LONG-TERM MONITORING SYSTEM DESIGN REPORT

Pantex Plant

Amarillo, Texas

April 2009

Long-Term Monitoring System Design Report
for the U.S. Department of Energy/
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Pantex Plant, Amarillo, Texas

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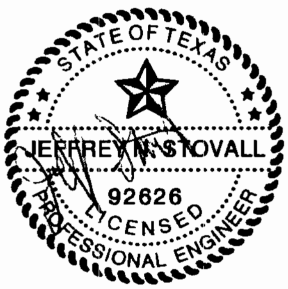

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ACRONYMS

B&W Pantex	Babcock & Wilcox Technical Services Pantex, LLC
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CMS/FS	Corrective Measure Study/Feasibility Study
COPC	Constituents of potential concern
COV	Coefficient of variation
Cr(VI)	Hexavalent chromium
EPA	United States Environmental Protection Agency
FCT	Former Cooling Tower
FGZ	Fine-grained zone
GSI	Groundwater Services, Incorporated
GWPS	Groundwater Protection Standard
HE	High explosive
HSU	Hydrostratigraphic unit
LTMO	Long-term monitoring optimization
MAROS	Monitoring and Remediation Optimization System
NNSA	National Nuclear Security Administration
NWS	National Weather Service
OSTP	Old Sewage Treatment Plant
PTC	Princeton Transport Code
PQL	Practical quantitation limit
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDX	Research Development Explosive (cyclo-trimethylene trinitramine)
RFI	RCRA Facility Investigation
ROD	Record of Decision
RRS	Risk Reduction Standard
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TTU	Texas Tech University
USDOE	U.S. Department of Energy
WMG	Waste management group
WWTF	Wastewater Treatment Facility

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1. INTRODUCTION

This report presents the proposed long-term groundwater monitoring (LTM) well network that 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. This report also presents the methods for evaluation 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.

The primary purpose of the LTM network is to ensure that 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 5-year review. The LTM network will also be reevaluated during the 5-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, as described in greater detail in Section 1.3. 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. DESIGN STRATEGY

A LTM design strategy was formulated by the Pantex Core Team, a four-member committee established to facilitate better communication and streamline decision-making through the integrated RCRA-Comprehensive Environmental Response Compensation and Liability Act (CERCLA) cleanup process at Pantex Plant. The Core Team includes one member each from EPA, TCEQ, U.S. Department of Energy (USDOE)/ National Nuclear Security Administration (NNSA), and Babcock & Wilcox Technical Services, Pantex, LLC (B&W Pantex). The following steps outline the LTM network design strategy:

1. Develop monitoring objectives for each water-bearing unit.
2. Evaluate the existing well network in each water-bearing unit (Ogallala Aquifer and perched groundwater) with respect to each objective to identify areas where additional monitoring is needed.
3. Use statistical or mathematical monitoring network optimization tools to evaluate the existing well network and optimize the spatial distribution and frequency of monitoring.
4. Combine the results of the different evaluation methods to develop the final LTM network.

This design strategy was applied separately to perched groundwater and the Ogallala Aquifer to develop a LTM network for each aquifer. The monitoring objectives are described in the following section. The combined results of the different evaluations and final network designs are presented in Section 2 for perched groundwater and in Section 3 for the Ogallala Aquifer.

1.3. LONG-TERM MONITORING NETWORK OBJECTIVES

1.3.1 Perched Groundwater

Three objectives were identified for monitoring wells in perched groundwater: Plume Stability, Response Action Effectiveness, and Uncertainty Management. Some of the Response Action Effectiveness wells will be used to satisfy requirements under the Compliance Plan for Point of Compliance with the

Groundwater Protection Standards (GWPS). Some of the Uncertainty Management Wells will be used to satisfy requirements in the Compliance Plan for periodic evaluation of the closest water bearing unit near sources of contamination.

1.3.1.1 Plume Stability

The purpose of plume stability wells is to determine if impacted areas (plumes) of perched groundwater are expanding and affecting clean perched groundwater and to monitor the changes occurring within the perched plumes. Plume stability wells are located along the edges of the perched plumes where GWPSs are currently being met (note that some areas of perched groundwater are currently impacted above GWPSs to the extent of perched saturation and should show a decline in concentrations over time) and within perched plumes in areas where plumes may be expanding. The focus of monitoring in plume stability wells will be on constituents specific to the plume, Zone, waste management group (WMG), or unit where the well is located. The expected conditions for the plume stability wells are that changes in concentrations of constituents can be identified over time at various locations within and around the plumes.

1.3.1.2 Response Action Effectiveness

The purpose of response action effectiveness wells is to determine the effectiveness of response measures, indicate when RAOs for perched groundwater have been achieved, and validate modeling results or provide data that can be used to refine modeling. The focus of monitoring in response action effectiveness wells will be on constituents specific to the plume, Zone, WMG, or unit where the well is located. The expected conditions for the response action effectiveness wells are that, over time, indicators of the reduction in volume, toxicity and mobility of constituents will be observed. These indicators may include stable or decreasing concentrations of constituents or declining water levels in areas where response measures have been implemented.

1.3.1.3 Uncertainty Management

The purpose of uncertainty management wells in perched groundwater is to confirm expected conditions identified in the RCRA Facility Investigations (RFIs) and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units evaluated in a baseline risk assessment. Uncertainty management wells are located downgradient of risk assessment units, using a Zone or WMG approach, in areas where perched groundwater is the underlying groundwater or downgradient of known source areas, such as the ditches and playas that contributed much of the constituent mass currently found in perched groundwater. Uncertainty management wells will be used to confirm expected conditions for each Zone, WMG, or unit through monitoring.

Some of the Uncertainty Management Wells will also be 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. Pantex recommends this sampling be conducted every 5 years to correspond to the 5-year review and will focus on wells near the source areas.

1.3.2 <u>Ogallala Aquifer</u>

Two objectives were identified for monitoring wells in the Ogallala Aquifer: Early Detection and Uncertainty Management. Specific wells in the Ogallala Aquifer serve as Point of Exposure wells to also satisfy requirements in the Compliance Plan. Some of the 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.

1.3.2.1 Early Detection

The purpose of early detection wells is to identify breakthrough of constituents to the Ogallala 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 will be on indicator constituents, defined as COCs and degradation products in overlying or upgradient perched groundwater that will most likely be detected following breakthrough to the aquifer. Because of the cleanup actions that have been implemented to protect the Ogallala Aquifer, the expected conditions for the early detection wells are that constituents are not detected above background, the practical quantitation limit (PQL), or GWPSs and that constituents do not reach potential points of exposure above GWPSs.

1.3.2.2 Uncertainty Management

The purpose of uncertainty management wells in the Ogallala Aquifer is to confirm expected conditions identified in the RFIs and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units closed to RRS 3. Uncertainty management wells will be located downgradient of RRS 3 units, using a Zone or WMG 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.

Some of 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. Pantex recommends this sampling be conducted every 5 years to correspond to the 5-year review and will focus on wells near the source areas.

Figure 1-1. Pantex Plant Location Map

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2. PERCHED GROUNDWATER

This section summarizes the development of the LTM network for perched groundwater beneath Pantex Plant and presents the final LTM network. The strategy used to develop the monitoring network is presented in Section 1.2 and comprised the following steps:

1. Develop monitoring objectives.
2. Evaluate the existing well network with respect to each objective to identify areas where additional monitoring is needed.
3. Use statistical or mathematical monitoring network optimization tools to evaluate the existing well network and optimize the spatial distribution and frequency of monitoring.
4. Combine the results of the different evaluation methods to develop the final LTM network.

The monitoring objectives developed for perched groundwater are described in Section 2.1, the evaluation of the existing well network with respect to each objective is discussed in Section 2.2, and a summary of the statistical monitoring network optimization is provided in Section 2.3. The final LTM network is presented in Section 2.4 with a justification for each proposed new well.

2.1. MONITORING OBJECTIVES

The monitoring objectives developed for perched groundwater, described in Section 1.3.1, are plume stability, response action effectiveness, and uncertainty management. Plume stability wells are intended to determine if constituent plumes in perched groundwater are expanding and to monitor the changes occurring within the plumes. Monitoring in plume stability wells will be focused on constituents specific to the plume, Zone, WMG, or unit where the well is located. Two major plumes, defined by spatial extent, are found in perched groundwater. The southeast plume occurs beneath the eastern side of Pantex Plant and extends southeast beneath TTU property and across FM 2373. The extent of the southeast plume is defined primarily by the extents of RDX and hexavalent chromium, but high explosives, volatiles, and inorganics comprise the plume. The RDX and hexavalent chromium plumes are shown in Figure 2-1 and Figure 2-2. The Zone 11 plume occurs beneath Zone 11 and extends northeast to Playa 1 and south beneath TTU property. Perchlorate defines the extent of the Zone 11 plume, but TCE and other volatiles and high explosives are also found within the plume. The perchlorate plume is shown in Figure 2-3.

Response action effectiveness wells are used to determine the effectiveness of response measures, indicate when RAOs for perched groundwater have been achieved, and validate modeling results or provide data that can be used to refine modeling. Remediation of perched groundwater in the two major plumes will be accomplished through the use of four response action systems. The Southeast Pump and Treat System, Playa 1 Pump and Treat System, and Southeast In Situ Bioremediation System have been installed for the southeast plume. The locations of these systems are shown on Figure 2-1 and Figure 2-2. The Zone 11 In Situ Bioremediation System, designed to intercept the Zone 11 plume, is currently under construction south of Zone 11, as depicted in Figure 2-3.

Uncertainty management wells in perched groundwater provide information to confirm expected conditions identified in the RFIs and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units closed to RRS 3. These wells are discussed further in Section 2.4.2.

2.2. EVALUATION OF EXISTING WELL NETWORK

The existing (as of May 2008) perched groundwater monitoring network, shown in Figure 2-4, was evaluated with respect to each objective to identify areas where additional monitoring is needed. This evaluation resulted in the proposed addition of seven wells (PTX06-1130, PTX06-1131, PTX06-1133, PTX06-1146, PTX06-1147, PTX06-1150, and PTX06-1151) to the network to satisfy the monitoring objectives. Two additional wells (PTX06-1148 and PTX06-1149) were added to provide information for the design and to monitor effectiveness of the Zone 11 ISB response action. Two downgradient performance monitoring wells were also added for each of the ISB systems (PTX06-1153, PTX06-1154, PTX06-1155, and PTX06-1156) to verify ISB treatment effectiveness.

Based on evaluation of the existing network, PTX-BEG3 is recommended for removal from the LTM system. This well was drilled to a depth of 434 ft by the Bureau of Economic Geology in 1992 to gather geologic information as part of the initial investigation. The lower part of the boring was plugged, but the completed well was screened 28 ft into the FGZ. Analytical data from PTX-BEG3 collected since 1992 do not indicate the presence of contamination. However, because this well is in the northeastern corner of Pantex where constituents have been detected in perched groundwater at nonactionable levels, it will be plugged and abandoned as a precaution against providing a pathway through the FGZ.

The proposed perched groundwater LTM network as well as the monitoring objectives satisfied by each existing and proposed well is shown on Figure 2-5.

2.3. SUMMARY OF LONG-TERM MONITORING OPTIMIZATION RECOMMENDATIONS

The current groundwater monitoring network was 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. 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 articulated 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* report (GSI, 2008) included in Appendix B.

2.3.1 <u>Project Goals and Objectives</u>

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.

2.3.2 <u>Results</u>

The monitoring system for perched groundwater was evaluated using analytical and hydrogeologic data from sampling events conducted between January 2000 and May 2007. 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 network reduces monitoring effort and cost in some areas, but includes the addition of new wells in areas where further characterization would support site-monitoring goals and also increases data collection effort in some areas to provide a dataset that fulfills statistical requirements for evaluating the effects of the remedies discussed in the Corrective Measure Study/Feasibility Study (CMS/FS) (BWXT, 2007b). A summary of the recommended changes to the monitoring network is presented in Table 2-1.

2.4. LONG-TERM MONITORING NETWORK FOR PERCHED GROUNDWATER

The recommendations from the LTMO analysis were combined with the results of the evaluation against monitoring objectives to develop the final proposed well network shown in Figure 2-5. The following section describes how the recommendations from the LTMO analysis were incorporated into the final proposed well network. Section 2.4.2 provides an analysis of how the proposed well network satisfies the requirement for LTM to address uncertainties regarding the vertical extent of constituents beneath soil release units.

2.4.1 Incorporation of LTMO Recommendations

As described in Section 2.3.2, the 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. These sectors were further refined according to the extents of constituent plumes, as shown in Figure 2-6, to allow a list of specific indicator constituents to be developed for each area for the *Sampling and Analysis Plan*. The most widespread and mobile contaminants at Pantex, such as high explosives and VOCs, will be included on the indicator lists for all areas. Additional contaminants identified only in specific areas of perched groundwater (e.g., hexavalent chromium or perchlorate) will only be included in the indicator lists for certain areas.

The Southeast sector was extended to include several wells on the western side of Zone 12. In the Southwest sector, the extent of perched groundwater underlying Zone 10, Playa 2, and southwest of Zone 4 in the western portion of the sector was removed from the sector. The remainder of the Southwest sector, encompassing the area affected by migration of perchlorate from Zone 11, was renamed the Zone 11 sector. In the North sector, the area surrounding the Burning Ground and Playa 3 was defined as the Burning Ground area. The area north and northwest of Playa 1 encompassing the northern portion of the RDX plume was retained as the North sector, while the remaining portions of the North and Southwest sectors were grouped into a Miscellaneous area. The Miscellaneous area includes wells near Zone 10, Playa 2, Pantex Lake, and the Old Sewage Treatment Plant.

The proposed LTM network for perched groundwater is shown in Figure 2-5. The final network includes a total of 113 perched wells. New wells proposed for addition to the network are explained in Table 2-2. All seven new wells recommended in the LTMO analysis were included in the final network.

Four of the seven wells recommended in the LTMO analysis for elimination from the network based on the spatial redundancy analysis were retained because these wells fulfill one or more of the monitoring objectives. The other three wells (PTX06-1087, PTX07-1P03, and PTX10-1008) monitor unaffected groundwater and were removed. None of these wells will be plugged and abandoned because all wells are useful for obtaining water level measurements. Additionally, several wells in the Miscellaneous Area were recommended for 5-year sampling intervals.

Table 2-3 provides a complete list of all wells in the proposed long-term monitoring network for perched groundwater. The table includes the LTM objectives to be satisfied by each proposed well, the metrics to be used in evaluating data collected from the well, the expected condition, and proposed monitoring frequency. Evaluation metrics include water level trends, comparison of concentrations to the GWPS, and concentration trends; these metrics and the expected conditions are discussed in Section 5. Additional details on monitoring, including analyte lists, sampling procedures, and analysis methods, are provided in the *Sampling and Analysis Plan* (B&W Pantex, 2009).

The final perched LTM network consists of:

- 113 perched wells – 19 of those wells will be monitored for continued dry conditions, with 94 sampled for laboratory analysis. All wells will be sampled for natural attenuation parameters every two years to evaluate the natural breakdown of high explosives and chlorinated solvents. All wells will have water levels checked semi-annually.

- 52 wells recommended to be sampled semi-annually, 31 wells recommended for annual sampling, 4 wells recommended for quarterly sampling, and 7 wells recommended for 5-year sampling of indicator constituents. Corrosion parameters will also be collected to evaluate potential corrosion influence in stainless steel wells that are sampled for chromium.

