dissolved contaminants in the aquifer, and that these composite samples are strongly biased by the position and length of well screens, pumping rate during sampling, and ambient vertical flow in the well. Concentration averaging and ambient vertical flow in long-screened wells may result in underestimation of the maximum concentration present in the aquifer. In areas with vertical hydraulic

gradients, installation of a monitoring well may set up a local vertical flow system with the resulting flow in the wellbore often sufficient to compromise the integrity of samples collected from the well. Borehole flow and transport of contaminants in long-screen wells may also potentially contaminate parts of the aquifer that would not otherwise become contaminated in the absence of a long-screen well (McIlvride and Rector 1988; Reilly et al. 1989; Church and Granato 1996; Hutchins and Acree 2000; Elci et al., 2001; Elci et al. 2003; Britt 2005; Dumble 2006; Einarson 2006; Martin-Hayden and Britt 2006; Varljen et al. 2006; Britt et al. 2010).

Short-screen wells are often recommended as a cure-all for the issues of wellbore mixing and vertical flow, but may not always be practical or even desirable given budgetary constraints and monitoring objectives. After providing an excellent discussion of screen length issues including pros and cons of short and long well screens, Martin-Hayden (2000) states:

In truth, there is no single correct screen length and the investigator must decide on appropriate screen lengths given site characterization, quantitative estimates of data variability, and study objects (e.g., data quality objectives)

Based on published research on sampling methodology, nearly all of which has been carried out using data from short-screened shallow monitoring wells, researchers now acknowledge that the best sample obtainable from a borehole by pumping is a flow-weighted average of the total inflow across the entire screened interval. This average will always be biased toward dominant flows from higher permeability strata. However, no studies evaluating the effectiveness of different purge strategies or passive sampling specifically in long-screened monitoring wells have been published to date. In longer-screened wells, it is almost certainly the case that sufficient water volume is not removed to fully eliminate vertical mixing within the borehole column or to mobilize flows from all parts of the screen toward the pump (Dumble 2006). Therefore, it is imperative that the objective of monitoring be clearly stated and understood when designing or evaluating long-screened wells and associated sampling methodologies.

The debate over the appropriateness of the use of long-screened wells has been ongoing since at least the early 1980s. In one of the early published discussions on the adequate screen length for a monitoring well, Giddings (1987) made the following argument:

Detection monitoring networks are designed to provide the earliest possible indication of contaminant escape and are not intended to define the rate of movement or exact flow path of the contaminant. With this goal clearly in mind, the designer can utilize long screen lengths...to achieve a construction of a monitoring well network that is sensitive in terms of providing the earliest detection, comprehensive in terms of monitoring all flow paths, and economical in terms of construction costs and analytical costs.

Giddings argues that in the context of detection monitoring only within an appropriate hydrogeologic setting, long-screen wells provide the most comprehensive coverage of the aquifer and therefore the

best chance of detection of potential contamination. More recent research of vertical flows and mixing in long-screen wells highlights the need for ensuring that borehole flow and mixing processes do not result in unacceptable dilution of sampled water or cross-contamination of the aquifer.

Low-Flow Sampling of Long-Screen Wells

From the discussion above, it is clear that the processes affecting purge parameter stabilization in a short-screen well are not the same as those for a well with a much longer screen. Parameter stabilization in short-screen wells often requires the purging of one-third to one-half of a well volume (Nielsen and Nielsen 2006). These volumes are rarely purged from long-screen wells because purging would require several hours at typical low-flow purge rates. The “micropurge” technique, adapted from the low-flow sampling procedure, requires only sufficient flushing of the pump and discharge tubing (suggested two calculated pump/tubing volumes) before a representative sample can be collected. Micropurge, like low-flow, sampling provides representative samples because it relies on natural flow through the screened interval of a well and in-well mixing processes. Micropurge samples from long-screen wells are identical to low-flow samples because of these processes. Indeed, if flow through is not occurring in long-screen wells, low-flow methods would be inapplicable because the water sampled would come primarily from within the wellbore. Thus, flow through and mixing are required for low-flow sampling of a long-screen well, and if these processes are occurring, then micropurge or passive methods will provide equally representative samples.

Evaluation of High Plains Aquifer Monitoring Well Construction

Well Construction Review

Most High Plains Aquifer wells were installed as part of the investigation and are screened across the entire saturated thickness. Eight newer High Plains Aquifer monitoring wells were installed in 2009 and 2010 with screens that provide flexibility to sample from both the uppermost part of the aquifer and the deeper part of the aquifer based on the results of a 2008 flow study conducted by the USGS (described below). These wells were constructed using multiple screened intervals (30 to 40 ft each) separated by blank casing within the upper 30 to 100 feet of saturation as illustrated in Figure 4. The length of the upper screen intervals for each well was based on the anticipated or observed rate of decline of the water table. The blank casing sections are 15 ft long and include bentonite seals in the wellbore annulus. These sections enable placement of diverters or packers to completely isolate the upper screened interval. The diverters and dedicated pumps are adjusted as necessary to account for the declining Ogallala Aquifer water table.

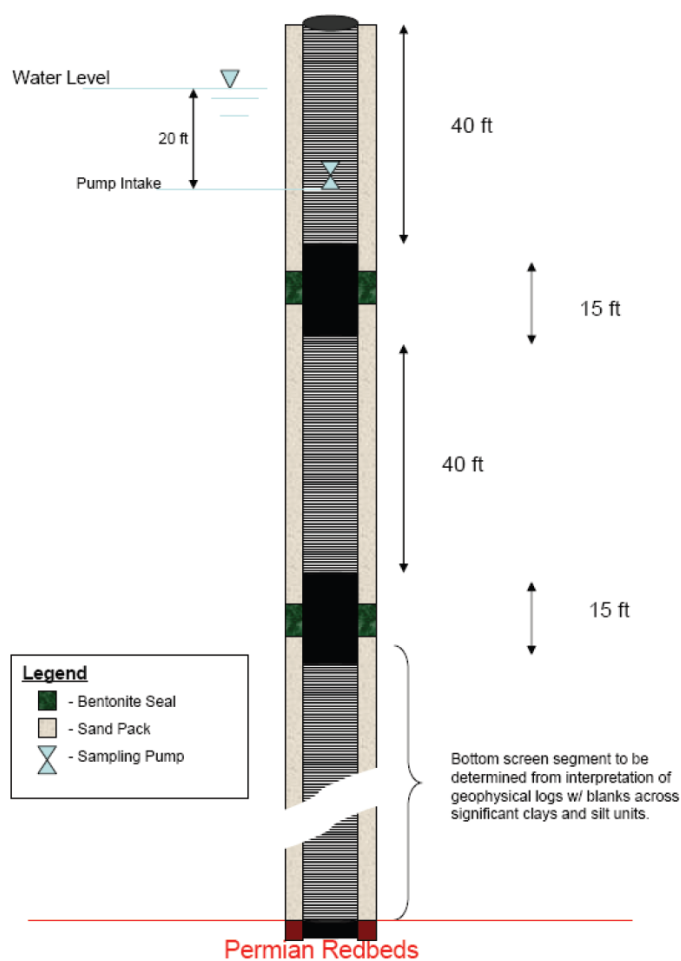


Figure 4 Example Well Construction Diagram

A summary of screen and saturated thickness information is provided in Table 2. This table was compiled from available data in the Pantex Well-Info database and December 2011 measured depths to water. While only one well (PTX06-1076) has what might typically be considered a “short” screen (<20 ft), about one-third of the wells have relatively short screen segments across the upper section of the aquifer that can be isolated for sampling.

Table 2 Screen Lengths of Pantex High Plains Aquifer Wells

Well ID	Year Installed	Sampled as Multi-Level Well?	Number of Screen Segments	Saturated Thickness (ft)	Submerged Screen Length (ft)
PTX01-1010	2000	Yes	3	350	278
PTX01-1011	2000	Yes	2	298	237
PTX01-1012	2000	Yes	3	386	337
PTX01-1013	2000	Yes	3	364	311
PTX06-1033	1996	No	1	100	101
PTX06-1043	1999	No	1	181	185
PTX06-1044	1999	Yes	2	130	90
PTX06-1056	2000	No	1	81	76
PTX06-1057A	2000	No	1	337	292
PTX06-1058	2000	No	1	129	129
PTX06-1059	2000	No	1	128	128
PTX06-1060	2000	No	1	143	125
PTX06-1061	2000	No	1	365	365
PTX06-1062A	2001	Yes	2	394	351
PTX06-1064	2001	No	1	280	286
PTX06-1068	2001	Yes	2	279	262
PTX06-1072	2001	Yes	2	130	111
PTX06-1074	2002	No	1	194	200
PTX06-1075	2002	No	1	43	60
PTX06-1076	2002	No	1	16	14
PTX06-1137A	2009	Yes	2	112	97
PTX06-1138	2009	Yes	2	128	113
PTX06-1139	2009	Yes	2	116	103
PTX06-1140	2009	Yes	4	203	155
PTX06-1143	2009	Yes	3	186	158
PTX06-1144	2009	Yes	5	271	218
PTX06-1157	2009	Yes	5	403	250
PTX07-1R01	2010	No	3	79	27
PTX08-1011A	2000	No	1	198	190
PTX-BEG2	1992	No	1	30	30

Results of USGS Vertical Flow Study

The U.S. Geological Survey (USGS), in cooperation with B&W Pantex through the USDOE/NNSA, collected borehole geophysical data consisting of vertical flow rates measured under ambient and pumped flow conditions, fluid resistivity/temperature, and natural gamma radiation in four monitoring wells (PTX01–1012, PTX06–1044, PTX06–1056, and PTX06–1068) during July–September 2008 to analyze vertical flow in screened intervals of the wells. Hydraulic properties (transmissivity values) of the section of High Plains (Ogallala) aquifer penetrated by the wells also were computed. Unusually large drawdowns occurred at two monitoring wells (PTX06–1044 and PTX06–1056) while the wells were

pumped at relatively low rates (about 1.5 gal/min), adversely affecting the accuracy of the calculated transmissivity values. Accordingly, those wells were redeveloped and logs were run again after redevelopment during ambient and pumped flow conditions in the two monitoring wells.