- 42 wells are recommended for 5-year sampling of a modified 40 CFR Part 264 Appendix IX groundwater list to satisfy uncertainty management requirements. Corrosion parameters will also be collected at stainless steel wells.

A table listing all wells and their coordinates (northings and eastings) is included in Appendix D.

2.4.2 Response Action Performance Monitoring

In Situ Bioremediation Systems

Designated wells within and downgradient of the *in situ* bioremediation systems will be sampled quarterly to evaluate system performance and to determine when subsequent injections of bioremediation amendment are needed as described in the bioremediation system O&M plans. This sampling will be specific to the type of contaminants that are being treated and will verify required water quality conditions in the aquifer. Within the treatment zone, sufficient data must be collected to demonstrate that highly 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. Downgradient of the treatment zone, data must demonstrate that objectives of the response action are being achieved; specifically, COC concentrations must be below GWPSs.

A subset of the bioremediation amendment injection wells will be sampled for a limited set of analytes, including geochemical parameters, amendment degradation products, and primary COCs and degradation products, that provide key information on the health and condition of the treatment zone. Eight wells in each ISB system have been designated for ISB treatment zone performance monitoring as shown in Figure 2-8. Quarterly sampling frequency is recommended for these wells because conditions within the barrier can change more rapidly than ambient conditions in the aquifer, and frequent sampling is needed for determination of amendment injection frequency.

Downgradient performance monitoring wells will be sampled for the complete list of indicator constituents plus geochemical parameters, amendment degradation products, and metals. Two new performance monitoring wells will be installed approximately 225 ft downgradient of the southernmost row of amendment injection wells of each ISB system. In addition, existing monitoring wells that are downgradient of the ISB treatment zones within a distance of about two to three years' travel time are also designated as performance monitoring wells. Downgradient performance monitoring wells are also shown in Figure 2-8. Quarterly sampling is recommended for the two new downgradient wells installed at each barrier to provide a comprehensive temporal dataset to confirm barrier performance. Existing downgradient wells* are recommended for semi-annual monitoring.

Pump and Treat Systems

Because the primary metric for success of the pump and treat systems is decreasing perched groundwater thickness, as determined through periodic water level measurements, routine monitoring of water levels will provide the basis for determining flow direction, hydraulic gradient, and saturated 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. Extraction wells will be sampled annually to measure concentrations of non-volatile COCs to supplement data collected through the monitoring well network. In addition, treatment process effectiveness will be evaluated through routine monitoring of unit processes as specified in the *Sampling and Analysis Plan*.

2.4.3 Monitoring of Soil Release Units

TCEQ and EPA conditionally approved the investigations of soil release units with a requirement for LTM downgradient of release units to address uncertainties regarding the vertical extent of constituents. For purposes of monitoring the soil release units, the units were grouped by Zone or Waste Management Group and downgradient wells were identified in the first groundwater encountered. The perched LTM network contains an adequate number of wells to monitor soil units across the plant where the perched groundwater is the first groundwater encountered. Landfill areas to the west have adequate cover material and results of investigations indicate that soil contamination is limited, so downward migration of contamination is unlikely. Additionally, downgradient Ogallala Aquifer wells will be used to monitor for those units.

Soil release units and perched groundwater monitoring wells are shown in Figure 2-9. A listing of the soil release units and the associated downgradient monitoring wells is provided in Table 2-4. This list contains all units that were evaluated in a baseline risk assessment. In addition to monitoring for indicator contaminants in perched groundwater, these wells will also be monitored for a larger list of analytes (based on a modified 40 CFR Part 264 Appendix IX list provided in the *Sampling and Analysis Plan*) on a 5-year sampling interval.

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*PTX06-1118 is upgradient of the Southeast ISB treatment zone, but was affected by injection of bioremediation amendment. Therefore, it is designated as a downgradient performance monitoring well and will be sampled for the ISB performance monitoring parameters.

Table 2-1. Summary of LTMO Recommendations

Sector	Recommended Well Additions		Recommended Well Removals	
Southeast	2	PTX06-1130, PTX06-1135	1	PTX06-1014
Southwest	4	PTX06-1126, PTX06-1127, PTX06-1131, PTX06-1134	6	PTX06-1006, PTX06-1087, PTX07-1P02, PTX07-1P03, PTX07-1Q02, and PTX10-1008
North	1	PTX06-1136	None	

Table 2-2. Proposed New Long-Term Monitoring Wells for Perched Groundwater

Well Identifier	Location	Purpose
PTX06-1130 PTX06-1146 PTX06-1147	East of FM 2373	Provide information regarding the effects of the Southeast Pump and Treat System and help characterize the nature and extent of perched groundwater impacts east of FM 2373.
PTX06-1131	Southwest of Zone 10	Monitor for the potential migration of constituents from release units in Zone 10. No perched groundwater impacts have been identified associated with Zone 10 in the three existing wells in this area, but these wells were installed to monitor the landfills northwest of Zone 10.
PTX06-1133	Near the southeastern extent of perched groundwater	Monitor the stability of the southeast plume fringe where plume has migrated beyond the existing wells.
PTX06-1126 PTX06-1127 PTX06-1148 PTX06-1149 PTX06-1150 PTX06-1151	South of Zone 11	Monitor the stability of the Zone 11 plume and effectiveness of Zone 11 ISB corrective action. Wells PTX06-1126 and PTX06-1127 were installed in early 2008 to monitor the stability of the Zone 11 plume on USDOE property and to provide information about the distribution of concentrations within the plume.
PTX06-1134	TTU property southwest of Zone 11	Delineate perchlorate plume downgradient of PTX06-1012.
PTX06-1135	TTU property south of Zone 11	Reduce spatial uncertainty in the vicinity of PTX06-1036, PTX06-1052, and PTX06-1053. A new well in this area may be beneficial for monitoring concentrations of hexavalent chromium and RDX and other high explosives.
PTX06-1136	North of Zone 4	Delineate RDX in perched groundwater downgradient of PTX06-1050.
PTX06-1153 PTX06-1154	Downgradient of Southeast ISB Treatment Zone	Monitor the effectiveness of the Southeast ISB corrective action.
PTX06-1155 PTX06-1156	Downgradient of Zone 11 South ISB Treatment Zone	Monitor the effectiveness of the Zone 11 South ISB corrective action.

Table 2-3. 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
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
Miscellaneous	PTX06-1049	Plume Stability, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	N	NA
Miscellaneous	PTX06-1055	Plume Stability	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX06-1071	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	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
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
Miscellaneous	PTX06-1131	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-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
Miscellaneous	PTX08-1010	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	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
North	PTX06-1048A	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	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
North	PTX06-1136	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
North	PTX07-1O01	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Semi-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
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
Southeast	PTX06-1010	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs

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	PTX06-1013	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-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	Semi-Annual	N	NA
Southeast	PTX06-1034	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	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
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	Trend/Compare to GWPS	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
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	PTX06-1069	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
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	Dry	Remain dry	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
Southeast	PTX06-1098	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
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	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1118	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1119	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1120	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1121	Plume Stability	Dry	Remain dry	NA	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

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	PTX06-1130	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1133	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1135	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
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
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
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
Southeast, Zone 11	PTX06-1008	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	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
Southeast, Zone 11	PTX06-1053	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	N	NA
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, Zone 11	PTX10-1013	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Zone 11	1114-MW4	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	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
Zone 11	PTX06-1012	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1035	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	N	NA
Zone 11	PTX06-1073A	Plume Stability	Dry	Remain dry	NA	N	NA
Zone 11	PTX06-1077A	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
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
Zone 11	PTX06-1134	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 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1149	Plume Stability	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1150	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1151	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	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
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
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
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

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 (B&W Pantex) 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*.

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Table 2-4. Monitoring of Soil Release Units for Perched Groundwater

Grouping	Release Units	Perched Wells
Zone 10		
WMG 12	AOC 3a: Former Boiler House Areas, Zone 10 AOC 14: Battery Storage Area, Scrap/Salvage Yard, (10-9) SVS 3: Carbon Black Burial Area-Zone 10 (Duplicate of SWMU 67) SVS 8: Abandoned Zone 10 Landfill Construction Debris Landfill SWMU 68d: Active Sanitary Landfill SWMU 84: Scrap and Salvage Yard, Bldg 10-9 SWMU 143a: Former Waste Drum Storage Areas/Bldg 10-9 SWMU 143b: Former Waste Drum Storage Areas/Bldg 10-7 SWMU 144: Zone 10 TNT Settling Pit (10-13) SWMU 145: Zone 10 TNT Settling Pit (10-17) SWMU 146: Zone 10 TNT Settling Pit (10-26) Zone 10 Building Construction Debris Landfills (5) Zone 10 Construction Debris Berms (A-I)	PTX07-1Q01 PTX07-1Q02 PTX07-1Q03 PTX06-1131
Zone 11		
WMG 1	AOC 8a: Solvent Leaks (Pad 11-12) AOC 8b: Solvent Leaks (Pad 11-13) SVS 2: Zone 11 Parallel Depression Near Bldg 11-26 SVS 5: Landfill East of 11-13 Pad (Construction Debris from Bldgs 11-12,11-13) SWMU 60: Landfill 9 (Group III) Building Demolition Debris Landfill SWMU 61: Landfill 10 (Group III) Building Demolition Debris Landfill SWMU 147: Zone 11 TNT Settling Pit (11-13) SWMU 149: Zone 11 TNT Settling Pit (11-26) SWMU 150: Building 11-12	1114-MW4 PTX08-1005 PTX08-1006 PTX06-1126 PTX06-1127
WMG 2	AOC 1: Transformer Leak Near 11-14A AOC 8c: Solvent Leaks (PAD 11-17) SWMU 3: Bldg 11-44 Drainage Ditch SWMU 12: Drainage Ditch Near 11-14 Pond & Pipeline SWMU 86: Waste Accumulation Area 11-14 Solvent Storage Shed SWMU 117: 11-44 HE Settling Tank SWMU 118: Bldg 11-44 Equalization Basin SWMU 119a: Bldg 11-44 HE Particulate Filters SWMU 120a: Bldg 11-44 Activated Carbon Filters SWMU 148: Zone 11 TNT Settling Pit (11-17)	
WMG 3	AOC 7a: Sulfuric Acid Spills (11-36) AOC 8d: Solvent Leaks (Pad 11-22) AOC 8e: Solvent Leaks (Bldg 11-36) SWMU 5/08: Drainage Ditch 11-36 SWMU 113: Overflows From 11-36 Collection System/Sump Unassigned Former Leaching Bed N of Bldg 11-50 & W of Bldg 11-36	
WMG 4	SWMU 5-09a: Building 11-17 Drainage Ditch SWMU 5/09b: Drainage Ditch 11-20 SWMU 5/11: Zone 11 Main Drainage Ditch SWMU 13: Surface Impoundment Solar Evaporation Pits at Bldg 11-51 SWMU 87: Building 11-20 Solvent Storage Shed Unassigned Evaporation Pit, East of Bay 3, Bldg 11-20 Unassigned Evaporation Pit, South of Bay 11, West of Bay 6, Bldg 11-20	
N/A	Unassigned - Former 11-15 Pond	

Table 2-4. Monitoring of Soil Release Units for Perched Groundwater, continued

Grouping	Release Units	Perched Wells
Zone 12		
WMG 5	AOC 7c: Sulfuric Acid Spills (12-64) SWMU 5/06a: Drainage Ditch 12-44 SWMU 5/06b: Drainage Ditch 12-81 SWMU 56: Landfill 5 (Group III) Building Construction Debris Landfill SWMU 57: Landfill 6 (Group III) Building Construction Debris Landfill SWMU 68a North: Original Misc Purpose Sanitary Landfill SWMU 103: Former Battery Storage Area, Bldg 12-81 SWMU 135: Subsurface Leach Beds, Bldg 12-44	PTX08-1008 PTX08-1009
N/A	SWMU 5-12b: Perimeter Drainage Ditch from Zone 12 to SWMU 5-143c	
WMG 6/7	AOC 10a: Building 12-43A Pesticide Rinse Area AOC 13a: Former Cooling Tower in Zone 12 (Pad) AOC 13b: Former Cooling Tower in Zone 12 (Piping/Soil) SWMU 1: Bldg 12-17 Drainage Ditch SWMU 2: Bldg 12-43 Drainage Ditch SWMU 5/04a: Drainage Ditch 12-19 SWMU 5/04b: Drainage Ditch 12-73 SWMU 5/05: Drainage Ditch Between Bldgs 12-21 & 12-24 SWMU 5/07: Drainage Ditch 12-41 SWMU 5/12a: Zone 12 Main Drainage Ditch SWMU 54: Landfill 3 SWMU 55: Landfill 4 SWMU 119b: High Explosives Filters SWMU 120b: Carbon Filters SWMU 121: High Explosives Settling Tank SWMU 122a: Bldg 12-43 Equalization Tank/Soil SWMU 122b: Bldg 12-24N/12-43 Vicinity Soil SWMU 123: Concrete Sump & Waste Water Treatment Unit	PTX06-1002A PTX06-1003 PTX06-1005 PTX06-1010 PTX06-1011 PTX06-1088 PTX06-1095A PTX08-1007 PTX08-1009
WMG 9	AOC 5: Electrical Equipment Bone Yard near Building 12-5 AOC 10b: Pesticide Rinse Area (Bldg 12-51) AOC 12: Bldg 12-5D Paint Shop Area/ Solvent Pit SWMU 5-02a: Building 12-51 Drainage Ditch SWMU 5/02b: Drainage Ditch 12-67 SWMU 5-02c: Building 12-110 Drainage Ditch Capacitor Bank Rupture Zone 12	PTX06-1002A PTX06-1003
WMG 10	AOC 15: DDT Release at Bldg 12-35 SWMU 5/01a: Drainage Ditch Bldg 12-5 SWMU 5/01b: Drainage Ditch Bldg 12-5B Bldg 12-5 Concrete Sump	PTX10-1013
N/A	SWMU 136: Subsurface Leaching Systems, Bldg 12-59	PTX06-1008
Burning Ground		
WMG 13	SWMU 8: Playa 3 SWMU 14-24: Burning Ground-Explosive Burn Pads SWMU 25: Burning Ground-Explosive Burn Pad 11 SWMU 26: Burning Ground-Explosive Burn Pad 12 SWMU 27 Burning Ground-Explosive Burn Pad 13 SWMU 37: Burning Ground-Landfill 1 SWMU 38: Burning Ground-Landfill 2 SWMU 39: Burning Ground-Landfill 3 SWMU 40: Burning Ground-Landfill 4	PTX01-1001 PTX01-1002 PTX01-1008

Table 2-4. Monitoring of Soil Release Units for Perched Groundwater, continued

Grouping	Release Units	Perched Wells
	SWMU 41: Burning Ground-Landfill 5 SWMU 42: Burning Ground-Landfill 6 SWMU 43: Burning Ground-Landfill 7 SWMU 44: Burning Ground-Landfill 8 SWMU 45: Explosive Burn Cage SWMU 46: Explosive Burn Cage SWMU 47: Burning Ground-Evaporation Pit SWMU 48: Burning Ground Solvent Evaporation Pans SWMU 49: Burning Ground Solvent Evaporation Pans SWMU 50: Burning Ground Solvent Evaporation Pans SWMU 51: Burning Ground Solvent Evaporation Pans SWMU 52: Burn Racks and Flashing Pits Unassigned Burning Ground-Explosive Burn Pad 16 Unassigned: Demonstration Facilities	
Other Units		
WMG 11 North	SWMU 6: Playa 1	OW-WR-38 PTX08-1001 PTX08-1002
WMG 11 North	SWMU 68b: General Purpose Sanitary Landfill 1	PTX07-1O01 PTX07-1O02 PTX07-1O03 PTX07-1O06
WMG 11 North	SWMU 82: Nuclear Weapon Accident Residue Storage	PTX06-1050
WMG 11 South	SWMU 5/13 (a, b, and c): Drainage Ditch to Playa 1	PTX06-1002A PTX06-1007 PTX08-1001 PTX08-1002 PTX10-1013
WMG 11 South	SWMU 68c: General Purpose Sanitary Landfill 2	PTX07-1P05
N/A	AOC 11: Fire Training Area Burn Pits	PTX06-1077A
N/A	SWMU 4: Building 11-50 Drainage Ditch	PTX08-1005
N/A	SWMU 5-15a & b: Drainage Ditch to Playa 4	PTX06-1053 PTX06-1134
N/A	SWMU 7: Playa 2	PTX06-1085 PTX06-1086
N/A	SWMU 9: Playa 4	PTX06-1053
N/A	SWMU 10: Pantex Lake	PTX06-1082 PTX06-1083
N/A	SWMU 58: Landfill 7	PTX06-1077A
N/A	SWMU 64: Landfill 13	PTX07-1R03
N/A	SVS 7a and 7b: Igloo Demolition Debris Landfills Zone 4 (SVS 7a) and Zone 5 (SVS 7b)	PTX06-1049 PTX06-1096A PTX06-1097

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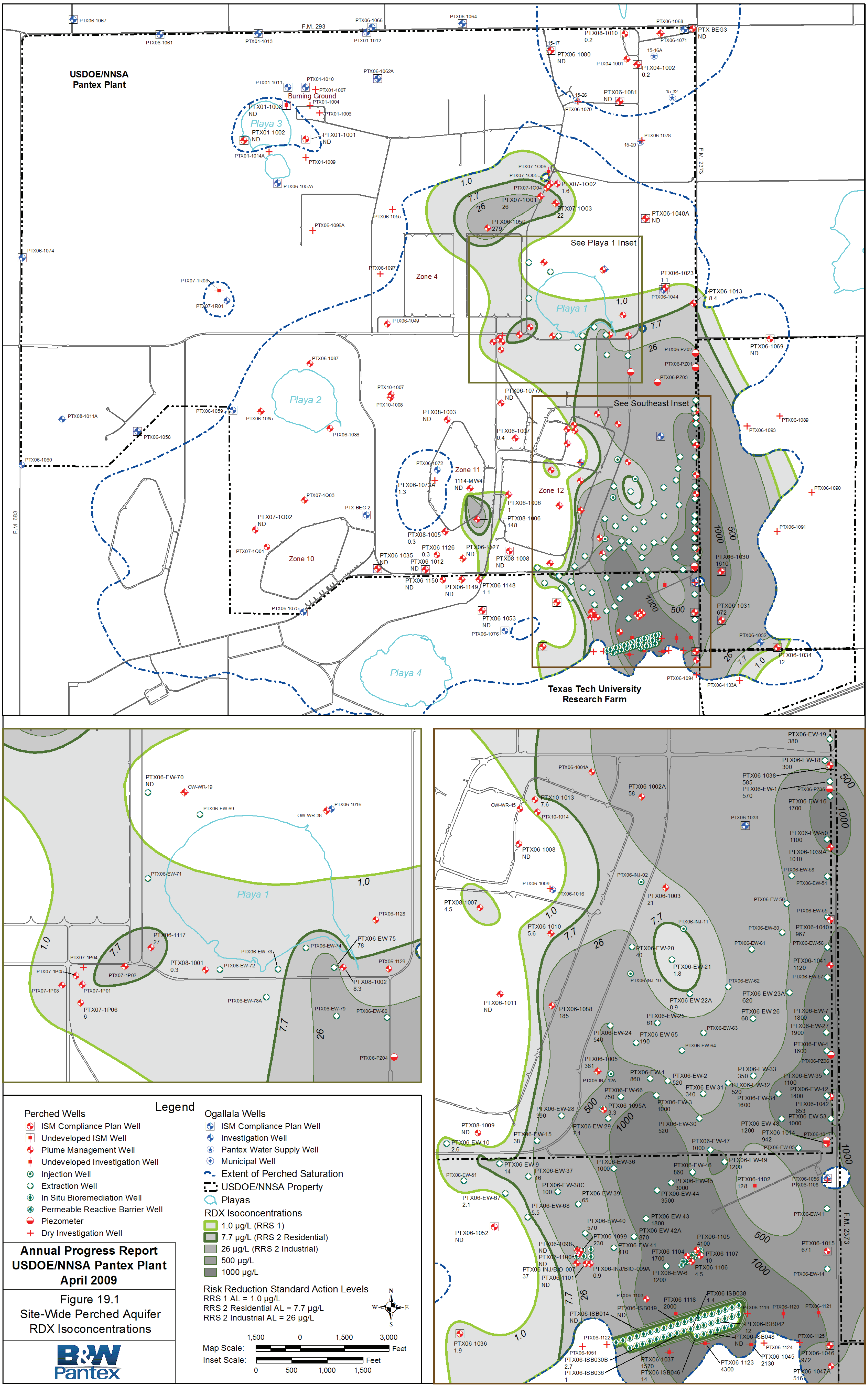

Figure 2-1. Perched Groundwater RDX Isoconcentrations

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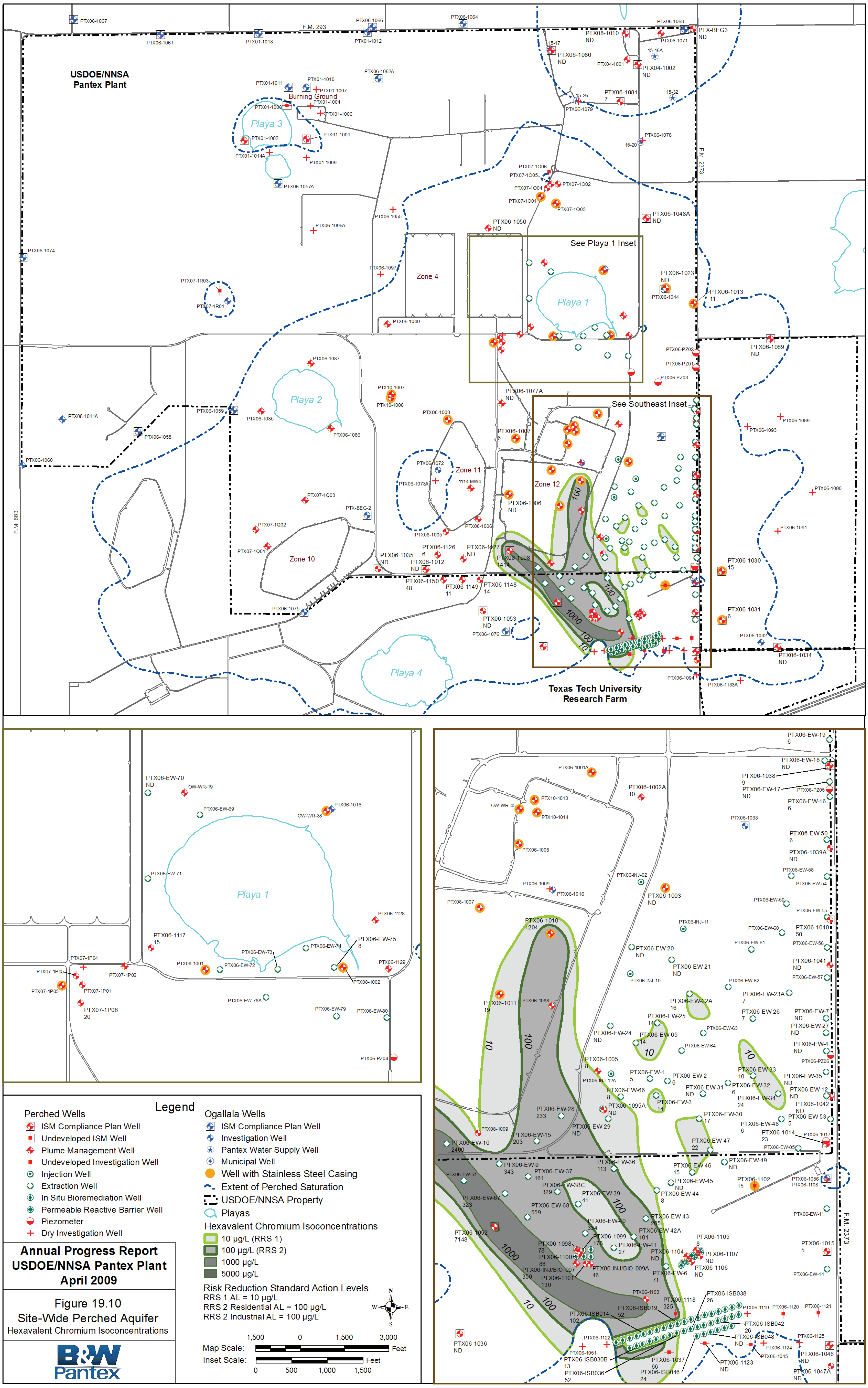

Figure 2-2. Perched Groundwater Hexavalent Chromium Isoconcentrations

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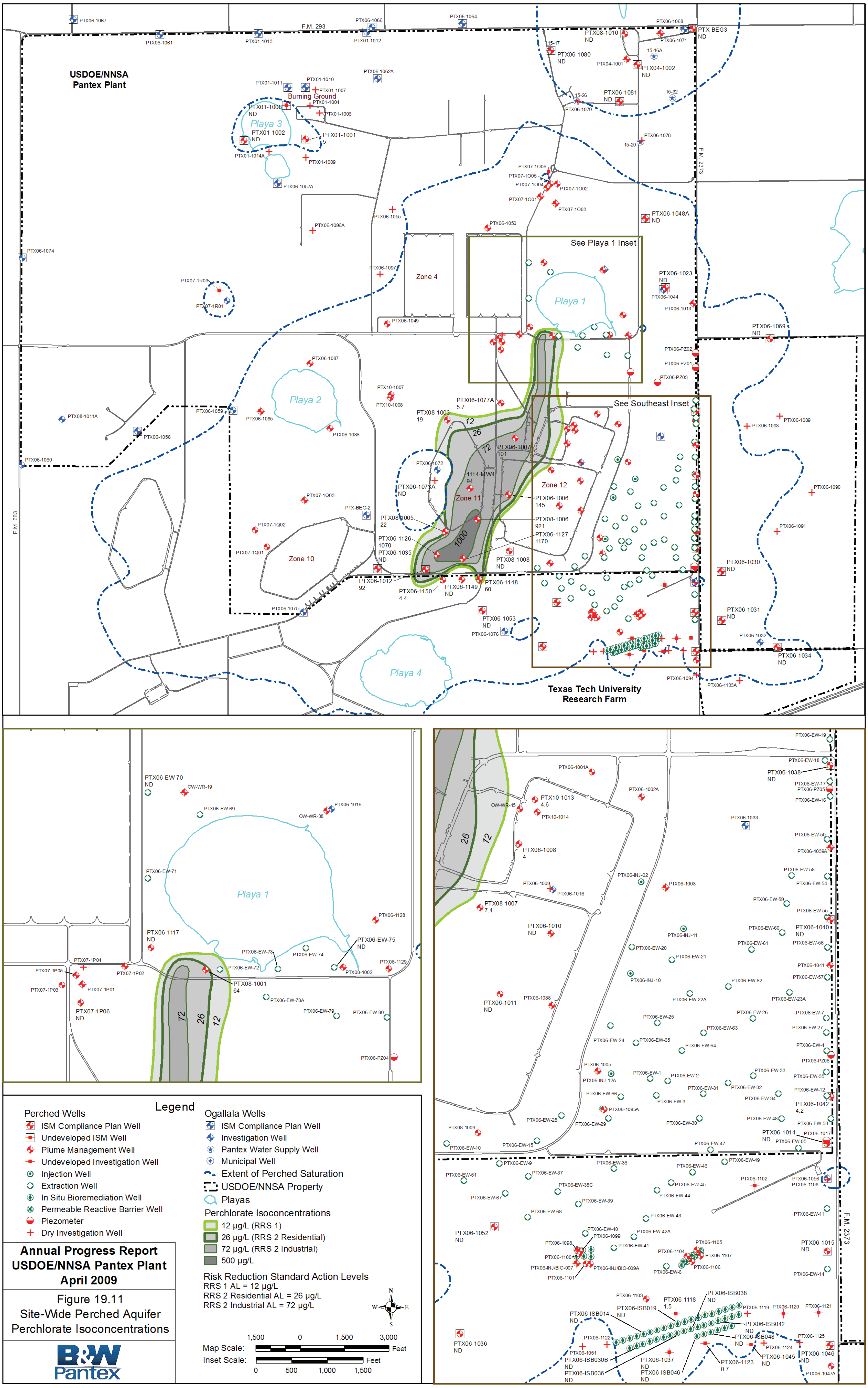

Figure 2-3. Perched Groundwater Perchlorate Isoconcentrations

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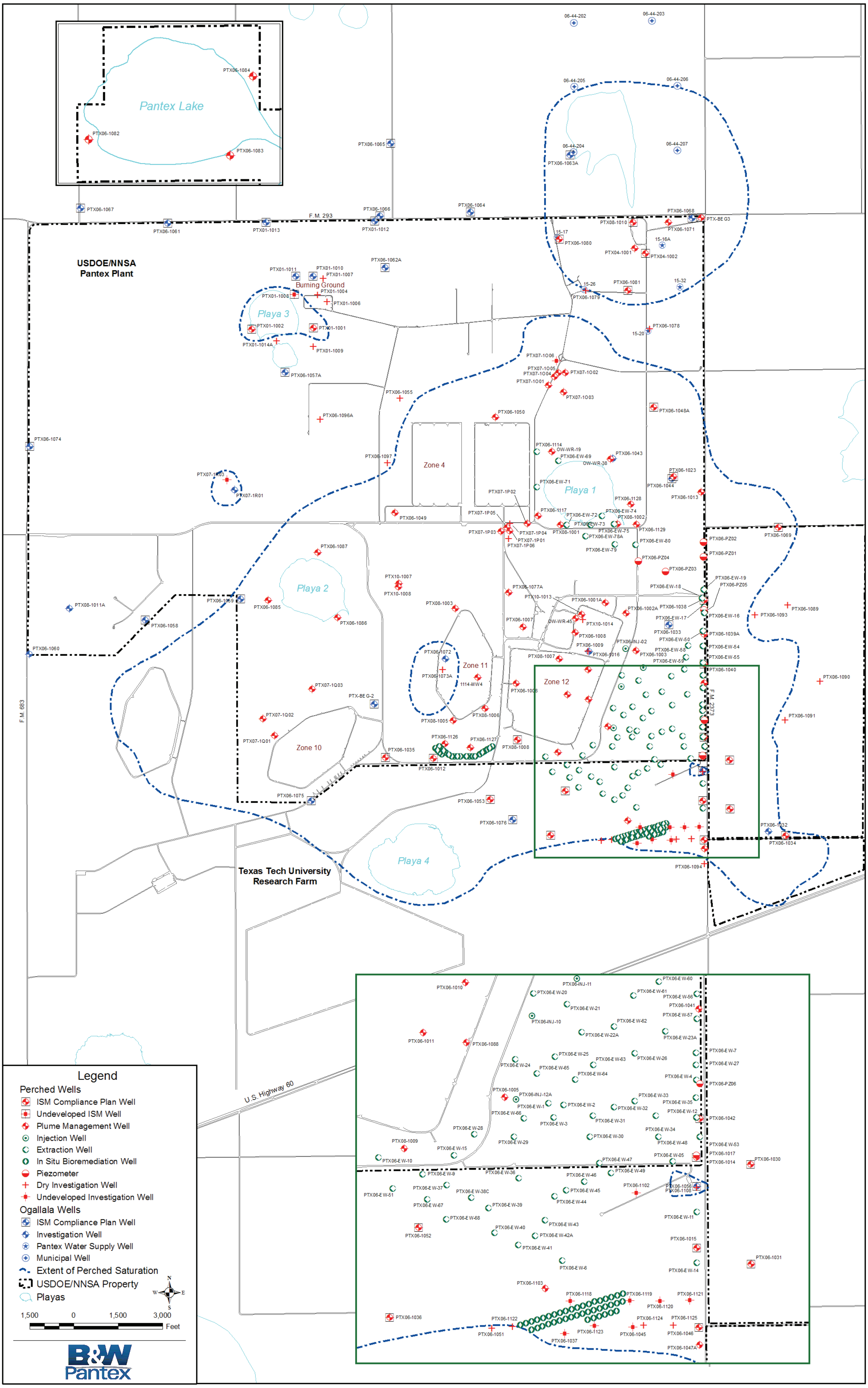