Flowmeter and fluid resistivity/temperature data were analyzed by (1) plotting the logs with existing pertinent information such as other geophysical logs and casing and well-construction records provided by B&W Pantex, (2) evaluating the flowmeter data to identify potential zones of fluid movement to or from the wellbore and the magnitude and direction of vertical flow, (3) evaluating the flowmeter data with the USGS Flow-B numerical model to compute total transmissivity and distribution of transmissivity and head (as depth to water) in the screened intervals, and (4) plotting the transmissivity and head values on the logs.

Summary of Results for Individual Wells

PTX01-1012

Logs collected in monitoring well PTX01–1012 during ambient conditions indicate a dynamic environment that probably was affected by pumping of nearby irrigation or public-supply wells. Downward vertical flow ranged from 0.2 to 2.1 gal/min. During pumping, downward vertical flow that occurred during ambient conditions was either reversed or reduced. Estimated total transmissivity for the four identified production zones taken together was calculated to be about 3,100 ft²/d. The zone of highest transmissivity (1,860 ft²/d) corresponds with a sand unit at about 650 ft bgs to 715 ft bgs.

This well is constructed with 3 screened intervals separated by blank casing and sealed annulus. The upper screen zone extends from the water table at about 500 ft bgs to 650 ft bgs. Downward vertical flow was observed from screened interval above 650 ft bgs to intervals below 650 ft bgs. Only about 1% of the total transmissivity was observed in the zone from 600 to 650 ft bgs, but this interval included only 40 ft of open screen and excludes approximately 100 ft of saturated thickness above 600 ft bgs.

PTX06-1044

Logs collected in monitoring well PTX06–1044 during ambient conditions after redevelopment indicate a near-static environment with minimal downward vertical flow (~0.17 gal/min). During pumping there was upward vertical flow at rates ranging from 0.5 to about 4.8 gal/min. Estimated total transmissivity after redevelopment for the five identified production zones taken together was calculated to be about 520 ft²/d. The zone of highest transmissivity (486 ft²/d) corresponds with a thin sand unit.

Minimal downward ambient vertical flow was observed only in the upper zone from 495 ft to 530 ft bgs; no vertical flow was observed in deeper zones. The most productive zone was observed between 530 ft to 540 ft bgs, but may be indicative of higher transmissivity of the entire screened interval below 530 ft bgs. Transmissivity above the first blank interval was not estimated because of pumping drawdown and the short screened interval below the water table.

This well is constructed with 2 screened intervals separated by blank casing only (annulus is not sealed). The upper zone extends from the water table near 480 ft bgs to 493 ft bgs, providing an opportunity to sample as a short-screened well for several years.

PTX06-1056

Logs collected in monitoring well PTX06–1056 during ambient conditions after redevelopment indicate a near-static environment with no vertical flow from about 401 to 456 ft bgs. A very small amount of downward vertical flow occurred during ambient conditions at 461 ft bgs. During pumping there was upward vertical flow at rates ranging from 0.7 to about 2.9 gal/min. Estimated total transmissivity after redevelopment for the five identified production zones taken together was calculated to be about 330 ft²/d. The zone of highest transmissivity (264 ft²/d) was 453 to 460 ft bgs, but the observed dominant zones of inflow were from 451 to 456 ft bgs and 431 to 436 ft bgs.

This well is constructed with a single screened interval to 470 ft bgs with the water table near 395 ft bgs.

PTX06-1068

Logs collected in monitoring well PTX06–1068 during ambient conditions indicate a static environment with no vertical flow. During pumping there was upward vertical flow at rates ranging from 0.4 to 4.8 gal/min. Estimated total transmissivity for the four identified production zones taken together was calculated to be about 200 ft²/d and is evenly distributed among the selected zones. No dominant zones of inflow were observed.

This well is constructed with 2 screened intervals separated by blank casing and sealed annulus. The upper zone extends from the water table at about 510 ft bgs to 754 ft bgs.

Overall Conclusions from USGS Vertical Flow Study

The flow study revealed that little to no vertical flow occurs in the High Plains Aquifer wells under ambient conditions except in the far northern portions of the Plant where some downward flow occurs as a result of pumping from irrigation and municipal water supply wells. The most transmissive zones of the aquifer, where present, were found in the upper portions of the well screens. The need to redevelop two of the four wells selected for the study suggests that other wells in the monitoring network may be in need of redevelopment to improve hydraulic communication with the aquifer.

Statistical Evaluation of Low-Flow Purge Data

A statistical analysis was completed on field data collected for 43 Ogallala wells to assess the purge time of ten minutes to determine if the time allotted allowed for adequate stabilization of field parameters: temperature, specific conductance, dissolved oxygen, pH, and oxidation-reduction potential (ORP). The last three field parameter values recorded for each sampling event were used for comparison against the following stabilization criteria.

Table 3 Field Parameter Stabilization Criteria

Parameter	Stabilization Criteria
Temperature	±0.2 degree C
Specific Conductance	± 3% of reading
Dissolved Oxygen	±10% of reading or ±0.2 mg/L, whichever is greater
ORP	±20 mV
pH	±0.2 pH units

From the stabilization data analysis, a summary table was generated showing the number of sampling events (unique sample IDs) for each well and fraction of events stabilized for each parameter along with an overall tally that summarizes the whole dataset. Of the parameters collected, specific conductance and dissolved oxygen, along with drawdown, are often cited as the most suitable analytes for judging stability of purge water (Hart et al. 2000, Barcelona et al. 2005). As seen in the table, stabilization of specific conductance occurred for an average of 90 percent of the sampling events while dissolved oxygen stabilization occurred for 72 percent of the events. Stabilization for specific conductance (± 3% of reading) was achieved in all sampling events for less than half of the wells. Only about one-fourth of the wells reached stabilization for dissolved oxygen (±10% of reading or ±0.2 mg/L, whichever is greater) in all sampling events.

When considering stabilization, the flow through cell volume is important to address when determining both purge times as well as the temporal difference between measurements recorded. According to the Pantex SAP, three minutes of flow are collected prior to the first water quality measurement followed by a purge time of ten minutes. Field parameters are collected at one-minute intervals during the ten-minute purge time. Based on information provided by Pantex, the flow through cell volume is 450 mL. At a purge rate of 0.3 to 0.8 L/min, the flow through cell volume is replaced every 1.6 to 0.6 minutes, respectively. With these flow rates, the flow through cell volume is not always replaced within one minute to represent an independent measurement of the groundwater quality. A smaller flow through cell can address the independence of the groundwater aliquots for measurements or the purge time can be adjusted with varying purge rates to insure independent water quality measurements are used to determine stabilization prior to sampling.

Table 4 Fraction of Events Field Parameters Met Stabilization Criteria Prior to Sampling

Well ID	# of Sample Events	Stabilization Criteria Attainment				
		Temperature	Specific Conductance	Dissolved Oxygen	pH	ORP
OW-WR-39	4	0.50	0.75	0.25	0.75	0.75
OW-WR-46	18	0.94	1.00	1.00	1.00	1.00
OW-WR-47	17	0.53	0.76	0.29	0.94	0.94
OW-WR-48	17	0.71	0.94	0.94	1.00	1.00
PTX01-1003	9	1.00	1.00	1.00	1.00	1.00
PTX01-1010	35	0.86	0.91	0.83	0.94	0.97
PTX01-1011	19	0.89	0.89	1.00	1.00	1.00
PTX01-1012	20	0.70	0.95	0.30	0.95	0.95
PTX01-1013	35	0.74	0.94	0.83	0.94	0.94
PTX06-1016	1	1.00	1.00	0.00	1.00	1.00
PTX06-1032	4	0.75	1.00	1.00	1.00	1.00
PTX06-1033	26	0.77	0.92	0.62	1.00	0.96
PTX06-1043	18	0.83	1.00	0.83	1.00	1.00
PTX06-1044	24	0.79	0.88	0.54	1.00	1.00
PTX06-1056	23	0.91	0.91	0.91	0.96	1.00
PTX06-1057A	18	0.89	0.94	1.00	1.00	1.00
PTX06-1058	19	0.89	0.95	1.00	1.00	1.00
PTX06-1059	18	0.72	0.78	0.28	0.83	0.94
PTX06-1060	11	0.73	1.00	0.91	1.00	1.00
PTX06-1061	19	0.79	0.89	0.37	1.00	1.00
PTX06-1062A	38	0.68	1.00	0.92	1.00	1.00
PTX06-1063A	28	0.75	0.89	0.39	0.96	1.00
PTX06-1064	31	0.94	0.97	0.65	0.97	1.00
PTX06-1065	26	0.96	1.00	0.77	1.00	1.00
PTX06-1066	28	0.79	0.86	0.89	0.96	0.93
PTX06-1067	16	0.88	1.00	0.38	1.00	0.75
PTX06-1068	34	0.85	0.94	0.82	0.94	0.82
PTX06-1072	16	0.94	0.88	0.31	1.00	1.00
PTX06-1074	18	0.94	0.94	0.94	0.89	0.83
PTX06-1075	18	0.89	1.00	0.67	0.94	1.00
PTX06-1076	21	0.86	0.90	0.81	0.95	0.95
PTX06-1137A	6	1.00	1.00	1.00	1.00	1.00
PTX06-1138	4	1.00	1.00	1.00	1.00	0.75
PTX06-1139	4	0.75	1.00	0.75	1.00	1.00
PTX06-1140	4	0.75	1.00	0.50	1.00	1.00
PTX06-1141	3	0.67	1.00	1.00	1.00	1.00
PTX06-1143	4	1.00	1.00	1.00	1.00	1.00
PTX06-1144	4	1.00	1.00	0.75	1.00	1.00
PTX06-1157	3	1.00	1.00	1.00	1.00	1.00
PTX07-1R01	14	1.00	1.00	0.86	1.00	1.00
PTX08-1011A	4	1.00	1.00	0.75	1.00	1.00
PTX-BEG2	22	0.77	0.82	0.91	1.00	1.00
Total	701	0.80	0.90	0.72	0.94	0.93