Figure 2-4. Well Location Map

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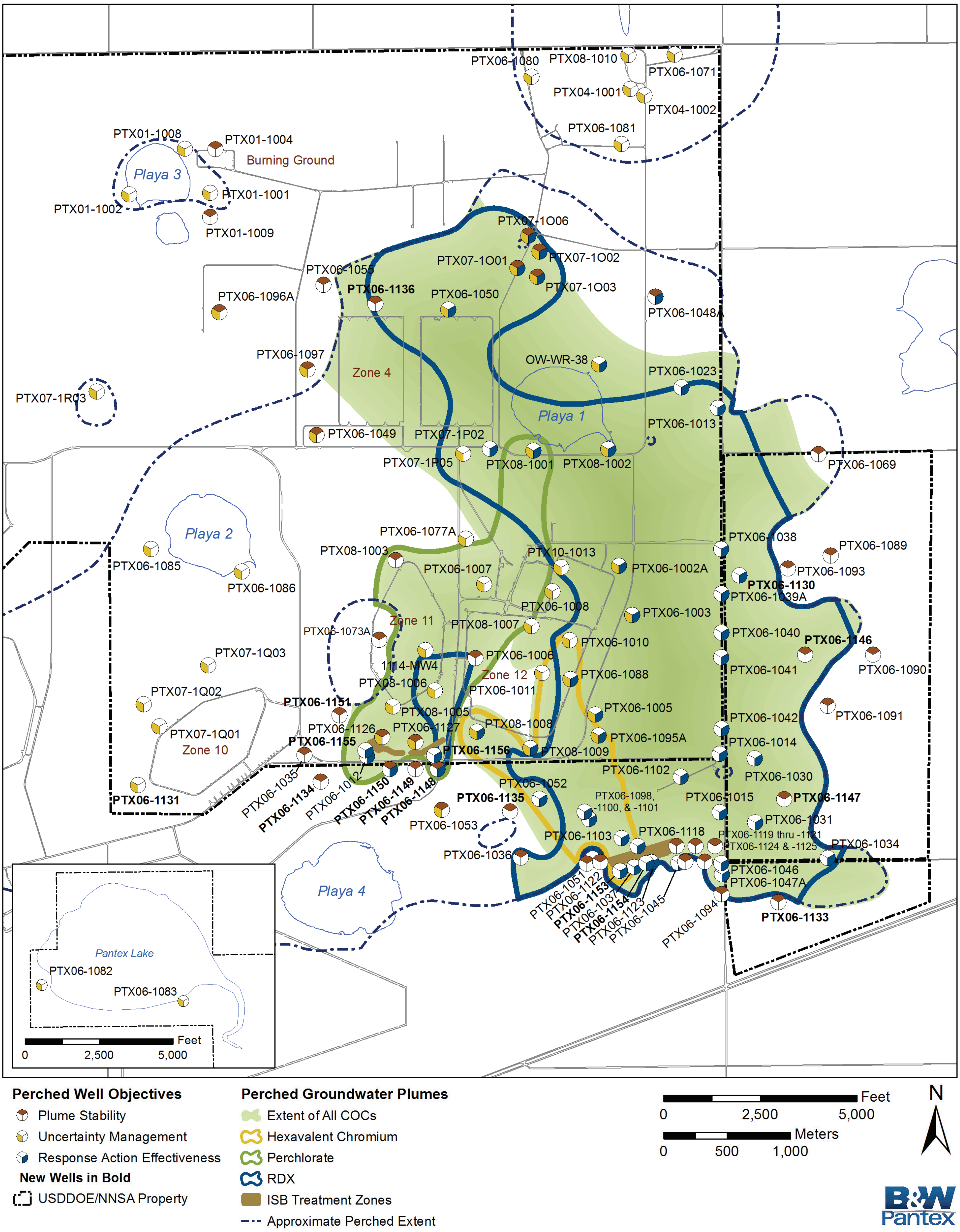

Figure 2-5. Perched Groundwater Long-Term Monitoring Network

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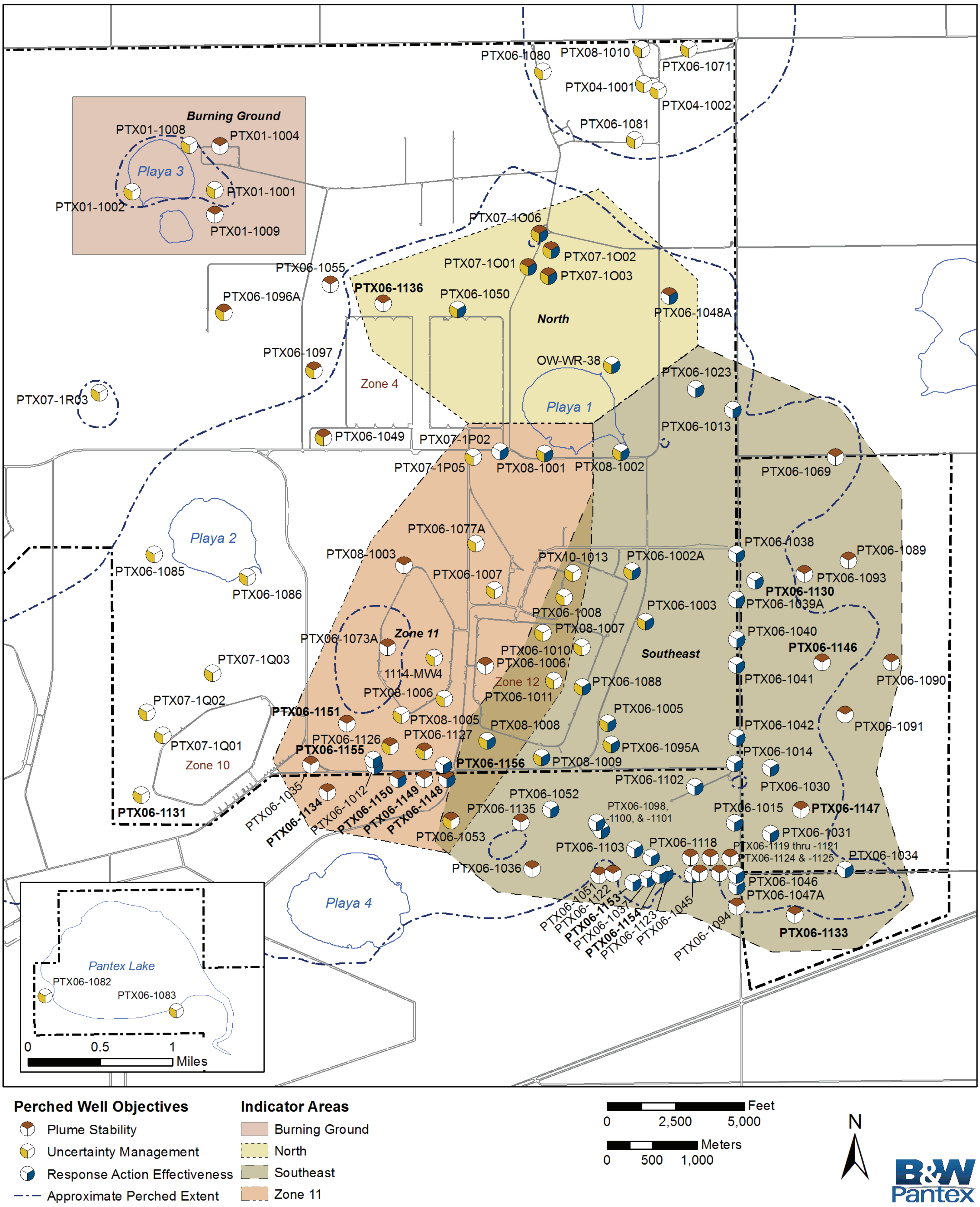

Indicator Constituents	Indicator Area				
	Burning Ground	Miscellaneous	North	Southeast	Zone 11
Primary List (Explosives, VOCs, Boron)	x	x	x	x	x
Chromium (Total & Hexavalent)				x	
1,4-Dioxane					x
Perchlorate	x				x

Primary Indicator Constituent List

High Explosives (12)

RDX	2-Amino-4,6-dinitrotoluene
MNX	4-Amino-2,6-dinitrotoluene
DNX	1,3-Dinitrobenzene
TNX	2,4-Dinitrotoluene
HMX	2,6-Dinitrotoluene
TNT	1,3,5-Trinitrobenzene

VOCs (7)

1,2-Dichloroethane
Chloroform
Tetrachloroethene (PCE)
Trichloroethene (TCE)
cis-1,2-Dichloroethene
trans-1,2-Dichloroethene
Vinyl Chloride

Metals (1)

Boron

Figure 2-6. Indicator Constituent Areas for Perched Groundwater

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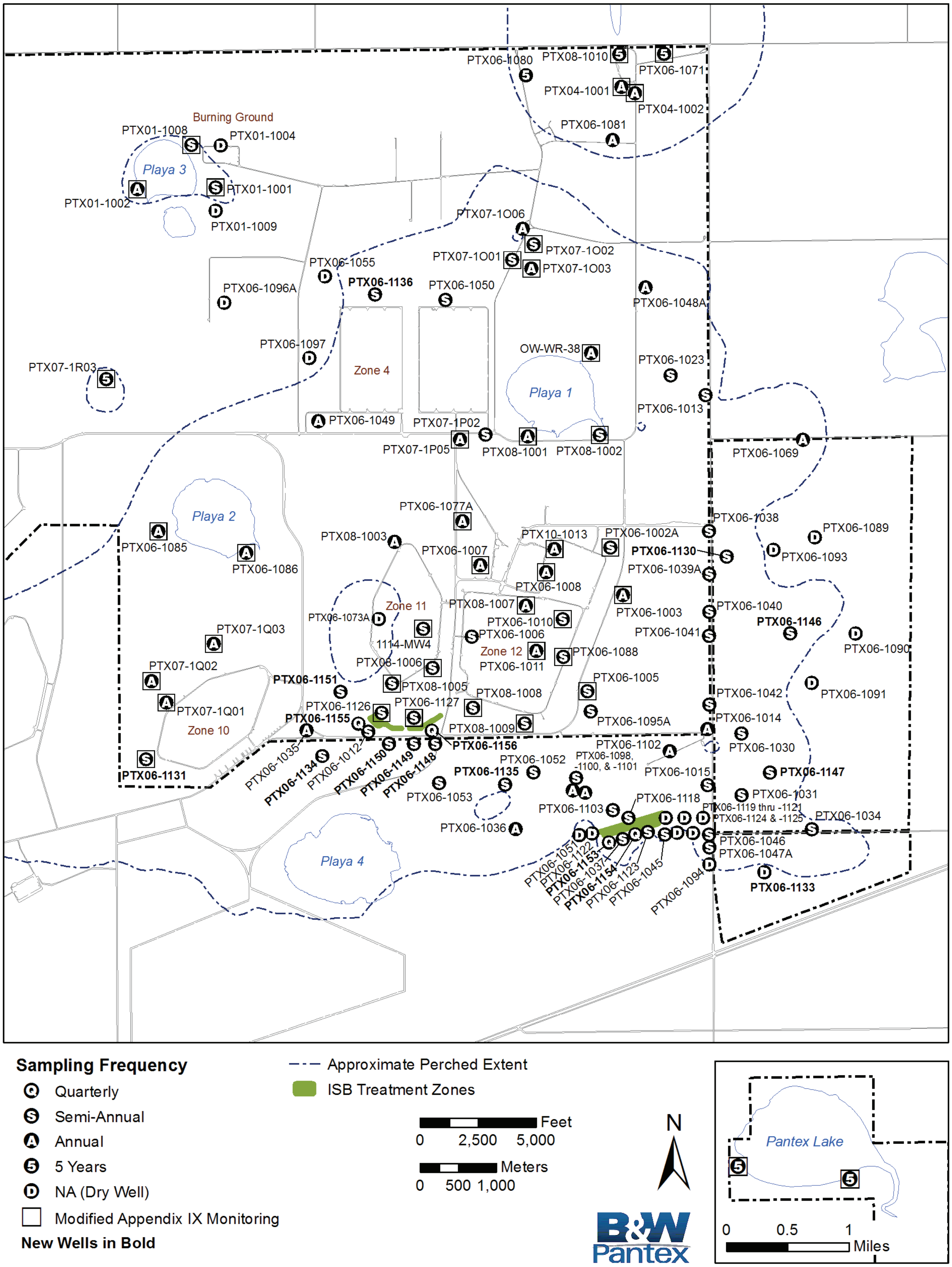