High Plains Aquifer Monitoring Program Recommendations

Monitoring Objectives

The purpose of groundwater monitoring wells in the High Plains Aquifer at Pantex Plant is detection of constituents potentially migrating to the aquifer from historical releases. To achieve this objective, the well network must provide broad coverage of the aquifer downgradient of potential source areas in overlying perched groundwater or the unsaturated zone. The wells must monitor this area laterally such that a contaminant plume cannot escape undetected between two wells and vertically so that contaminants do not pass above or below the screened interval of a monitoring well. The wells must monitor for a broad range of constituents (high explosives, metals, inorganics, and volatile organics) with very low limits of detection.

Aquifer Conditions

The High Plains Aquifer comprises a relatively thick sequence of sand and gravel layers with some clayey layers present throughout the aquifer's thickness. Available data from aquifer testing at Pantex indicates the aquifer is very permeable with hydraulic conductivities ranging from 0.7 to 13 ft/day (Stanton et al. 2009). The USGS flow study revealed that little to no vertical flow occurs in the High Plains Aquifer wells under ambient conditions except in the far northern portions of the Plant where some downward flow occurs as a result of pumping from irrigation and municipal water supply wells. The most transmissive zones of the aquifer, where present, were found in the upper portions of the well screens.

Well Construction

Newer wells were constructed using multiple screened intervals (30 to 40 ft each) within the upper 30 to 100 feet of saturation separated by blank casing sections 15 ft long with bentonite seals in the wellbore annulus. These blank sections allow complete isolation of the screened intervals through the placement of diverters or packers. Older wells were typically completed with continuous well screen across the entire saturated interval and do not allow for zone isolation.

Conclusions

Based on the available information summarized above and the current understanding of the mechanics of groundwater sample collection, the existing High Plains Aquifer monitoring network is acceptable for detection monitoring. The data obtained from the vertical flow study indicate that monitoring wells in good hydraulic communication with the aquifer should meet the assumptions of sustained horizontal flow through with little or no ambient vertical flow between aquifer strata. Under these conditions, ambient concentrations in wells would be expected to represent flow-weighted averages of

concentrations in the aquifer. Because all potential contaminant sources are located above the water table, the highest concentrations of potential contaminants would be found in the upper portion of the aquifer. Ambient in-well concentrations would be most similar to concentrations in the upper portion of the aquifer because zones of higher transmissivity were observed in the upper portions of well screens and vertical ambient flows, where observed, are downward. Therefore, samples obtained from these wells are representative of conditions in the upper zone of saturation where potential contaminants are expected. Wells with multiple screened intervals that can be isolated can also provide representative data of conditions lower in the aquifer. However, in the event of contaminant detection, these wells may facilitate spreading of contamination to deeper layers of the aquifer.

Because the assumptions of thorough mixing and horizontal flow through appear to be valid for these wells, use of low-flow or passive sampling methods should be equally appropriate for most wells. The existing sampling protocol is equivalent to the low-flow “micropurge” method described in the literature (Kearl et al. 1994; Shanklin et al. 1995) and is an acceptable method for sampling these wells.

Recommendations

1. The assumption that the well is in good hydraulic communication with the aquifer is the key to obtaining representative samples in long-screen wells by any method. During the USGS flow study two of the four wells were found to need redevelopment to improve hydraulic communication. Therefore, well-specific evaluations of flow through should be conducted on all wells. A potential method for evaluating well performance is the single borehole tracer dilution test. Wells exhibiting signs of poor flow through performance should be redeveloped and retested.
2. The use of a default purge time for all wells regardless of purge flow rate or well-specific conditions is arbitrary and leads to inconsistent attainment of purge parameter stabilization. For continued use of low-flow purging and sampling, Pantex should consider development of well-specific purge stabilization criteria based on non-parametric tolerance interval (Hart et al. 2000) or adopt a volume-based criteria to achieve a minimum two-volume purge of the sample tubing and pump.
3. The available hydrogeologic data indicates that in-well concentrations should be representative of conditions in the upper portion of the aquifer, but dilution of potential contaminant concentrations is still of concern because of the low limits of detection. Dilution of aquifer concentrations in the well can be reduced by limiting the screen length. Therefore, Pantex should consider installing packers below the uppermost sampling interval in additional wells where appropriate (having blank casing) to reduce the effective screen length for sampling and increase the sensitivity of detection monitoring.
4. Recent advances in passive sampling technology have led to the availability of several passive samplers. Multiple government-funded research studies at several DoD facilities have demonstrated that passive samplers can provide representative data with quality as good as or better than low-flow methods with significantly lower costs and labor requirements. These

studies have also led to increased regulatory acceptance of passive sampling technologies. In long-screen wells like those found at Pantex, the requirements of well flow through and mixing are the same for both low flow sampling and passive sampling. Pantex should consider testing of passive samplers, specifically the Snap Sampler in combination with baffles to isolate the sample interval. The use of Snap Samplers would increase the number of wells that can be sampled in a day from one or two to potentially eight, reduce the need for maintenance of sampling equipment and pumps, and reduce the initial cost of dedicated sampling equipment for new wells. By reducing sampling time, more focus could be placed on well maintenance. The Snap Sampler would also reduce concern for artifactual contamination of samples by corrosion of stainless steel pump components.

5. The well construction design specified in the Long-Term Monitoring System Design Report (Stovall and Jarrett 2009) provides flexibility for sampling from multiple intervals, allows isolation of individual screen intervals, and extends the life span of wells in relation to the declining water table of the aquifer. Several wells have been constructed using this design and successfully sampled at multiple depths using available sampling equipment. Therefore, this design should continue to be used for future detection monitoring wells in the High Plains Aquifer.

Other Recommendations

1. The time interval for collection of purge stabilization parameters should be revised to allow for turnover of water in the flow-through cell based on purge flow rate and cell volume.
2. Sampling procedures should include additional decontamination of non-dedicated equipment with the use of DI water, a surfactant wash, and additional rinse with DI and/or isopropanol.

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Appendix D

Ogallala Aquifer Sampling Improvement Plan (B&W Pantex, 2013)



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Ogallala Aquifer Sampling Improvement Plan for USDOE/NNSA Pantex Plant Groundwater Remedial Action Projects

May 2013

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Introduction

This Sampling Improvement Plan has been developed as a result of the Sampling Evaluation for High Plains Aquifer Monitoring Wells (RPS Espey 2012), which was conducted as part of the draft Five Year Review. The objective was to evaluate existing Ogallala Aquifer monitoring wells and sampling methods at the Pantex Plant due to concerns regarding sample representativeness from these wells. To address these concerns, the project was commissioned to review state-of-the-industry sampling methods, evaluate well construction details of the wells, and develop recommendations for changes to the sampling program, if warranted.

The overall conclusions of the study were:

- The existing Ogallala monitoring well network is acceptable for detection monitoring.
- The use of low-flow or passive sampling methods should be equally appropriate for most wells. The existing sampling protocol is equivalent to the low-flow “micropurge” method described in the literature and is an acceptable method for sampling these wells. However, Espey recommended several improvements to the program, including:
 - Conducting well-specific evaluations of natural flow-through;
 - Developing well-specific purge criteria based on achieving a minimum two-volume purge of the sample tubing and pump;
 - Installation of packers in additional wells where appropriate to reduce the effective screen length for sampling and increase the sensitivity of detection monitoring; and
 - Testing of the passive Snap Sampler in combination with zone isolation baffles.

Therefore, the remainder of this plan will evaluate each of these recommendations and provide a path forward for improving the Ogallala aquifer program.

I. Well-specific Evaluations of Natural Flow-Through

The Espey evaluation stated that good hydraulic communication with the surrounding formation is the key factor in obtaining representative samples, whether passive or micropurge methods are used. Furthermore, the Espey Report recommended well-specific evaluations of flow-through such as single borehole tracer dilution testing and rehabilitation of wells that exhibit poor flow-through characteristics. While Pantex concurs that good hydraulic communication is the key factor, the benefit of conducting well-specific tests is rather unclear, considering two of the four wells tested required redevelopment and showed little vertical flow (good horizontal flow and hydraulic connection to the formation) after development. Rather than requiring continuous testing, Pantex proposes to implement a comprehensive Well Maintenance Program which will include a maintenance

schedule for all Ogallala aquifer wells in the LTM. All wells will be scheduled for maintenance a **minimum** of every 3 years. The maintenance shall include:

- A pre-maintenance well video to document well condition
- Brushing/bailing the upper 50 feet of saturated screen interval, or a 50 foot interval surrounding the pump intake if the pump is not set in the upper interval of the formation.
- A post-maintenance well video to document maintenance effectiveness

The primary benefit of this plan is that all maintenance activities can be conducted using current Pantex personnel and equipment while tracer testing would require subcontractors and significant cost. Note the 3 year maintenance schedule is based on observations from well videos and analytical data suggesting screen corrosion. As data is collected and evaluated, this schedule may be modified as needed.

Additional detail will be provided in the Well Maintenance Plan, which will be submitted in December 2013. The Plan will be periodically evaluated and updated, as necessary.

II. Installation of Packers

As discussed in the 2012 Espey Report, research suggests that conventional monitoring wells yield blended or composite samples that mask the true vertical distribution of dissolved contaminants in the aquifer, and that these composite samples are strongly biased by the position and length of well screens, pumping rate during sampling, and ambient vertical flow in the well. These effects in long-screened wells may result in underestimation of the maximum concentration present in the aquifer. As a result, Espey suggested the installation of packers or diverters in appropriate wells to reduce the effective screen length.

Table 1 summarizes current water levels and diverter information for all Ogallala aquifer LTM wells with multiple screens. All wells currently sampled as multi-level wells (all intervals sampled every 5 years) have diverters installed in either the first blank below the pump intake or in the blanks above and below the pump. Of the remaining wells with multiple screens, eight have the potential to install packers or diverters in the blanks. The installation of packers or diverters in these wells will effectively reduce the screen length and, to a degree, the mixing and in-well dilution. However, four of these wells will still have effective screen lengths of over 100 ft and significant mixing. In addition, the current method of “hanging” weighted rubber diverters with the pump and discharge line may not be appropriate as this system was designed for shorter screened intervals. Pantex has experience with assembling and installing the diverters while inflatable packers would require additional equipment and inflation lines will likely interfere with sampling equipment.

Therefore, Pantex recommends the installation of diverters in the three wells with saturated screen lengths of 85 feet or less (PTX01-1010, PTX01-1013, and PTX06-1072) and consider

adding diverters to the remaining wells as water levels in the Ogallala aquifer continue to decrease and effective screen length is reduced.

Table 1. Ogallala LTM Wells with Multiple screens

Well ID	Year Installed	Current Water Level, ft bgs	Sampled as Multi-Level Well?	Number of Screen Segments	Appx. Thickness of Upper Saturated Screened Interval	Notes
PTX01-1010	2000	496.10	N	3	70	diverter could be installed, 565-570 ft bgs
PTX01-1011	2000	492.75	N	2	110	diverter could be installed, 598 - 650 ft bgs
PTX01-1012	2000	507.17	N	3	130	diverter could be installed, 642-653 ft bgs
PTX01-1013	2000	504.14	N	3	85	diverter could be installed, 584-590 ft bgs
PTX06-1044	1999	487.12	N	2	--	logs do not indicate an annular seal in saturated interval of the borehole
PTX06-1062A	2001	501.03	N	2	265	diverter could be installed, 764-786 ft bgs
PTX06-1068	2001	518.85	N	2	255	diverter could be installed, 761-770 ft bgs
PTX06-1072	2001	415.68	N	2	85	diverter could be installed, 498-506 ft bgs
PTX06-1137A	2009	466.28	N	2	--	current water level in blank between intervals
PTX06-1138	2009	460.12	Y	2	--	diverter installed
PTX06-1139	2009	435.32	Y	2	--	diverter installed
PTX06-1140	2009	478.35	Y	4	--	diverter installed
PTX06-1141	2009	474.41	Y	3	--	diverter installed
PTX06-1143	2009	490.70	Y	5	--	diverter installed
PTX06-1144	2009	490.00	Y	5	--	diverter installed
PTX06-1157	2010	397.60	Y	3	--	diverter installed

III. Sampling Methods (Snap Samplers and Micropurge vs. Current)

Pantex currently uses a modified low-flow sampling method using dedicated Bennett sampling pumps. The wells are purged for 10 minutes using an unmeasured flow rate, defined as 0.3 to 0.8 L/minute. During the purge, a multiparameter meter with a flow-through cell (YSI) is used to document water quality/geochemical conditions. In addition, samples are collected and turbidity is measured in the field to determine whether field

filtration is necessary. Currently, Pantex policy is to filter the groundwater for specific analytes (metals and general chemistry) if the water turbidity exceeds 10 NTUs at the end of the purge. The samples are first filtered with a 10-micron filter and then a second set of metals samples are filtered with a 0.45-micron filter if the turbidity is not reduced to <10 NTUs. Filtration is required due to colorimetric metals methods and other method requirements. False chromium detections are of particular concern.

A. Snap Samplers

As discussed in the 2012 Espey Report, Snap Samplers (manufactured by ProHydro, Inc.) are a passive sampling technology that consists of a double end opening sampling bottle deployed down a well on a holder (sampler) that is attached to a trigger mechanism. The sampler is deployed down the well and allowed to passively equilibrate for a period of time. Then the sampler is triggered, closing the ends of the bottle and capturing an instantaneous representation of well conditions. One of the major advantages of this technology is that sample bottles can be sent directly to the laboratory, so the samples are never exposed to ambient air, resulting in more representative and consistent VOC concentrations.

1. Sample Volume Requirements

Since the Snap Sampler technology is a “one shot” technology, the sample volume that can be collected during one sampling event will be an important factor in determining the practicality of transitioning to this method. It could be possible to collect the required volume during multiple events, but the size and scope of the sampling program (> 300 well sampling events conducted in 2012) would likely prevent this from being practical or cost-effective. Therefore, the following discussion is based on the assumption that the entire sample volume will be collected during a single sampling event.

Table 2 summarizes the sample volume currently collected from the Ogallala aquifer monitoring wells. As shown in Table 2, three general types of data are collected in the long-term monitoring program:

- Perched aquifer COCs for detection of breakthrough to the lower Ogallala Aquifer
- General chemistry parameters to monitor the water chemistry and geochemical conditions in the aquifer
- Modified Appendix IX analytes in select wells for uncertainty management. Currently, 11 of the 30 sampled Ogallala aquifer wells are sampled for Appendix IX analytes every 5 years as part of the 5-year review.

The sample volumes listed in Table 1 also include all volumes needed to meet Pantex’s stringent laboratory requirements. Pantex currently requires all matrix spike and matrix spike duplicate QA/QC runs to be conducted using actual Pantex groundwater. To this end, an additional sample bottle (for every analysis) is

collected from the first well sampled every day. So the only way to accommodate this would be to include enough Snap Samplers provide enough sample volume in **every** well.

In addition, several factors contribute to an even larger sample volume. In keeping with industry standards, one duplicate sample is collected for every 20 sampled wells. Only COCs (HEs, metals, and VOCs) are collected for the duplicates. It may be possible to designate one or two wells where duplicates may be taken, but this will require an additional 3.6-liter volume.

Another factor that must be considered when estimating the required sample volume is the potential for TCEQ co-sampling. In recent years, the TCEQ has co-sampled a majority of the Ogallala aquifer wells. For example, from January - June 2013, the TCEQ has requested to co-sample 20 of the 27 Ogallala aquifer monitoring wells scheduled. The TCEQ typically collects samples for HEs, VOCs, metals, and perchlorate, which require approximately 3-liters of additional sample volume.

All of these factors combined would necessitate a sample volume of over 15 liters. Not all wells would necessarily require this volume, but it reflects the worst-case scenario, i.e a single well that is being sampled for Appendix IX analytes, duplicates, and QA/QC parameters, and is being co-sampled by the TCEQ.

As part of this evaluation, the Pantex Sampling and Analysis Department contacted the laboratories currently under contract to determine the minimum sample volume required to meet the method and QA/QC requirements. As summarized in Table 2, in some cases, the laboratory requirements are much lower than the volume collected. However, standard bottle sizes must be used, which will increase the volume collected. These lower volumes reduce the total volume needed to approximately 12 liters. Based on this required sample volume, a proposed sampler string assembly is included in Appendix B. Note that the proposed assembly provides additional volume (~1 L) in case of spillage, etc. by maximizing the number of samplers on the final string.