Figure 2-7. Sampling Frequency for Perched Groundwater

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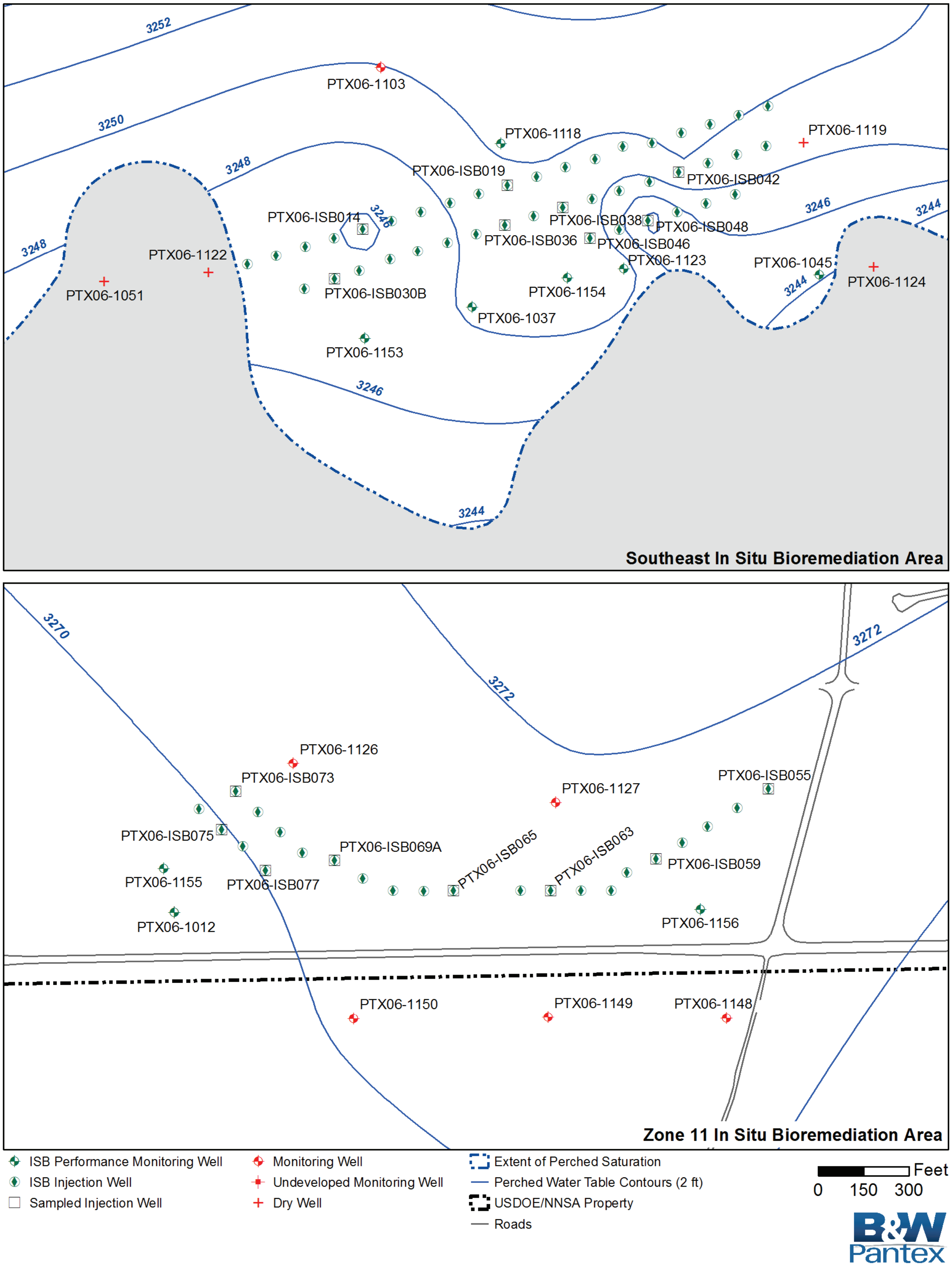

Figure 2-8. ISB Performance Monitoring Sampling Locations

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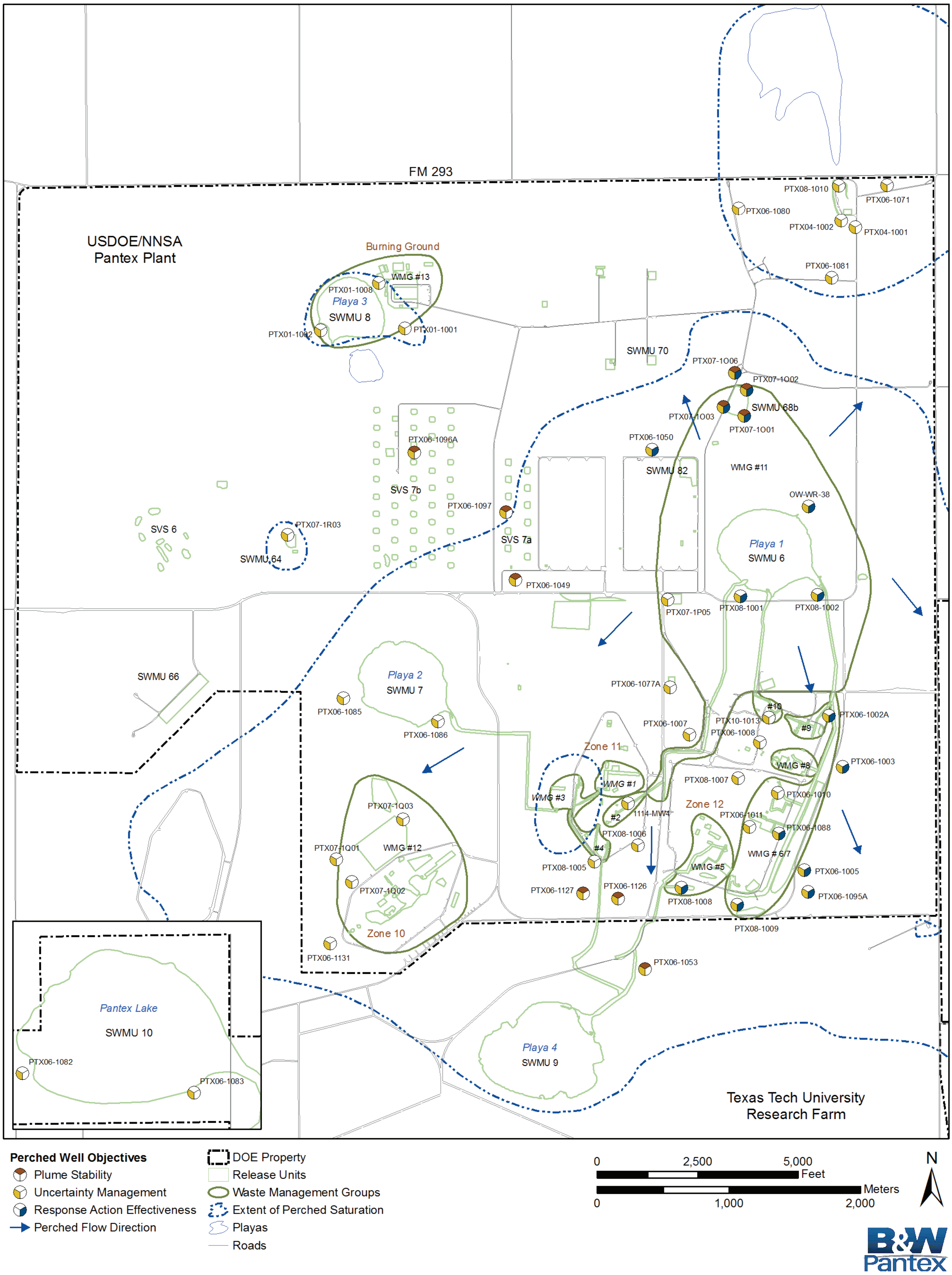

Figure 2-9. Monitoring of Soil Release Units for Perched Groundwater

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3. OGALLALA AQUIFER

This section describes the development of the LTM network for the Ogallala Aquifer beneath Pantex Plant. The general strategy used to develop the monitoring network is presented in Section 1.2. This strategy was adapted for the Ogallala Aquifer well network and comprised the following steps:

1. Develop monitoring objectives.
2. Use mathematical monitoring network optimization tools to optimize the spatial distribution of monitoring for early detection of potential impacts to the Ogallala Aquifer from perched groundwater.
3. Evaluate the existing well network with respect to each objective to identify areas where monitoring is needed.
4. Combine the results of the different evaluation methods to develop the final LTM network.

The monitoring objectives developed for the Ogallala Aquifer are early detection and uncertainty management. These objectives were described in Section 1.3.1. A summary of the monitoring network optimization is provided in Section 3.1, and the evaluation of the existing well network with respect to each objective is discussed in Section 3.2. The final LTM network is presented in Section 3.3.

3.1. SUMMARY OF MONITORING WELL PLACEMENT OPTIMIZATION

As part of the evaluation of the need for additional monitoring wells to be installed near Pantex Plant for early detection of potential groundwater impacts to the Ogallala Aquifer, an optimization tool was used to identify best locations for these new monitoring wells in the area east of FM 2373. This is the area where modeling predicted contaminants in perched groundwater might migrate to the Ogallala Aquifer (BWXT Pantex/SAIC, 2007). This assessment was performed independently by Mr. Larry Deschaine of Science Applications International Corporation (SAIC), using the Plumefinder technology developed by Dr. George Pinder at the University of Vermont Research Center for Groundwater Remediation Design. Mr. Deschaine made recommendations for the locations of 3 new Ogallala Aquifer monitoring wells using the Plumefinder technology and incorporating the results of previous modeling. The summary presented below was taken from the *Optimization of Monitoring Well Placement for Breakthrough Detection in the Ogallala Aquifer* report (SAIC, 2008), included in Appendix B.

3.1.1 Analysis Methods

This effort focused on the area east of FM 2373, downgradient of the area where modeling predicted contaminants in perched groundwater might migrate through the FGZ (BWXT Pantex/SAIC, 2007). Because of its widespread occurrence in perched groundwater and relatively high mobility, the high explosive compound RDX was modeled to determine the best locations for the wells. Although source strength and location are not directly measured, insight can be gleaned from the corrective measures study/feasibility study (CMS/FS) (BWXT Pantex/SAIC, 2007) modeling efforts.

The Ogallala Aquifer beneath the impacted perched groundwater is not accessible for investigation, because of the concern that drilling through perched groundwater may create pathways allowing the spread of contamination. As a result, irreducible uncertainty stemming from a lack of field data is present in the area of interest. The uncertainty specifically pertains to the hydraulic conductivity, potentiometric surface, and the elevation of the redbeds marking the base of the aquifer.

Modeling is combined with optimal estimation techniques to address this uncertainty. Specifically, geostatistical representations of the Ogallala Aquifer hydraulic conductivity fields are coupled with flow and transport simulations to determine the areas of greatest uncertainty in potential RDX plume location. This approach, known as the "PlumeFinder," is technology which integrates groundwater flow and transport simulation, geostatistical simulation, Monte Carlo simulation, and Kalman filter analysis to optimize monitoring well locations. In the analysis conducted, plume location (plume fringe) is defined as the 1 ppb isopleth contour for RDX and investigated over a 50-year simulation period. The areas of greatest uncertainty in the 1 ppb isopleth location then become candidates for new well locations, which in turn reduce the uncertainty in plume delineation by the maximum amount possible. To locate the leading edge of the RDX plume, both the retardation of RDX and potential biodegradation were ignored. This results in a conservative estimate (shortest travel time) to the fringe of the eastern perched groundwater while identifying the best location for early detection monitoring well placement. The actual travel time for RDX to migrate within the Ogallala Aquifer, if it occurs, is expected to be longer than simulated in this analysis.

3.1.2 Results

Delineation of potential future plumes can be improved by adding three new monitoring wells (PTX06-1137, PTX06-1138, and PTX06-1139) at locations determined using the PlumeFinder technology in combination with previous modeling results. These locations are shown in Figure 3-1. Installation of new wells, in concert with the existing Ogallala Aquifer monitoring wells, increases the certainty of early plume detection. A new well located using PlumeFinder reduces the maximum measure of uncertainty of plume delineation beyond the fringe of the perched aquifer by 72 percent. Two additional wells located beyond the eastern extent of perched groundwater provide early detection of potential contamination originating along the fringe of perched groundwater. Because most of the projected plume is beneath the perched aquifer, most of the uncertainty in its extent resides there. This demonstrates the contribution of irreducible uncertainty resulting from safe investigative practices, i.e., imposing the constraint that no wells be drilled through the perched groundwater to investigate a hypothetical plume.

3.2. EVALUATION OF EXISTING WELL NETWORK

The existing Ogallala Aquifer monitoring network was evaluated with respect to each objective to identify areas where additional monitoring is needed. This evaluation resulted in the proposed addition of four wells (PTX06-1140, PTX06-1141, PTX06-1143, and PTX06-1144) to the network in areas downgradient of perched contaminant plumes or soil release units to satisfy the early detection and uncertainty management monitoring objectives. The results of this evaluation are summarized in Table 3-1. These wells are identified on Figure 3-1.

A total of eight existing wells (PTX06-1059, PTX06-1060, PTX06-1063A, PTX06-1065, PTX06-1066, PTX06-1067, PTX06-1074, and PTX06-1075) were proposed for removal from the network because they either do not satisfy any of the monitoring objectives or will be replaced by one of the proposed new wells.

Four of these wells (PTX06-1063A, PTX06-1065, PTX06-1066, and PTX06-1067) are located north of the northern boundary of USDOE/NNSA property (Pantex Plant). Justification for removing these wells from the monitoring network is two-fold. First, removal eliminates ingress/egress (i.e., Access Agreements) with neighboring landowners. Second, Ogallala monitoring wells currently exist onsite along the northern boundary and, with one additional well (PTX06-1144) discussed above, will satisfy the LTM objectives. Removal of the four wells from the monitoring network decreases the number of samples but does not compromise the capability of the network. The following discussion addresses each offsite well and the justification for removal from the monitoring network.

- PTX06-1063A is located approximately 2,100 ft north of the USDOE boundary, immediately adjacent to the City of Amarillo well #623. Samples cannot be collected from PTX06-1063A while #623 is pumping because of the cone of depression caused by the production well. Well PTX06-1144 is proposed as a replacement for this well.

- PTX06-1065 is located about 2,600 ft north of the USDOE boundary, far enough from any release units that information from this well is of limited use. Other wells onsite (PTX01-1010, PTX01-1011, PTX01-1012, PTX01-1013, and PTX01-1062A) lie upgradient of this well and provide the necessary monitoring information to satisfy the monitoring objectives.

- PTX06-1066 is located immediately downgradient (about 230 ft) of existing onsite well PTX01-1012 and is therefore redundant.

- PTX06-1067 does not provide useful information regarding potential contamination sources at Pantex because it is near the northwest corner of the USDOE boundary and is not downgradient of any soil release units or impacted perched groundwater.

The other four wells (PTX06-1059, PTX06-1060, PTX06-1074, and PTX06-1075) proposed for elimination from the network are located along the western or southwestern boundaries of the USDOE/NNSA property upgradient of any soil release units or impacted perched groundwater associated with Pantex Plant. Therefore, these wells do not satisfy any of the monitoring objectives. These wells will be retained for monitoring of upgradient water quality in the Ogallala Aquifer.

3.3. LONG-TERM MONITORING NETWORK FOR THE OGALLALA AQUIFER

The recommendations from the PlumeFinder analysis were combined with the results of the evaluation against monitoring objectives to develop the final proposed well network shown in Figure 3-1 and 3-2 for each monitoring area. The proposed network includes 19 existing wells and seven new wells. In addition, four upgradient wells located along the southern and western boundaries of Pantex Plant will be retained for upgradient boundary monitoring, but are not included in the LTM network. The frequency of sampling for the Ogallala LTM network is provided in Table 3-2 and is depicted in Figure 3-3.

3.3.1 Final Network Recommendations

Table 3-2 provides a complete list of all wells in the proposed long-term monitoring network for the Ogallala Aquifer along with the LTM objectives, evaluation metrics, and proposed sampling frequency of each well. The LTM network is depicted in Figure 3-1.

- The final recommended network for the Ogallala Aquifer includes 26 monitoring locations, with 48 groundwater samples analyzed annually.

- Semiannual sampling is recommended for 22 locations. Annual sampling is recommended at 4 locations.

- All wells will be sampled for indicator constituents as shown in Figure 3-2 based on COCs and degradation products in overlying or upgradient perched groundwater.

- Because the definition of uncertainty management wells is different for the Ogallala, only a small subset of uncertainty management wells was identified for monitoring of soil release units.

- A larger list of constituents (Modified Appendix IX list as presented in the Sampling and Analysis Plan) is recommended to be monitored every five years in 9 uncertainty management wells near soil source areas.

A table listing all wells and their coordinates (northings and eastings) is included in Appendix B.

3.3.2 Monitoring of Soil Release Units

TCEQ and EPA conditionally approved the investigations of soil release units with a requirement for LTM downgradient of release units to address uncertainties regarding the vertical extent of constituents. For purposes of monitoring the soil release units, the units were grouped by Zone or Waste Management Group and downgradient wells were identified in the first groundwater encountered. Because the first groundwater encountered beneath the most of the soil units is the perched groundwater, there are fewer Ogallala uncertainty wells to be monitored at source areas for the modified Appendix IX list (see Table 3-2 and Figure 3-3 for wells proposed for the 5-year modified Appendix IX monitoring). The Ogallala wells proposed for soil uncertainty management adequately address units outside of the perched groundwater footprint. There are few Ogallala wells on the western side of Pantex. Landfill areas to the west have adequate cover material and results of investigations indicate that soil contamination is limited, so downward migration of soil contaminants is unlikely. Downgradient Ogallala wells will be used to monitor for landfill units to the west.

Soil release units and monitoring wells are shown in Figure 3-4. A listing of the soil release units and the associated downgradient monitoring wells is provided in Table 3-3.

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

Well Identifier	Location	Purpose
PTX06-1137 PTX06-1138 PTX06-1139	East of FM 2373	Provide early detection monitoring downgradient of the southeast perched groundwater plume as recommended in the PlumeFinder analysis.
PTX06-1140	East of FM 2373	Provide early detection monitoring downgradient of the southeast perched groundwater plume, supplement to the three wells recommended in the PlumeFinder analysis.
PTX06-1141	Northwest of Zone 4	Monitor downgradient of several soil release units on the western side of Pantex Plant and adjacent to the northwestern extent of perched groundwater.
PTX06-1143	Near the northern extent of perched groundwater north of Playa 1	Monitor downgradient of the impacted perched groundwater northwest of Playa 1 and downgradient of soil release units.
PTX06-1144	Northern Pantex property boundary	Monitor downgradient of the firing sites and several other soil release units.

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Table 3-2. Proposed Long-Term Monitoring Network for the Ogallala Aquifer

Indicator Area[1]	Well ID[2]	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List[3] Monitoring Frequency	Multiple Sampling Depth Frequency[4]	Appendix IX Monitoring List[5]	Appendix IX Monitoring Frequency[6]
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	N	5 Yrs
Northwest	PTX06-1068	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
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	I, 5-Yr	Y	5 Yrs
Northwest	PTX06-1143	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	Y	5 Yrs
Northwest	PTX06-1144	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 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	PTX06-1032	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1056	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1137	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast	PTX06-1138	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast	PTX06-1139	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast	PTX06-1140	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 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 Monitor wells on the west/southwest boundary are not listed here but are depicted in Figures 3-1 and 3-2. These wells do not support the LTM objective but they are used to monitor upgradient water quality.
3 Refer to the Pantex Sampling and Analysis Plan (B&W Pantex, September 2008) or the Corrective Action Compliance Plan Table IIIA for the indicator monitoring lists.
4 The new wells that will be completed with blanks between the screened intervals were selected for this sampling because the intervals could be isolated during sampling. These wells will be sampled initially, before the pumps are installed. Pumps will be removed and sampling will be conducted to correspond to the 5-year sampling event for the 5-Year Review under CERCLA and the Compliance Plan. These samples will be analyzed for the indicator list of constituents.
5 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 Pantex Sampling and Analysis Plan (B&W Pantex, September 2008).
6 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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Table 3-3. Monitoring of Soil Release Units for the Ogallala Aquifer

Grouping	Release Units	Ogallala Wells
Burning Ground		
WMG 13	SWMU 8: Playa 3 SWMU 14-24: Burning Ground-Explosive Burn Pads SWMU 25: Burning Ground-Explosive Burn Pad 11 SWMU 26: Burning Ground-Explosive Burn Pad 12 SWMU 27 Burning Ground-Explosive Burn Pad 13 SWMU 37: Burning Ground-Landfill 1 SWMU 38: Burning Ground-Landfill 2 SWMU 39: Burning Ground-Landfill 3 SWMU 40: Burning Ground-Landfill 4 SWMU 41: Burning Ground-Landfill 5 SWMU 42: Burning Ground-Landfill 6 SWMU 43: Burning Ground-Landfill 7 SWMU 44: Burning Ground-Landfill 8 SWMU 45: Explosive Burn Cage SWMU 46: Explosive Burn Cage SWMU 47: Burning Ground-Evaporation Pit SWMU 48: Burning Ground Solvent Evaporation Pans SWMU 49: Burning Ground Solvent Evaporation Pans SWMU 50: Burning Ground Solvent Evaporation Pans SWMU 51: Burning Ground Solvent Evaporation Pans SWMU 52: Burn Racks and Flashing Pits Unassigned Burning Ground-Explosive Burn Pad 16 Unassigned: Demonstration Facilities	PTX01-1010 PTX01-1011 PTX06-1062A
WMG 3	AOC 7a: Sulfuric Acid Spills (11-36) AOC 8d: Solvent Leaks (Pad 11-22) AOC 8e: Solvent Leaks (Bldg 11-36) SWMU 5/08: Drainage Ditch 11-36 SWMU 113: Overflows From 11-36 Collection System/Sump Unassigned Former Leaching Bed N of Bldg 11-50 & W of Bldg 11-36	PTX06-1072
Other Units		
N/A	SWMU 64: Landfill 13	PTX07-1R01
N/A	SWMU 66: Landfill 15 Demolition Debris Landfill	PTX06-1058
N/A	SWMU 70: Firing Site 5	PTX06-1143
N/A	SVS 6: Unnumbered Zone 7 Landfills Demolition Debris Landfills	PTX06-1057A
N/A	SVS 7a and 7b: Igloo Demolition Debris Landfills Zone 4 (SVS 7a) and Zone 5 (SVS 7b)	PTX06-1141

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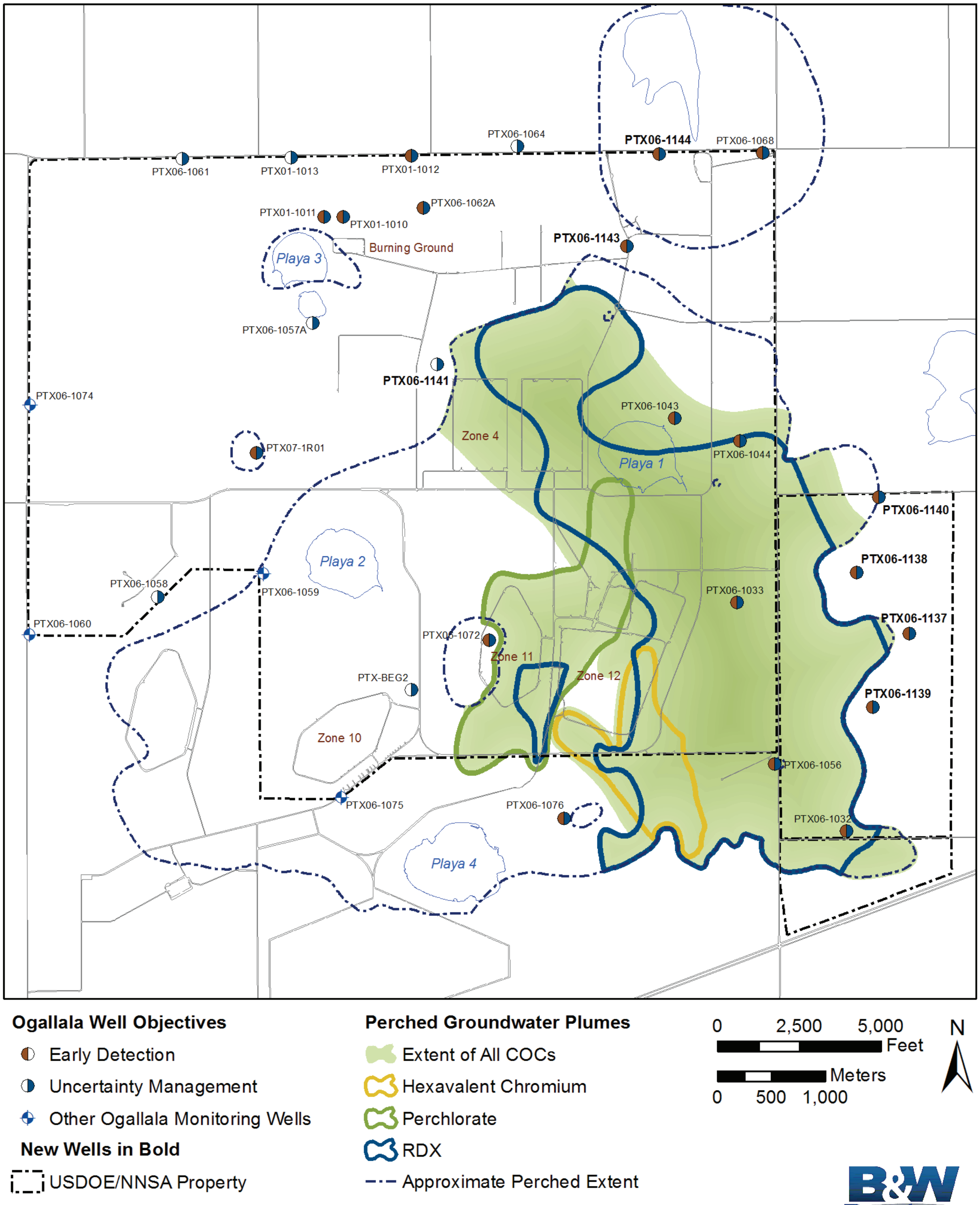

B&W Pantex

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

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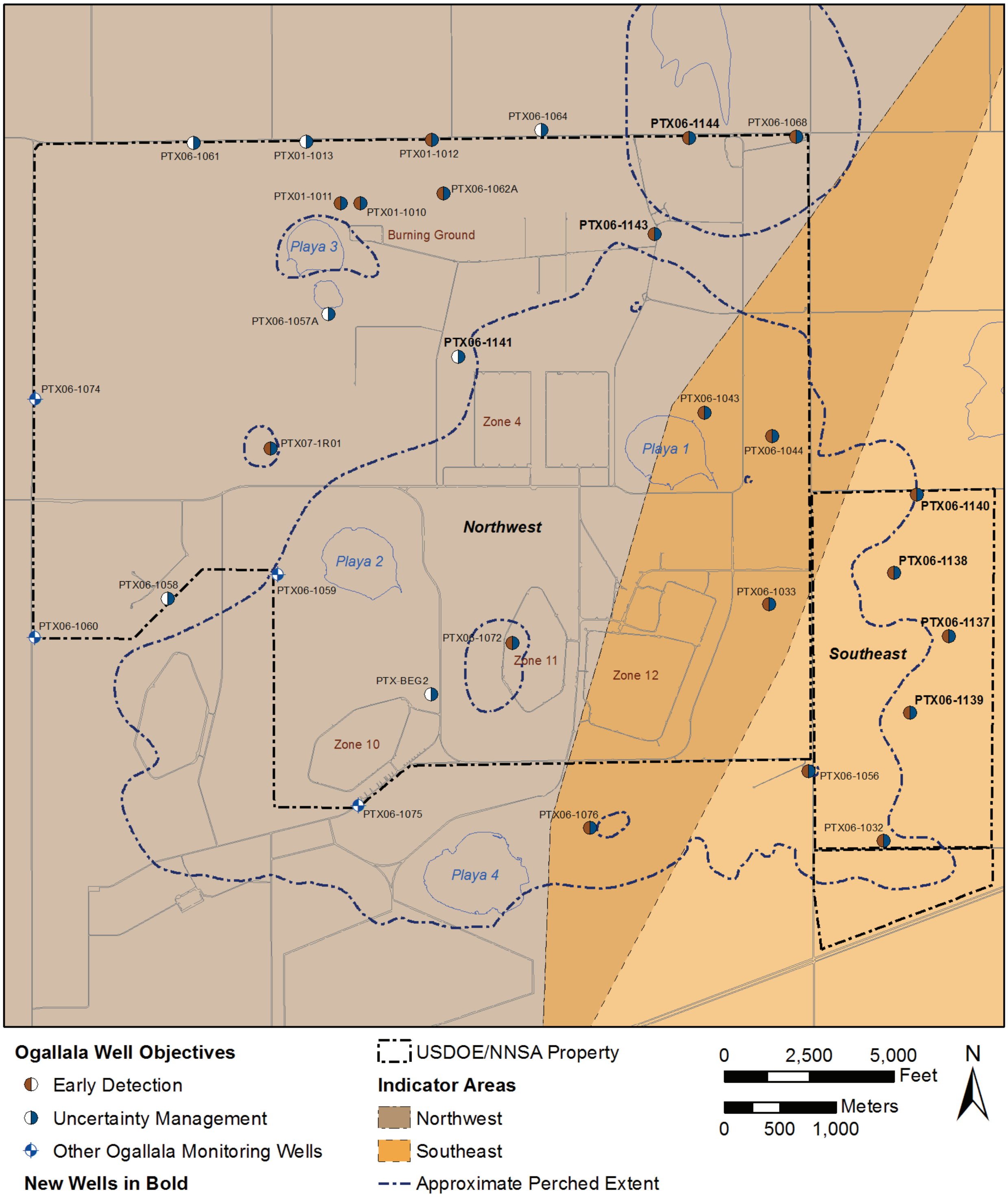

Indicator Constituents	Indicator Area	
	Southeast	Northwest
Primary List (Explosives, VOCs, Boron)	x	x
Chromium (Total & Hexavalent)	x	
Perchlorate		x