If these lower sample volumes are considered, then one other issue must be noted. Currently, there can be enough sample volume remaining that can be used in later analysis to confirm unexpected results. For example, in December 2012, the analytical results suggested that the HE results were switched for two samples (one groundwater sample and one rinsate sample). The field sampling procedures were evaluated and no potential for switching the samples in the field were found. The lab was contacted, and even though the hold times had been exceeded, there was enough remaining sample to re-run HEs. The subsequent results indicated the samples were indeed switched at some point during the extraction/analysis process. The wells were then re-sampled and the original data were rejected. If these

smaller sample volumes are implemented then this capability will be reduced. Wells can always be resampled and the data can be determined to be unusable if not confirmed, but there may not be a mechanism to reject the data. Keep in mind this HE data, in particular, was validated.

Table 2. Sample Volume Comparison

Analyte/Analyte List	Current Sample Volume (ml)	Lab Required Sample Volume (ml)	Proposed Sample Volume (ml)	Container Description
COCs				
VOCs	120	120	120	3, 40 mL VOA vials
Metals, including corrosion indicators, total chromium, boron	500	450	500	1 HDPE bottle
High Explosives	3000	3000	3000	2, 1-L amber glass bottles, plus 1 additional amber bottle for MS/MSD
Perchlorate	500	30	100	1 amber glass bottle
Cr(VI)	500	75	100	1 HDPE bottle
General Chemistry Parameters (collected every 2 years)				
Anions, including Br, Cl, F, SO ₄	1000	30	100	1 HDPE bottle
TDS	1000	210	250	1 HDPE bottle
Alkalinity	500	250	250	1 HDPE bottle
Nitrate	0	0	0	no additional volume needed
Appendix IX Analytes (collected every 5 years)				
VOCs	0	0	0	no additional volume needed
Metals	0	0	0	no additional volume needed
Isotopic Uranium	1000	150	250	1 HDPE bottle
Mercury	0	0	0	no additional volume needed
Sulfide	500	75	100	1 HDPE bottle
1,4-Dioxane	120	120	120	3, 40 mL VOA vials

Total:

8740

4890

7120

4420

(no Appx. IX Analytes)

Note: these volumes do not account for duplicate and TCEQ co-sampling volumes

2. Snap Sampler Components and Assembly

A Snap Sampler assembly is comprised of the following components:

- Wellhead Dock
- Trigger and trigger line (pneumatic, due to well depth)
- Samplers – each sampler can hold either one 40-ml VOA or one 350-ml POLY sample bottle. A maximum of 6 samplers can be connected together and operated by one trigger/line assembly
- Sample bottle – the VOA bottle should be removed from the sampler and sent to the laboratory without disturbance, but the 350-ml bottles can be emptied into the appropriate containers and then placed back into the sampler for re-use.
- Weight/baffle attached to the bottom, to reduce the potential for stuck equipment and mixing in the casing.

Note that multiple “strings” of samplers can be placed in a single well, but each string must have its own trigger and trigger line. So the Snap Sampler technology, in and of itself, does not limit sample volume. However, cost, length and weight of equipment down hole, and potential for getting equipment stuck during installation increase dramatically with sample volume.

3. Discussion

Based on the required sample volume and sampler volume limitations discussed in previous sections, seven or eight sampler strings would have to be deployed in a single well to be able to collect the current required sample volume. Appendix B illustrates typical sampler strings based on assumed sample volumes. The entire length of the string of samplers would likely exceed 40 feet and would cost over \$10,000 per well. The risk of breaking and/or getting equipment stuck in the casing would be extremely high.

In addition, two other issues must be noted if the Snap Samplers are implemented. The first is that it would be impossible to collect field parameters with this method. Originally, the YSI field data was collected to demonstrate stabilization, but this data has recently been used as an additional line of evidence when unexpected conditions occur in Ogallala Aquifer wells. For example, the ORP data collected at PTX06-1068 indicated that geochemical conditions supported the formation of hexavalent chromium from corrosion of the sampling pump.

The second issue identified with Snap Samplers is the inability to filter the groundwater prior to collecting the sample. As discussed in a previous section, metals, excluding boron, and general chemistry samples must be filtered as their results are affected by sample turbidity. Currently, filtering is accomplished using an in-line filter on the pump discharge line. Without this capability, field filtration

becomes extremely difficult and some sample volume would be lost during the filtering process. However, it should be noted that sample turbidity may be reduced using this passive sampling technology, eliminating the need for filtration altogether.

If Snap Samplers are still considered to be viable (given the limitations and issues discussed above), several options are available for reducing required sample volume and/or equipment downhole.

It may be possible to split the sampling into two separate events. In other words, collect a portion of the analytes with the Snap Sampler, then re-deploy the sampler and return within a few weeks after equilibration to collect the remaining analytes. However, effectively doubling the travel time and sampling time at each well would likely be a significant strain on both Pantex sampling technician and TCEQ Region 1 resources. This may be an option for the uncertainty management sampling conducted every 5 years, but the additional sample volume required for these analyses is relatively low compared to the rest of the analytes.

One alternative to reduce volume could be to eliminate sampling for the general chemistry parameters, reducing the required sample volume by 2500 mL (approximately 1 string of samplers). These analytes are not defined in the Compliance Plan or LTM Design, but are defined in the Sampling and Analysis Plan. Therefore, this change would need to be discussed with regulators prior to moving forward with this option. Another issue to keep in mind is that moving to this passive sampling technology would not allow for collection of the field parameters currently collected during the low-flow purge, so eliminating the general chemistry parameters would mean that no Ogallala aquifer geochemical data would be collected in this program.

Another possibility would be to use the 350-mL sample bottles in every sampler. Then all samples could be decanted into their appropriate sample containers from the 350-mL bottle. However, this introduces the potential of volatilization of VOCs, which conflicts with one of the primary benefits of transitioning to the Snap Samplers.

Another more controversial option could be utilized to reduce the required sample volume. Due to its mobility and widespread occurrence, RDX has been viewed as the primary risk driver for the Pantex plant. This concept has been carried through the conceptual site model and subsequent modeling in support of the Corrective Measures Study/Feasibility Study. Currently all Ogallala aquifer monitoring wells are sampled for VOCs and HEs and select monitoring wells are sampled for perchlorate and Cr(VI) depending on indicator areas. Considering the chemical and physical properties of the perched aquifer volatile organic COCs, it is highly unlikely these

chemicals will ever reach the Ogallala aquifer, assuming vertical movement from the above perched aquifer. If VOCs were removed from the analyte list for Ogallala wells, this could free up three samplers for the 350-ml bottles and almost double the sample volume collected in a series of strings. However, this change would require a Compliance Plan modification that would fundamentally change the Ogallala aquifer sampling program. Serious discussions should take place with regulators prior to considering this option.

Another option would be to remove VOCs from the regularly sampled analyte list and include them in the Appendix IX analytes sampled every 5 years. A separate 5-year sampling event could be conducted and the Snap Sampler string could be modified to collect all required volatile analytes. However, it must be noted that Snap Samplers were designed to be dedicated to one well, so either dedicated samplers would need to be purchased and segregated for each well or samplers would require a rigorous decontamination process, including collection and analysis of rinsate samples.

B. Micropurge

Some researchers have demonstrated that samples taken directly from the screened interval are representative of groundwater in the surrounding formation and that purging to stabilization is unnecessary. This technique, known as “micropurge” sampling, is an adaptation of the low-flow sampling procedure and requires only sufficient flushing of the pump and discharge tubing (suggested two calculated pump/tubing volumes) before a representative sample can be collected. Under this protocol, field parameter information is collected as part of the routine sampling procedure to determine and confirm baseline site conditions and monitor hydrogeologic changes within the aquifer.

A transition from the current modified low-flow method to this sampling method has several advantages, including:

- The micropurge volume is well-specific and not arbitrarily applied throughout the program, as with the current modified low-flow method purge time.
- The method can be conducted using the same fundamental sampling equipment, requiring only slight additions (flow measurement)
- The method is not volume limited, so co-sampling, QA/QC samples, etc. can be collected with no implications.
- Field parameter data can continue to be collected.

The transition from the current modified low-flow sampling to a micropurge procedure would be a relatively simple process. The Bennett sampling pumps currently installed can be utilized for the micropurge. A general sampling procedure would include:

1. Purge a set volume of two pump/tubing volumes at a low flow rate (<1 L/min). Field parameters would continue to be collected during the purge as per the modified low-flow method.
2. The purging and sampling flow rate shall be monitored (and recorded) to ensure the flow rate does not exceed 1 L/min. Flow measurement could be accomplished through either calculation (time to purge a specific volume) or possibly an in-line flow meter.
3. Once the required purge volume has been achieved, collect the required sample volume. (The purge volume will slightly vary from well to well, based on the length of tubing and drop tube)

The only issue identified with the micropurge method in this evaluation is that by monitoring and limiting the purge/sampling flow rate, the sampling time at each well may increase. This assumed increase in sampling time is unknown, but the purge/sampling time is estimated to be approximately 45 minutes, based on an assumed flow rate of 0.5 liters/minute and a 500-ft long, ½-inch discharge line. However, when compared to the logistical issues associated with Snap Samplers, this is a relatively minor issue.