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

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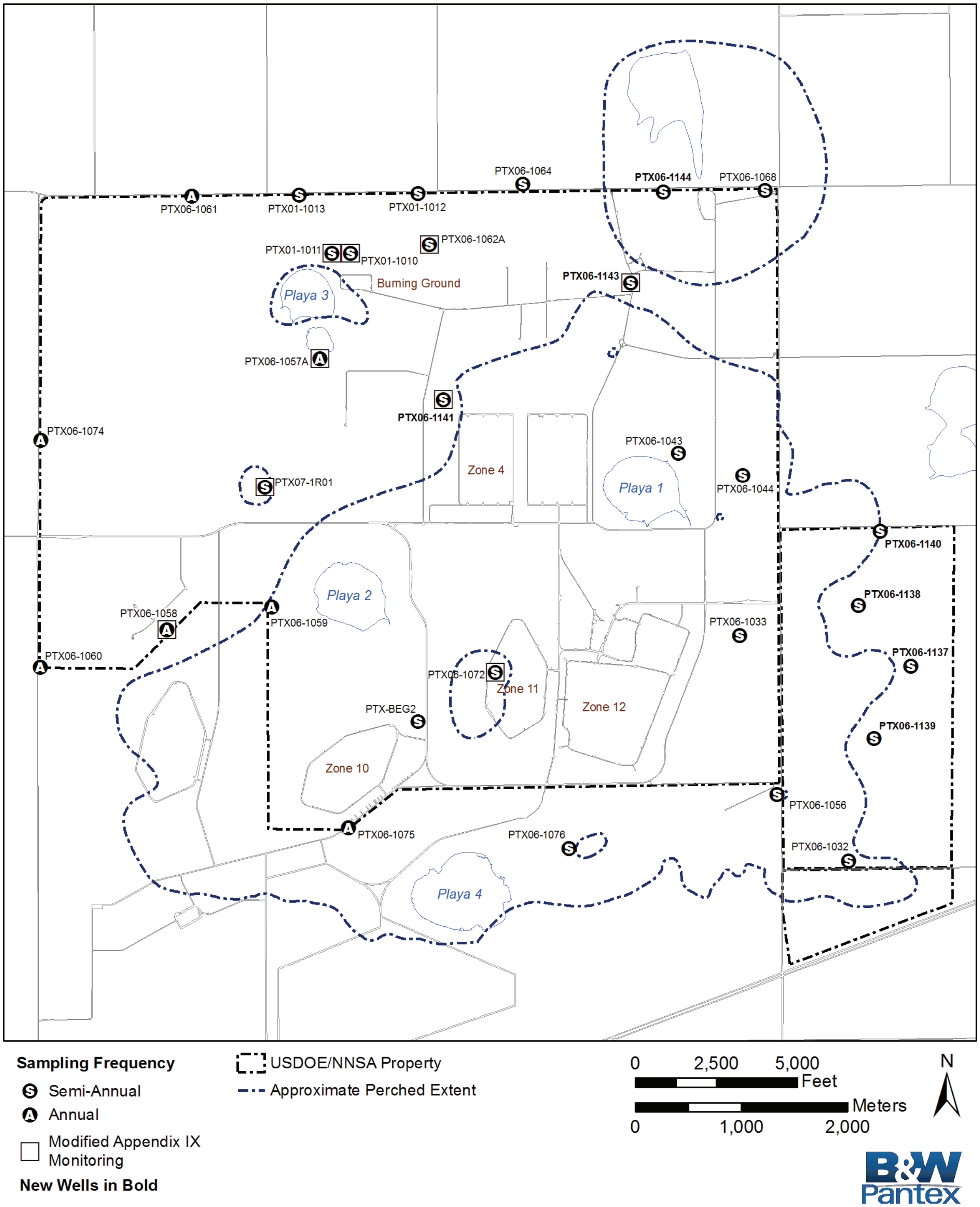

Figure 3-3. Ogallala LTM Network Sampling Frequency

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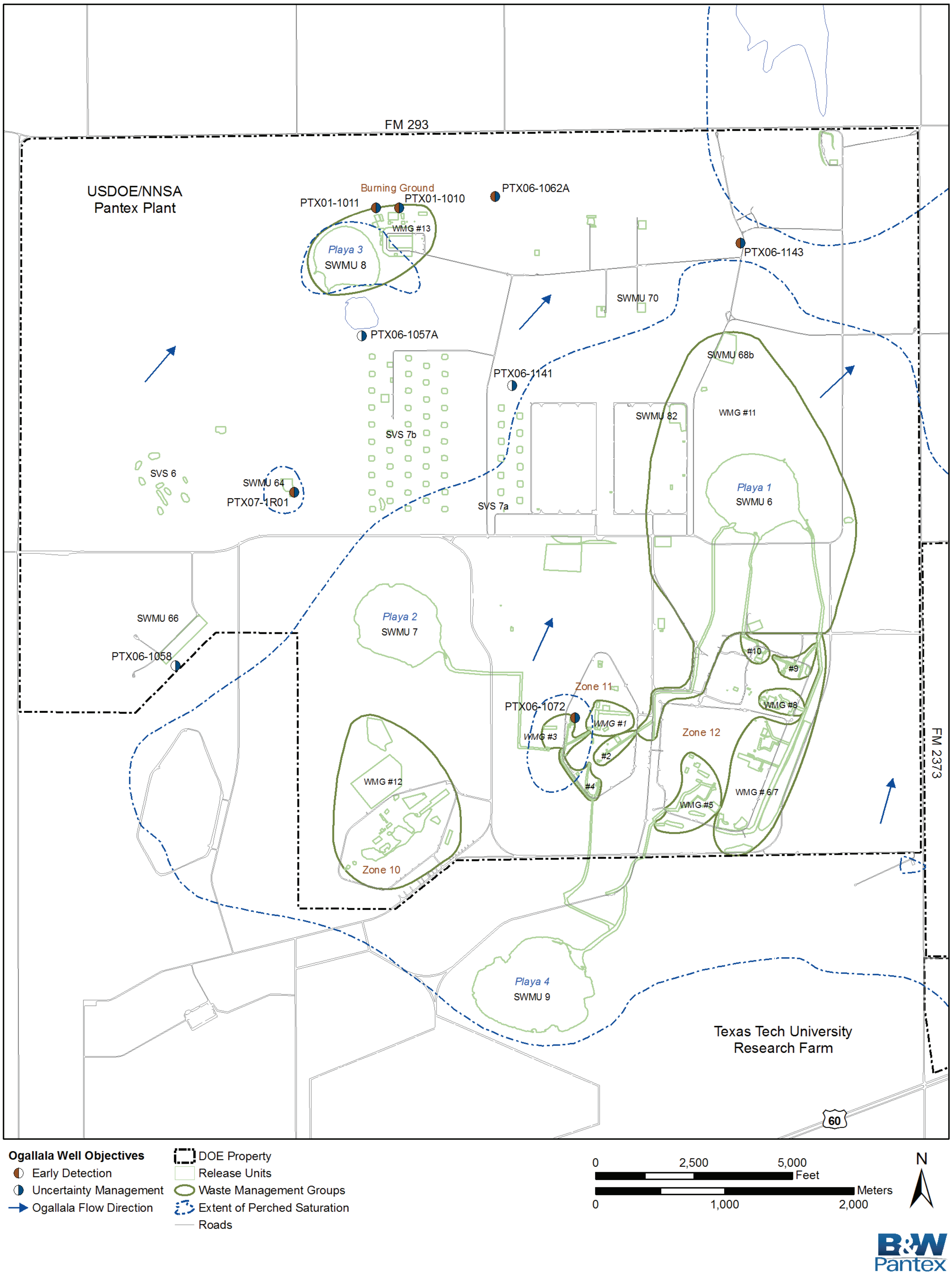

Figure 3-4. Monitoring of RRS 3 Soil Release Units for the Ogallala Aquifer

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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—the wells will be screened across the entire perched saturated interval. This construction allows for better monitoring of declining perched groundwater levels as the response action process is implemented to remove the water and beneficially use it, instead of injecting it back into the perched zone. A modified Attachment B Well Specification sheet is included in Appendix E to this report. Well completion and lithologic logs for existing perched wells that will be part of the LTM Network are presented in Appendix F.

4.2. PERCHED SAMPLE INTAKE PLACEMENT

Table 4-1 provides the sample intake placement for perched monitoring wells. This placement corresponds to the sampling depth in the well. Most of the wells that comprise the LTM Network have already been installed, so the sample intake levels listed reflect the actual current placement. Recommendations for sample intake placement are also included for new 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 feet of saturated thickness.

4.3. OGALLALA WELL CONSTRUCTION AND SCREENED INTERVALS

Most Ogallala Aquifer wells were previously installed as part of the investigation and are screened across the entire saturated thickness. Construction completion and lithologic logs for the existing Ogallala Aquifer monitoring wells that will be part of the LTM Network are provided in Appendix F. Some of these wells, PTX01-1012, PTX06-1044, PTX06-1056, and, PTX06-1068 were evaluated by the USGS in July and August 2008 to determine if different lithologies intercepted by the screens are more transmissive than others, resulting in intervals of preferential flow. Results of the USGS flow study, presented in Appendix B, indicate that more transmissive zones generally occur within the lower depths of the aquifer from Playa 1 to the south. Therefore, the screened intervals for the new wells will intercept the entire saturated interval. The uppermost part of the aquifer will be sampled in areas close to a potential source of contaminants and the deeper part of the aquifer will be the target for wells intended to monitor for contaminants at a point distal to a potential source.

All new Ogallala Aquifer monitoring wells will 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.

The modified Attachment B Well Specifications and proposed well screen construction for each of the new Ogallala Aquifer monitoring wells are presented in Appendix E.

A field geologist will record the lithology observed during drilling, and geophysical logs will be recorded in each fluid-filled borehole immediately after reaching total depth. Geophysical logging will consist of spontaneous potential, natural gamma, and resistivity (16 inch and 64 inch). The field geologist will interpret these logs to determine final adjustments to construction of the screens for monitoring of transmissive zones within the aquifer. Upper screen segments and blank casing sections may also be adjusted based on interpretation of the field information. Deeper screen segments will be constructed to intercept the most transmissive zones while blocking off major clay and silt-containing units with blank casing sections. The screen construction decision process is described in greater detail in Appendix F.

4.4. OGALLALA SAMPLE INTAKE PLACEMENT

Table 4-2 provides the proposed sample intake placement for Ogallala Aquifer monitoring wells. This placement corresponds to the sampling depth in the well. Most of the wells that comprise the LTM Network have already been installed, so the sample intake levels reflect the actual current placement. Some sample intake placements have been adjusted based on the results of the USGS flow study and correlation to lithologic descriptions acquired during drilling of each existing well. Recommendations for sample intake placement are also included for the proposed new wells, but may be adjusted after the acquiring lithologic descriptions and geophysical logs. 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).

Initial sampling in the new Ogallala Aquifer wells will be conducted at multiple depths using procedures described in the *Sampling and Analysis Plan*. Dedicated sample pumps will then be installed in the wells at the proposed sample intake depth. Routine samples at the proposed frequency for indicator constituents will be obtained from this depth. At the 5-year sampling event, the dedicated sample pumps will be removed and samples will be obtained from multiple depths in the new wells.

Table 4-1. Sample Intake Information for Perched Groundwater Wells

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	3276.83	3264.4	12.4	18.4	3258.5
OW-WR-38	Active	3302.99	3293.0	10.0	15.0	3288.0
PTX01-1001	Active	3277.87	3270.3	7.6	7.8	3270.1
PTX01-1002	Active	3294.95	3286.2	8.7	11.5	3283.5
PTX01-1008	Undeveloped	3292.91	3289.2	3.7	5.2	3287.7
PTX04-1001	Active	3305.72	3295.4	10.4	18.5	3287.3
PTX04-1002	Active	3305.48	3300.1	5.4	18.6	3286.8
PTX06-1002A	Active	3286.20	3276.1	10.1	17.8	3268.4
PTX06-1003	Active	3279.58	3275.1	4.5	6.7	3272.9
PTX06-1005	Active	3263.93	3247.2	16.7	21.1	3242.8
PTX06-1006	Active	3276.56	3258.6	17.9	25.9	3250.7
PTX06-1007	Active	3280.18	3275.7	4.5	25.7	3254.5
PTX06-1008	Active	3282.70	3280.8	1.9	11.9	3270.8
PTX06-1010	Active	3284.67	3267.4	17.3	22.4	3262.2
PTX06-1011	Active	3272.43	3259.5	12.9	21.8	3250.6
PTX06-1012	Active	3268.88	3257.4	11.5	14.4	3254.5
PTX06-1013	Active	3295.07	3289.4	5.7	10.7	3284.4
PTX06-1014	Active	3258.71	3253.5	5.2	9.1	3249.6
PTX06-1015	Active	3246.26	3243.8	2.4	4.6	3241.6
PTX06-1023	Active	3298.47	3296.1	2.4	8.5	3290.0
PTX06-1030	Active	3252.32	3245.3	7.0	7.1	3245.2
PTX06-1031	Active	3247.12	3240.1	7.0	7.3	3239.8
PTX06-1034	Active	3242.56	3238.1	4.5	8.0	3234.5
PTX06-1035	Active	3267.11	3259.3	7.8	12.8	3254.3
PTX06-1036	Active	3251.64	3250.6	1.0	1.5	3250.1
PTX06-1037	Undeveloped	3248.36	3246.3	2.0	2.5	3245.9
PTX06-1038	Active	3279.68	3277.9	1.8	20.9	3258.8
PTX06-1039A	Active	3274.52	3268.2	6.3	14.4	3260.1
PTX06-1040	Active	3270.87	3264.8	6.0	18.3	3252.6

Table 4-1. Sample Intake Information for Perched Groundwater Wells (continued)

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)
PTX06-1041	Active	3270.38	3254.5	15.9	33.2	3237.2
PTX06-1042	Active	3261.37	3256.3	5.1	11.8	3249.6
PTX06-1045	Undeveloped	3244.16	3243.8	0.4	1.2	3242.9
PTX06-1046	Active	3245.65	3236.7	9.0	14.5	3231.2
PTX06-1047A	Active	3247.30	3243.0	4.3	7.7	3239.6
PTX06-1048A	Active	3304.53	3300.4	4.1	7.9	3296.7
PTX06-1049	Active	3281.83	3259.3	22.5	38.6	3243.3
PTX06-1050	Active	3299.70	3282.2	17.5	34.9	3264.8
PTX06-1052	Active	3262.27	3254.6	7.6	16.0	3246.3
PTX06-1053	Active	3271.13	3267.8	3.4	9.0	3262.1
PTX06-1069	Active	3278.42	3275.4	3.1	5.1	3273.4
PTX06-1071	Active	3305.45	3288.9	16.5	38.1	3267.4
PTX06-1077A	Active	3282.73	No Dedicated Pump[3]	NA	10.0	3272.7
PTX06-1080	Active	3268.29	3264.0	4.3	18.4	3249.9
PTX06-1081	Active	3303.73	3301.2	2.6	17.5	3286.3
PTX06-1082	Active	3294.27	3289.3	5.0	6.6	3287.6
PTX06-1083	Active	3291.63	3277.9	13.7	21.0	3270.6
PTX06-1085	Active	3268.71	3253.3	15.4	23.7	3245.0
PTX06-1086	Active	3270.36	3232.5	37.9	46.1	3224.3
PTX06-1088	Active	3271.94	3259.1	12.8	26.1	3245.8
PTX06-1095A	Active	3263.09	3258.8	4.3	18.8	3244.3
PTX06-1098	Active	3257.07	No Dedicated Pump[3]	NA	17.6	3239.5
PTX06-1100	Active	3256.57	No Dedicated Pump[3]	NA	13.8	3242.8
PTX06-1101	Active	3256.42	No Dedicated Pump[3]	NA	14.6	3241.9
PTX06-1102	Undeveloped	3254.13	3249.7	4.5	7.6	3246.6
PTX06-1103	Active	3249.56	No Dedicated Pump[3]	NA	21.6	3227.9
PTX06-1118	Undeveloped	3250.39	No Dedicated Pump[3]	NA	1.6	3248.8
PTX06-1120	Undeveloped	3248.49	No Dedicated Pump[3]	NA	5.5	3243.0
PTX06-1121	Undeveloped	3247.71	No Dedicated Pump[3]	NA	2.8	3244.9

Table 4-1. Sample Intake Information for Perched Groundwater Wells (continued)