IV. Conclusions

Pantex has carefully reviewed the High Plains Aquifer Sampling Evaluation and all appropriate data. Based on this review, Pantex has developed the following recommendations to improve the monitoring program:

1. Instead of conducting well-specific evaluations of flow-through, Pantex proposes the implementation of a comprehensive Ogallala aquifer well maintenance program to maintain a keen focus on maintaining well flow-through. This program will be detailed in the Well Maintenance Plan scheduled for completion in December.
2. Pantex proposes installing diverters in wells where the current water level is in a saturated screened interval less than 85-feet.
3. Based on the current sample volume requirements and construction of the Snap Samplers, the transition to passive sampling methods is not practical. Several options are available to reduce sample volume to a more manageable volume, but will require discussions with regulators. Other effects of the potential transition would be the loss of geochemical data and the inability to filter samples in the field.
4. Pantex recommends the potential transition to micropurge sampling. However, a pilot test should be conducted prior to implementing this method to ensure the continuity and comparability of data. The pilot test design is included in Appendix C.

Appendix A

Snap Sampler Manufacturer Information

THE **SNAP SAMPLER**®

BY PROHYDRO, INC.

US PAT. 7,178,435 UK PAT. GB 2,417,722



PASSIVE SAMPLING...SEALED IN SITU



**Equipment Design
Award Winner**



With wind power



PRICE LIST

valid through 2013

Snap Samplers:

Snap Samplers

PH40 (40 ml) Plastic (Acetal) Snap Sampler \$165.00 each
PH125 (125 ml) Plastic (Acetal) Snap Sampler (holds 125ml and 350ml bottles) \$165.00 each
Stack in any combination up to 6 on one trigger line; Snap Samplers come with stainless connector cables between samplers as required.

Triggers:

Mechanical Trigger *(for deployments up to ~50 feet/15m)*

Trigger Construction (includes cut to length, wireline assembly, fittings, ID tag) \$30.00 each
Plus Trigger line per foot \$1.25/ft
Or Trigger line per meter \$4.10/m

Pneumatic Trigger *(for deployments up to ~2000ft/600m)*

Downhole Pneumatic Actuator (approx 30psi to activate, any depth) \$195.00 each
Trigger Air Line Construction (includes cut to length, fittings and ID tag) \$25.00 each
Plus air line per foot (1/4 x 1/8 HDPE) \$0.25/ft
Or trigger air line per meter \$0.82/m
Weights are recommended with pneumatics submerged greater than ~50ft/15m

Electric Trigger on request

Well Docks/Weights: *(for secure well head protection and support of Snap Trigger lines)*

2-Inch (5-cm) Dock (locking well cap plus support ring, for SCH40 and SCH80 PVC) \$32.00 each
4-Inch (10-cm) Dock (locking well cap plus support ring, for SCH40 and SCH80 PVC) \$42.00 each
Custom Dock Adapter to fit odd-size casing to standard dock on request
3lb/1.4kg stainless steel weight \$50.00 each

Bottles:

Package of **two** 40 ml Snap Sampler VOA vials, includes septa caps and labels \$32.00/pack
Amber VOA vials \$36.00/pack

Package of **one** 125 ml Snap Sampler POLY bottle, includes septa caps and label \$16.00 each

Package of **one** 350 ml Snap Sampler POLY bottle, includes septa caps and label \$16.00 each

WWW.SNAPSAMPLER.COM
(585) 385-0023

PASSIVE SAMPLING...SEALED IN SITU

Tools and Supplies:

Standard Tool Kit

Standard Tool Kit includes two screw driver tools, one nipper tool, Standard Operating Procedure, laminated instruction cards, spare parts, screw repair kit and tool storage box\$49/ea.

Pneumatic Trigger Activation and Tool Kits

Pneumatic tool kits include the Standard Tool Kit, PLUS:

- Pressure block with 100psi pressure gauge and Schrader (bicycle pump) inlet valve, 12 volt air pump with cigarette plug connection
- Pelican Carry Case

Full kit\$395

Add 12v Rechargeable Battery Pack and charger

Includes cigarette plug connection for independent operation.....\$545

Electric Trigger Switch and Tool Kits

.....on request

Supplies and Replacement Parts

Spare Screw Driver Tool \$12.00/ea

Spare Nipper Tool \$22.00/ea

Stainless Ball-end Connector Cable \$12.00/ea.

Plastic-end, Spectra cable (*for most challenging geochemistries*) \$22.00/ea.

Plastic-end, Spectra cable (replace stainless cable in initial purchase)..... \$15.00/ea

Release pin set (set of 3 upper/lower/lever pieces for 40ml Snap Sampler) \$12.00/set

Release pin set (set of 3 upper/lower/lever pieces for 125ml Snap Sampler) \$12.00/set

Pack of replacement blue screws (12)..... \$10.00/pk

Don't forget to ask about our Pilot-to-Purchase Program (P2P)

(\$50 for each Snap Sampler, defer final purchase until second round of sampling)

Volume Pricing and Lease options: Available on request

PASSIVE SAMPLING...SEALED IN SITU

Graphic Ordering Sheet

WELL ID: _____

Choose items for each well

Copy and itemize for additional wells

DOCK

2-inch/50mm _____

4-inch/100mm _____

Custom Adapter _____ (specify)

TRIGGER

Manual Trigger _____ (max 50ft/15m)

Pneumatic trigger _____

Length _____ (Top of Casing to Top of Snap Sampler "string")

SNAP SAMPLERS

Number 40ml Snap Samplers _____

Number 125ml Snap Samplers _____

Maximum: 6 Snap Samplers total

BOTTLES

One bottle required for each Snap Sampler, for each sample collected

First event normally requires two sets of bottles (one to *deploy*, one to *redeploy* after first sample is collected)

_____ 40ml VOA Bottles

_____ 125ml POLY Bottles

_____ 350ml POLY Bottles

WEIGHT

For submergence greater than 50ft/15m)

3lb/1.4kg weight _____

Custom weight _____ (specify)

Well Dock:

>2-inch/50mm

>4-inch/100mm

>custom

Trigger:

>Manual (pull)

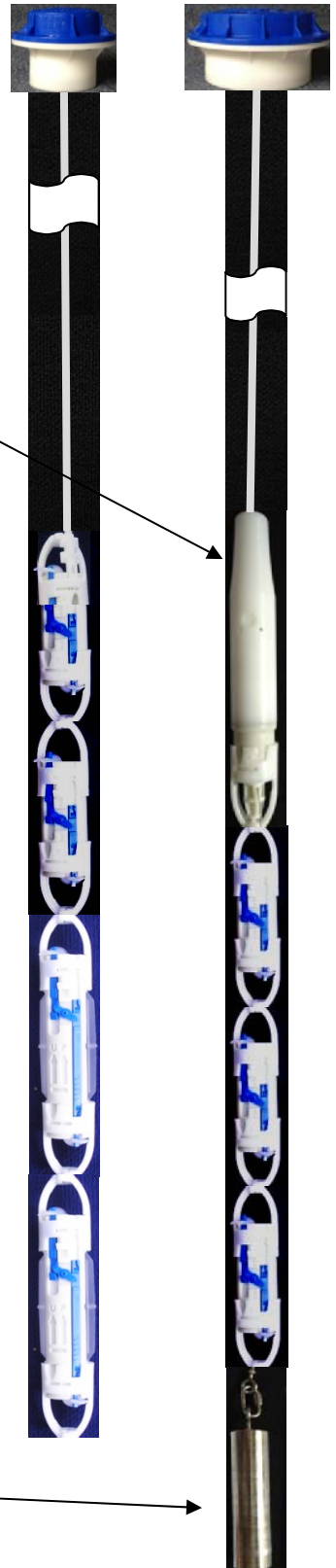
>Pneumatic

Snap Samplers:

>40ml

>125ml/350ml

Weight: (optional)



Appendix B

Proposed Snap Sampler String Assembly

Downhole Equipment, Appx IX analytes included

String	Sampler	Volume (ml)	Description
1	1	40	Pantex Sample
	2	40	Pantex Sample
	3	40	Pantex Sample
	4	40	TCEQ Sample
	5	40	TCEQ Sample
	6	40	TCEQ Sample
	Subtotal	240	
2	1	40	Duplicate Sample
	2	40	Duplicate Sample
	3	40	Duplicate Sample
	4	40	1,4-Dioxane
	5	40	1,4-Dioxane
	6	40	1,4-Dioxane
	Subtotal	240	
3	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
4	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
5	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
6	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
7	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
8	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
Total Sample Volume:		13080	

Downhole Equipment, Appx IX analytes excluded

String	Sampler	Volume (ml)	Description
1	1	40	Pantex Sample
	2	40	Pantex Sample
	3	40	Pantex Sample
	4	40	TCEQ Sample
	5	40	TCEQ Sample
	6	40	TCEQ Sample
	Subtotal	240	
2	1	40	Duplicate Sample
	2	40	Duplicate Sample
	3	40	Duplicate Sample
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	1170	
3	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
4	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
5	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
6	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
7	1	350	Sample Volume
	2	350	Sample Volume
	3	350	Sample Volume
	4	350	Sample Volume
	5	350	Sample Volume
	6	350	Sample Volume
	Subtotal	2100	
Total Sample Volume:		11910	

Appendix C

Micropurge Pilot Study – Test Plan

Micropurge Pilot Study Test Plan

I. Introduction

This pilot study plan has been drafted as a result of the High Plains Aquifer Sampling Improvement Plan, which concluded that that passive sampling is not practical and recommended a transition to a micropurge sampling technique. However, a pilot study is needed prior to full-scale implementation to:

- Ensure the COC data collected is consistent and comparable with the data collected using the current modified low-flow procedure
- Identify any issues with the sampling method that may affect the decision-making process

II. Well Selection

Even though the micropurge method is currently under evaluation for the High Plains aquifer wells, the first step is to test the method in perched aquifer wells since COC concentrations are currently non-detect in the High Plains aquifer monitoring wells. A subset of six perched aquifer wells was selected from the perched aquifer LTM wells, including:

- PTX06-1126
- PTX06-1034
- PTX06-1052
- PTX08-1008
- PTX08-1003
- PTX08-1005

These particular wells were chosen because they represent the typical concentration range (low and high values) observed in the perched aquifer for the following COCs:

- High explosives, RDX in particular
- Volatile COCs
- 1,4-dioxane
- Hexavalent chromium
- Perchlorate

Additionally, these wells are not currently or expected to be under the influence of a remedial action within the next few years, so these concentrations are not expected to change dramatically over the anticipated duration of the pilot study.

III. Sampling

All of the wells selected are sampled as required under the LTM design and SAP. Therefore, the sampling schedule for the pilot study was designed so the micropurge sampling can be conducted in conjunction with the regularly scheduled (modified low-flow) sampling. **The pilot study sampling must be completed within 15 days (before or after) of the regularly scheduled sampling.** A minimum of 2 sampling events at each well will be needed to obtain enough data to gain a level of confidence in the method, as discussed in Section IV. Five of the six wells chosen for the study are currently sampled semi-annually, so the data can be collected over a one-year period. PTX08-1003 is sampled annually, so the second pilot study sampling event shall be coordinated using an SRS request form.

The following procedure should be used for the micropurge sampling:

1. Sampling shall be performed using the same equipment used for the modified low-flow sampling equipment, including dedicated Bennet pump, YSI multparameter meter.
2. Purge the well at a low flow rate that must be less than 0.5 liters/minute. This flow rate must be measured and recorded at least twice during the purge.
3. Record field measurements using the YSI meter during the purge.
4. Purge the specified volume included in Table 2. This volume is double the estimated pump, intake line, and discharge line volume.
5. Disconnect the YSI meter.
6. Collect the groundwater samples as per DQO-045, Data Quality Objective for Groundwater Sampling.

During sampling, the sampling technicians should note any difficulties or unanticipated problems encountered during sampling.

Table 2. Micropurge Volumes

Well	Micropurge Volume (gal)
PTX06-1126	2.0
PTX06-1034	6.5
PTX06-1052	6.0
PTX08-1008	2.0
PTX08-1003	2.0
PTX08-1005	6.3

IV. Data Evaluation

It must be noted there can be significant variability in groundwater data at the Pantex plant. Most of this variability is due to general plume movement and/or effects of remedial actions. These issues can be addressed by limiting the time between sampling events (15 days) and choosing test

locations that should not be affected by the remedial actions. However, there is also some variability just due to the sampling and analytical processes that cannot be addressed, yet must be recognized when comparing the results of the two sampling methods. In order to attempt to quantify the consistency and/or variability of the groundwater analytical results, duplicate data collected from 2010 – 2012 was evaluated. A duplicate sample is collected every 20 wells as part of the general QA/QC program at Pantex.

As shown in Table 1, the major perched aquifer COCs were evaluated. 1,4-Dioxane was also included since it is a semi-volatile and may react differently to the change in sampling methods. As shown in the table, approximately 90% of the individual COCs duplicate data were within 20% of the original measured value. It should be noted that in the case of hexavalent chromium data, only data point exceeded the laboratory PQL of 15 ppb, and in this case, the duplicate result was identical. Since the colorimetric method used for hexavalent chromium has been proven to be unreliable at concentrations below the PQL, this data was not included in this evaluation.

Table 1. Duplicate Data Summary, 2010 - 2012

COC	Number of detected results	% of duplicate samples within 10% of original result	% of duplicate samples within 20% of original result
RDX	25	72	88
TCE	13	77	92
Cr(IV)	1	100	100
1,4-Dioxane	6	83	100
Perchlorate	5	100	100

Based on this evaluation, if the all COC concentrations measured in samples collected using the micropurge sampling method are within 20% of the corresponding values from the low-flow sampling method, the micropurge method should be considered to produce consistent and comparable results. If the micropurge data does not fall within 20% limits, then further evaluation may be necessary before a decision to transition to micropurge can be made. If only a few data points fall outside the 20% range, then additional data collection may be all that is needed to prove these are natural outliers and the transition

However, if analytical data is not consistent between the two sampling methods, i.e. a majority of the micropurge data fall outside the 20% range, it is likely that these results are not due to natural variability and other factors in the sampling method are contributing to the differences. In this case, a more detailed evaluation of both sampling methods, well conditions or other factors will be needed to determine what may be causing these differences and which method is producing the most representative results.

It must be noted that if it is determined the micropurge method results in more representative data and the decision to transition is made, the newly acquired data will not be comparable to data

previously collected and could lead to the calculation of false trends. The potential benefits and damages to the program must be carefully weighed during the decision making process.

Appendix E

Table of Wells and Coordinates

Well	Aquifer	Type	Installation Date	Easting – ft (NAD83)	Northing - ft (NAD83)
1114-MW4	Perched	IW	04/03/92	636151.9	3757809.4
OW-WR-38	Perched	IW	08/30/11	640649.0	3765214.2
PTX01-1001	Perched	IW	04/13/94	630593.0	3769641.9
PTX01-1002	Perched	IW	03/30/94	628496.9	3769597.0
PTX01-1004	Perched	IW	08/24/99	630729.8	3770768.7
PTX01-1008	Perched	IW	09/25/99	629943.0	3770782.9
PTX01-1009	Perched	IW	02/15/00	630594.7	3769018.5
PTX01-1010	Ogallala	IW	04/04/00	630576.9	3771397.3
PTX01-1011	Ogallala	IW	04/26/00	629986.5	3771397.3
PTX01-1012	Ogallala	IW	04/30/00	632664.2	3773264.1
PTX01-1013	Ogallala	IW	05/13/00	628976.9	3773218.3
PTX04-1001	Perched	IW	03/27/98	641458.1	3772334.7
PTX04-1002	Perched	IW	03/29/98	641818.0	3772165.3
PTX06-1002A	Perched	IW	02/09/93	641161.6	3759984.0
PTX06-1003	Perched	IW	09/28/92	641498.9	3758711.1
PTX06-1005	Perched	IW	01/11/93	640545.4	3756139.9
PTX06-1006	Perched	IW	12/09/92	637450.2	3757599.8
PTX06-1007	Perched	IW	01/24/93	637679.4	3759513.0
PTX06-1008	Perched	IW	12/08/92	639441.9	3759325.3
PTX06-1010	Perched	IW	10/23/92	639886.6	3758067.0
PTX06-1011	Perched	IW	11/05/92	639178.9	3757219.8
PTX06-1012	Perched	ISPM	05/03/95	634640.9	3755068.8
PTX06-1013	Perched	IW	05/24/95	643710.4	3764075.1
PTX06-1014	Perched	IW	05/23/95	643758.9	3755125.7
PTX06-1015	Perched	IW	03/10/95	643765.0	3753617.0
PTX06-1023	Perched	IW	10/05/95	642773.8	3764603.1
PTX06-1030	Perched	IW	05/09/96	644670.4	3755008.0
PTX06-1031	Perched	IW	05/06/96	644674.9	3753348.0
PTX06-1033	Ogallala	IW	09/12/96	642614.5	3759581.4
PTX06-1034	Perched	IW	02/06/98	646555.6	3752435.0
PTX06-1035	Perched	IW	02/26/98	633027.5	3755092.6
PTX06-1036	Perched	IW	02/11/98	638615.4	3752455.6
PTX06-1037	Perched	ISPM	03/12/98	641549.3	3752194.1
PTX06-1038	Perched	IW	03/05/98	643802.0	3760426.4
PTX06-1039A	Perched	IW	06/14/98	643807.5	3759272.6
PTX06-1040	Perched	IW	06/17/98	643811.2	3758262.9
PTX06-1041	Perched	IW	06/18/99	643803.6	3757622.8
PTX06-1042	Perched	IW	06/25/99	643812.2	3755779.9
PTX06-1043	Ogallala	IW	08/20/99	640711.0	3765225.2
PTX06-1044	Ogallala	IW	08/27/99	642706.2	3764538.5
PTX06-1045	Perched	ISPM	11/15/99	642697.7	3752300.0
PTX06-1046	Perched	IW	11/19/99	643802.6	3752292.6
PTX06-1047A	Perched	IW	02/29/00	643817.5	3752004.4

Well	Aquifer	Type	Installation Date	Easting – ft (NAD83)	Northing - ft (NAD83)
PTX06-1048A	Perched	IW	02/11/00	642103.4	3766957.6
PTX06-1049	Perched	IW	02/16/00	633343.5	3763377.0
PTX06-1050	Perched	IW	02/23/00	636746.0	3766622.1
PTX06-1051	Perched	IW	02/26/00	640332.9	3752279.1
PTX06-1052	Perched	IW	02/27/00	639100.9	3753957.7
PTX06-1053	Perched	IW	03/01/00	636576.7	3753672.1
PTX06-1055	Perched	IW	04/08/00	633521.9	3767254.9
PTX06-1056	Ogallala	IW	05/15/00	643767.0	3754642.9
PTX06-1057A	Ogallala	IW	08/29/00	629630.0	3768142.2
PTX06-1058	Ogallala	IW	08/26/00	624894.0	3759747.1
PTX06-1061	Ogallala	IW	09/22/00	625651.6	3773186.6
PTX06-1062A	Ogallala	IW	05/14/01	633017.2	3771685.2
PTX06-1064	Ogallala	IW	05/31/01	635900.5	3773557.9
PTX06-1068	Ogallala	IW	05/16/01	643403.7	3773360.3
PTX06-1069	Perched	IW	05/02/01	646317.0	3762879.6
PTX06-1071	Perched	IW	05/31/01	642601.5	3773219.4
PTX06-1072	Ogallala	IW	05/19/01	635047.5	3758434.6
PTX06-1073A	Perched	IW	12/05/01	634963.3	3758072.0
PTX06-1076	Ogallala	IW	03/25/02	637327.3	3752978.4
PTX06-1077A	Perched	IW	01/22/02	637201.8	3760689.5
PTX06-1080	Perched	IW	06/12/02	638901.0	3772644.0
PTX06-1081	Perched	IW	06/15/02	641222.4	3770912.3
PTX06-1082	Perched	IW	08/17/02	653856.3	3780321.6
PTX06-1083	Perched	IW	08/19/02	658643.5	3779777.8
PTX06-1085	Perched	IW	08/25/02	629059.8	3760418.3
PTX06-1086	Perched	IW	08/28/02	631411.8	3759843.3
PTX06-1088	Perched	IW	08/27/02	639902.1	3757059.4
PTX06-1089	Perched	IW	07/17/03	646637.3	3760259.0
PTX06-1090	Perched	IW	07/21/03	647727.5	3757684.4
PTX06-1091	Perched	IW	08/02/03	646554.0	3756363.4
PTX06-1093	Perched	IW	08/04/03	645529.0	3759922.3
PTX06-1094	Perched	IW	08/07/03	643813.8	3751494.6
PTX06-1095A	Perched	IW	08/29/04	640634.9	3755598.6
PTX06-1096A	Perched	IW	08/25/05	630823.6	3766548.4
PTX06-1097	Perched	IW	08/29/05	633104.4	3765068.6
PTX06-1098	Perched	ISPM	09/29/05	640266.1	3753628.4
PTX06-1100	Perched	ISPM	09/29/05	640286.0	3753579.5
PTX06-1101	Perched	ISPM	09/29/05	640383.6	3753437.1
PTX06-1102	Perched	IW	10/02/96	642751.1	3754532.9
PTX06-1103	Perched	IW	08/05/10	641222.6	3752963.4
PTX06-1118	Perched	ISPM	07/19/07	641644.9	3752736.1
PTX06-1119	Perched	IW	07/20/07	642646.1	3752739.0
PTX06-1120	Perched	IW	07/22/07	643152.4	3752735.0
PTX06-1121	Perched	IW	07/24/07	643645.6	3752750.1
PTX06-1122	Perched	IW	07/11/07	640677.3	3752308.7
PTX06-1123	Perched	ISPM	07/26/07	642052.0	3752319.9

Well	Aquifer	Type	Installation Date	Easting – ft (NAD83)	Northing - ft (NAD83)
PTX06-1124	Perched	IW	07/09/07	642877.9	3752327.4
PTX06-1125	Perched	IW	07/09/07	643377.5	3752331.1
PTX06-1126	Perched	IW	01/15/08	635034.7	3755562.9
PTX06-1127	Perched	IW	01/09/08	635901.9	3755432.0
PTX06-1130	Perched	IW	10/23/08	644270.4	3759745.0
PTX06-1131	Perched	IW	10/15/08	629371.7	3754232.9
PTX06-1133A	Perched	IW	11/17/08	645287.4	3751315.7
PTX06-1134	Perched	IW	03/15/09	633520.1	3754409.2
PTX06-1135	Perched	IW	10/08/08	638343.8	3753631.9
PTX06-1136	Perched	IW	11/01/08	634860.8	3766771.8
PTX06-1137A	Ogallala	IW	02/15/09	647900.9	3758635.7
PTX06-1138	Ogallala	IW	01/21/09	646285.3	3760503.8
PTX06-1139	Ogallala	IW	01/29/09	646768.7	3756376.1
PTX06-1140	Ogallala	IW	02/05/09	646959.4	3762807.7
PTX06-1141	Ogallala	IW	02/17/09	633445.4	3766872.9
PTX06-1143	Ogallala	IW	02/25/09	639244.7	3770496.8
PTX06-1144	Ogallala	IW	02/26/09	640253.0	3773320.5
PTX06-1146	Perched	IW	10/30/08	645978.9	3757691.9
PTX06-1147	Perched	IW	11/05/08	645431.9	3753953.2
PTX06-1148	Perched	ISPM	08/29/08	636467.0	3754719.7
PTX06-1149	Perched	ISPM	09/07/13	635864.1	3754717.6
PTX06-1150	Perched	ISPM	08/28/08	635234.0	3754718.2
PTX06-1151	Perched	IW	03/13/09	633936.0	3756123.6
PTX06-1153	Perched	ISPM	08/22/09	641184.1	3752089.4
PTX06-1154	Perched	ISPM	08/22/09	641870.5	3752278.9
PTX06-1155	Perched	ISPM	09/17/09	634603.7	3755215.6
PTX06-1156	Perched	ISPM	09/17/09	636378.9	3755076.5
PTX06-1157	Ogallala	IW	04/01/10	647102.0	3753702.0
PTX06-1158	Perched	IW	08/12/12	648138.0	3752025.9
PTX06-1159	Perched	IW	08/15/12	634015.0	3754843.5
PTX06-1160	Perched	IW	08/13/12	632835.7	3756274.1
PTX06-1166	Perched	IW	09/19/12	639750.3	3752799.7
PTX06-1167	Perched	IW	07/30/13	640913.7	3752653.0
PTX06-ISB014	Perched	ISB	10/01/07	641188.3	3752451.5
PTX06-ISB019	Perched	ISB	09/19/07	641666.3	3752597.6
PTX06-ISB024	Perched	ISB	07/18/07	642144.6	3752737.7
PTX06-ISB030B	Perched	ISB	09/17/07	641094.7	3752286.3
PTX06-ISB038	Perched	ISB	08/14/07	641850.2	3752524.2
PTX06-ISB042	Perched	ISB	08/25/07	642233.4	3752641.0
PTX06-ISB046	Perched	ISB	10/24/07	641939.3	3752422.7
PTX06-ISB048	Perched	ISB	10/24/07	642131.8	3752479.9
PTX06-ISB055	Perched	ISB	03/04/09	636606.1	3755477.4
PTX06-ISB059	Perched	ISB	02/25/09	636234.2	3755246.1
PTX06-ISB063	Perched	ISB	02/19/09	635886.3	3755141.1
PTX06-ISB069A	Perched	ISB	02/11/09	635170.0	3755241.0
PTX06-ISB071	Perched	ISB	11/25/08	634991.2	3755334.1

Well	Aquifer	Type	Installation Date	Easting – ft (NAD83)	Northing - ft (NAD83)
PTX06-ISB073	Perched	ISB	09/29/11	634821.3	3755453.7
PTX06-ISB075	Perched	ISB	09/28/12	634813.2	3755333.9
PTX06-ISB077	Perched	ISB	11/13/08	634942.8	3755207.6
PTX06-ISB082	Perched	ISB	08/26/09	636597.9	3755139.4
PTX07-1O01	Perched	IW	05/19/94	638532.5	3767695.2
PTX07-1O02	Perched	IW	05/31/94	639106.6	3768117.5
PTX07-1O03	Perched	IW	06/14/94	639046.6	3767462.6
PTX07-1O06	Perched	IW	02/10/00	638814.4	3768536.8
PTX07-1P02	Perched	IW	07/12/94	637817.7	3763019.1
PTX07-1P05	Perched	IW	09/28/98	637136.1	3762886.8
PTX07-1Q01	Perched	IW	04/12/94	629274.8	3755836.1
PTX07-1Q02	Perched	IW	04/22/94	628877.0	3756408.7
PTX07-1Q03	Perched	IW	05/09/94	630542.6	3757408.9
PTX07-1R01	Ogallala	IW	04/16/00	627914.3	3764159.9
PTX07-1R03	Perched	IW	08/22/99	627664.4	3764501.8
PTX08-1001	Perched	IW	09/21/13	638941.5	3762976.3
PTX08-1002	Perched	IW	08/27/13	640859.0	3763003.2
PTX08-1003	Perched	IW	10/07/92	635385.4	3760136.6
PTX08-1005	Perched	IW	10/20/92	635316.7	3756346.2
PTX08-1006	Perched	IW	11/02/92	636400.4	3756761.9
PTX08-1007	Perched	IW	09/01/11	638900.0	3758440.5
PTX08-1008	Perched	IW	01/10/93	637485.1	3755695.5
PTX08-1009	Perched	IW	02/10/93	638867.0	3755275.0
PTX08-1010	Perched	IW	09/16/92	641401.5	3773206.7
PTX10-1014	Perched	IW	06/29/92	639701.7	3759769.7
PTX-BEG2	Ogallala	IW	02/15/92	632652.5	3756906.6

IW - Investigation/Monitoring Well

ISPM - In-Situ Performance Monitoring Well

ISB - ISB Injection Well