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)
PTX06-1123	Undeveloped	3248.85	No Dedicated Pump[3]	NA	1.8	3247.0
PTX06-1126	Active	3270.92	3262.9	8.1	20.4	3250.6
PTX06-1127	Active	3271.85	3265.1	6.7	25.2	3246.6
PTX07-1O01	Active	3297.14	3296.1	1.1	5.0	3292.1
PTX07-1O02	Active	3297.87	3290.9	7.0	7.2	3290.7
PTX07-1O03	Active	3300.17	3297.4	2.8	9.4	3290.8
PTX07-1O06	Undeveloped	3289.66	3288.2	1.5	1.7	3288.0
PTX07-1P02	Active	3298.52	3283.9	14.6	17.0	3281.5
PTX07-1P05	Active	3296.66	3294.6	2.1	3.9	3292.8
PTX07-1Q01	Active	3265.47	3250.8	14.7	17.5	3248.0
PTX07-1Q02	Active	3265.20	3248.7	16.5	29.3	3235.9
PTX07-1Q03	Active	3267.91	3260.5	7.4	41.5	3226.4
PTX07-1R03	Undeveloped	3318.45	3316.0	2.5	5.0	3313.5
PTX08-1001	Active	3298.16	3291.2	7.0	9.6	3288.5
PTX08-1002	Active	3296.38	3293.2	3.1	10.1	3286.2
PTX08-1003	Active	3276.72	3262.6	14.2	24.4	3252.3
PTX08-1005	Active	3272.09	3259.1	13.0	14.6	3257.5
PTX08-1006	Active	3273.77	3269.3	4.5	34.7	3239.0
PTX08-1007	Active	3277.98	3264.2	13.8	22.9	3255.1
PTX08-1008	Active	3269.30	3263.6	5.8	24.1	3245.2
PTX08-1009	Active	3265.24	3253.6	11.7	17.7	3247.6
PTX08-1010	Active	3305.92	3304.6	1.4	21.9	3284.0
PTX10-1013	Active	3289.85	3276.0	13.8	17.9	3271.9
PTX06-1130	Proposed	3275.25	To Be Determined	~5	18.3	3257.0
PTX06-1131	Proposed	3263.43	To Be Determined	< 5	5.9	3257.5
PTX06-1133A	Proposed	Dry	No Dedicated Pump	NA	0	3239.8
PTX06-1134	Proposed	3267.47	To Be Determined	~5	8.2	3259.2
PTX06-1135	Proposed	3262.22	To Be Determined	< 5	2.5	3259.7
PTX06-1136	Proposed	3290.36	To Be Determined	~5	14.9	3275.5

Table 4-1. Sample Intake Information for Perched Groundwater Wells(continued)

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)
PTX06-1146	Proposed	3263.53	To Be Determined	~5	21.3	3242.2
PTX06-1147	Proposed	3246.70	To Be Determined	~5	15.9	3230.8
PTX06-1148	Proposed	3270.76	To Be Determined	~5	16.5	3254.3
PTX06-1149	Proposed	3270.82	To Be Determined	~5	16.2	3254.6
PTX06-1150	Proposed	3270.26	To Be Determined	~5	11.2	3259.1
PTX06-1151	Proposed	3268.69	To Be Determined	~5	16.2	3252.5
PTX06-1153	Proposed[4]		To Be Determined	~5		
PTX06-1154	Proposed[4]		To Be Determined	~5		
PTX06-1155	Proposed[4]		To Be Determined	~5		
PTX06-1156	Proposed[4]		To Be Determined	~5		
PTX01-1004	Dry	Dry	No Dedicated Pump	NA	0	3298.2
PTX01-1009	Dry	Dry	No Dedicated Pump	NA	0	3280.5
PTX06-1051	Dry	Dry	No Dedicated Pump	NA	0	3239.7
PTX06-1055	Dry	Dry	No Dedicated Pump	NA	0	3273.4
PTX06-1073A	Dry	Dry	No Dedicated Pump	NA	0	3274.1
PTX06-1089	Dry	Dry	No Dedicated Pump	NA	0	3263.1
PTX06-1090	Dry	Dry	No Dedicated Pump	NA	0	3254.8
PTX06-1091	Dry	Dry	No Dedicated Pump	NA	0	3261.2
PTX06-1093	Dry	Dry	No Dedicated Pump	NA	0	3274.4
PTX06-1094	Dry	Dry	No Dedicated Pump	NA	0	3243.5
PTX06-1096A	Dry	Dry	No Dedicated Pump	NA	0	3301.1
PTX06-1097	Dry	Dry	No Dedicated Pump	NA	0	3267.0
PTX06-1119	Dry	Dry	No Dedicated Pump	NA	0	3249.8
PTX06-1122	Dry	Dry	No Dedicated Pump	NA	0	3249.8
PTX06-1124	Dry	Dry	No Dedicated Pump	NA	0	3244.0
PTX06-1125	Dry	Dry	No Dedicated Pump	NA	0	3243.8

[1]Based on December 2008 measurements for most wells.
[2]Saturated thickness above the bottom of the well screen.
[3]No dedicated sample pumps have been installed in these wells because the wells have not been routinely sampled or because the well has low yield or limited saturated thickness. Dedicated sample pumps may be installed in one or more of these wells in the future.
[4]These wells have not been drilled as of the date of this report; no additional information is available.

Table 4-2. Sample Intake Information for Ogallala Aquifer Wells

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)
PTX01-1010	Active	3087.79	3081.2	6.6	358.8	2729.0
PTX01-1011	Active	3090.10	3019.1	71.0	307.3	2782.8
PTX01-1012	Active	3074.81	3067.7	7.1	397.8	2677.1
PTX01-1013	Active	3089.17	3011.4	77.8	372.1	2717.0
PTX06-1032	Active	3134.20	3102.0	32.2	36.9	3097.3
PTX06-1033	Active	3097.41	3084.5	12.9	105.1	2992.3
PTX06-1043	Active	3081.77	2910.1	171.7	188.7	2893.1
PTX06-1044	Active	3059.93	3045.5	14.5	133.8	2926.1
PTX06-1056	Active	3137.48	3126.8	10.7	76.8	3060.7
PTX06-1057A	Active	3105.99	To Be Determined	~20	296.6	2809.4
PTX06-1058	Active	3168.25	To Be Determined	~20	131.3	3037.0
PTX06-1061	Active	3100.40	3091.9	8.5	371.8	2728.6
PTX06-1062A	Active	3077.25	3068.8	8.5	395.5	2681.8
PTX06-1064	Active	3059.57	3053.2	6.4	289.3	2770.2
PTX06-1068	Active	3024.11	3004.1	20.0	289.2	2734.9
PTX06-1072	Active	3137.26	3127.2	10.1	132.9	3004.4
PTX06-1076	Active	3179.95	3170.3	9.6	14.3	3165.7
PTX07-1R01	Active	3125.31	To Be Determined	~20	151.0	2974.3
PTX-BEG2	Active	3156.99	3148.7	8.3	33.3	3123.7
PTX06-1137A	Proposed[3]	3066.04	To Be Determined	~15		
PTX06-1138	Proposed[3]	3076.94	To Be Determined	~15		
PTX06-1139	Proposed[3]	3095.29	To Be Determined	~15		
PTX06-1140	Proposed[3]	3052.75	To Be Determined	~15		
PTX06-1141	Proposed[3]	3085.68	To Be Determined	~20		
PTX06-1143	Proposed[3]	3058.49	To Be Determined	~20		
PTX06-1144	Proposed[3]		To Be Determined	> 150		

[1]Based on December 2008 measurements for most wells.
[2]Saturated thickness above the bottom of the well screen.
[3]These wells have been drilled, but construction details were not available as of the date of this report.

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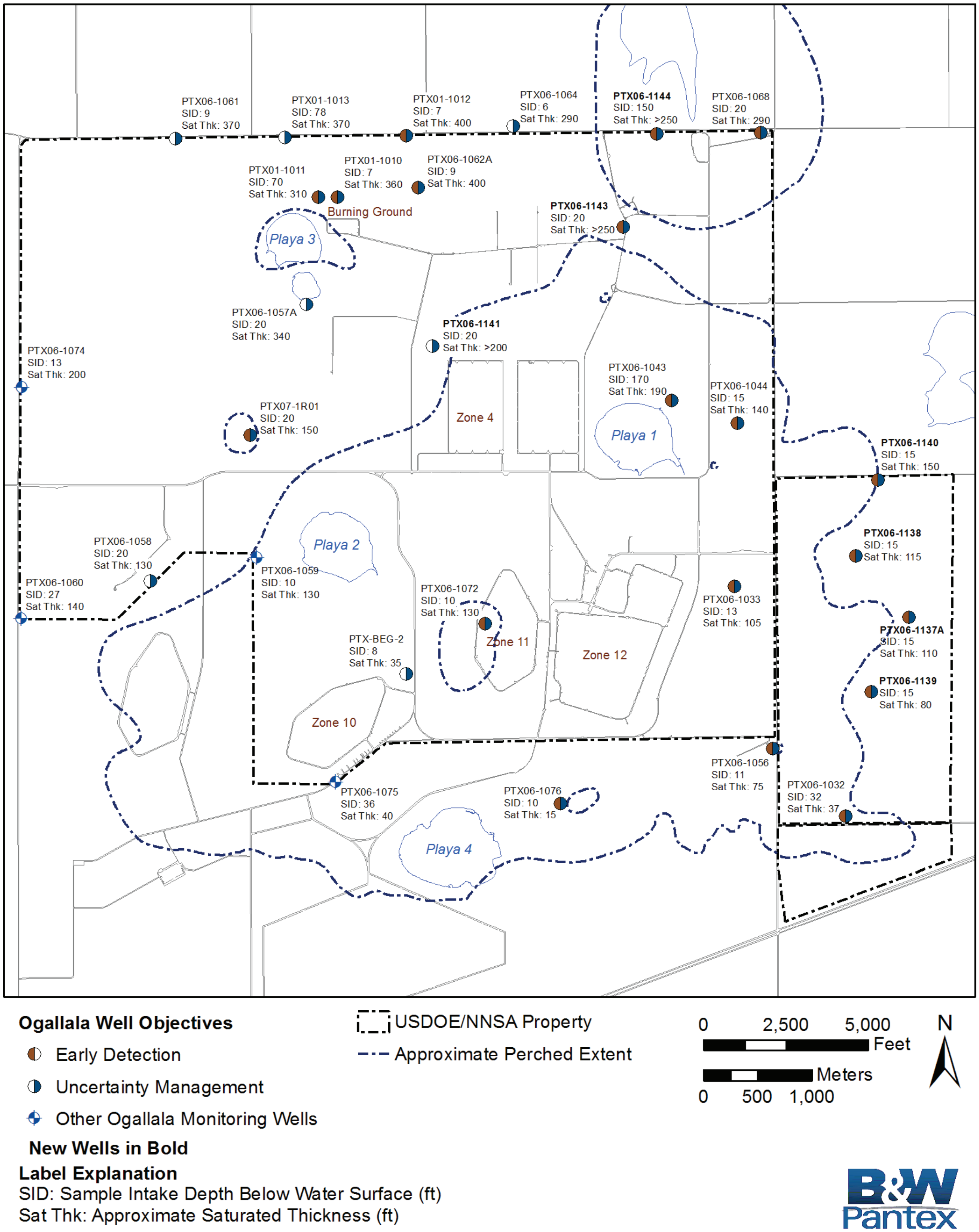

Figure 4-1. Sample Intake Depths for Ogallala Aquifer Wells

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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 is collected at various frequencies including quarterly, annually, and every 5 years. All data is reviewed as it is 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 is further reviewed at various frequencies according to the purpose for collection of the data. For example, quarterly data collected from ISB treatment zones is 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, such as concentration trends of primary COCs at select wells and charts of pump and treat system performance. The data will also support the 5-Year Review required under the IAG.

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 2-1 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 highly 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 GWPSs within 3 to 5 years.

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 levels 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 GWPSs 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 GWPSs. 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 estimate degradation rates. Quantitative analysis of natural attenuation for most COCs is not expected to be feasible until the second 5-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 GWPSs 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. 5-YEAR REVIEW

A 5-year review is required under the IAG in accordance with CERCLA §121(c) and the NCP (40 CFR Part 399.430(f)(4)(ii)). Data collected for the LTM system will also support the 5-year review. The evaluations performed for the annual report will be reviewed collectively to determine the performance of the response actions across a 5-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., $R^2 << 1$) 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. 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:

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

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

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

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

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

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

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

Standard Deviation

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

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

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 AFCEE. 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., $R^2 << 1$) 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 5-2.

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

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

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

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

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 six categories presented below.

Below background/PQL and GWPS: Concentrations are not expected to exceed background/PQL or the GWPS. This conditions 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.

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.

Remain dry: These wells are beyond the extent of perched saturation and serve as plume stability wells. These wells will be watched to ensure that the perched groundwater, and the contaminant plumes, is not expanding. The expected condition for these wells is that water will not be found.

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 ≤ 0	< 90% and COV ≥ 1	No Trend
S ≤ 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 ≥ 1	No Trend
Negative	< 90% and COV < 1	Stable
Negative	90–95%	Probably Decreasing
Negative	> 95%	Decreasing

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6. SUMMARY AND CONCLUSIONS

This report documents the development of the proposed long-term groundwater monitoring well network and the methods for evaluation of the response actions based on the monitoring well network for Pantex Plant.

Pantex is proposing that a total of 139 perched and Ogallala wells be monitored. Twenty-six Ogallala monitor wells and 113 perched wells are recommended for monitoring. The objectives for the development of the network are to evaluate the following:

Perched

- Plume stability
- Response Action Effectiveness
- Uncertainty Management

Ogallala

- Early Detection
- Uncertainty Management

The frequency of sampling and the monitoring lists were recommended to evaluate each well for indicator parameters (as presented in the *Sampling and Analysis Plan*, B&W Pantex 2009). In addition, a larger list of constituents (modified Appendix IX as presented in the *Sampling and Analysis Plan*) is recommended for monitoring every 5 years to be used in conjunction with the 5-Year Review required by the Compliance Plan and CERCLA. The monitoring well network will also be reviewed each 5 years to make recommended changes.

The well construction designs for new perched and Ogallala wells were recommended to ensure that final monitoring well placement and sampling will allow for early detection of contaminants and to evaluate the final remedial actions at Pantex.

This plan also provides the methods for evaluating compliance with the response action objectives for the perched groundwater at Pantex. These evaluations will be performed annually and documented in annual progress reports. Evaluations include comparison of monitoring data against the applicable standards, concentration trending, evaluation of water levels, and evaluation of well conditions.

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APPENDIX A

Hydrogeologic Description of Pantex Plant

A. HYDROGEOLOGY

This appendix describes the hydrogeologic setting of Pantex Plant, including geology and water resources.

A.1. TOPOGRAPHY

Pantex Plant is located in the Texas Panhandle on the High Plains portion of the Great Plains Physiographic Province. This area is a broad, flat plateau that gently slopes east and south and is known as the *Llano Estacado* (Spanish for "Staked Plain"). Topographic elevation across Pantex Plant ranges from approximately 3,501 to 3,595 feet (1,067 to 1,096 m) above mean sea level (amsl), with an average elevation of approximately 3,554 feet (1,083 m) amsl (Table A-1). The topography is relatively flat with slopes ranging from approximately 0.00005 in upland areas to approximately 0.07 near closed drainage basins containing ephemeral lakes (known as playas). The average topographic slope across the Plant area is approximately 0.006 (Table A-1).

A.2. LOCAL GEOLOGY

The shallow subsurface stratigraphy in the area of Pantex Plant is comprised of the following geologic units (in order of increasing age of formation and depth below land surface):

- Blackwater Draw Formation (Pleistocene Epoch)
- Ogallala Formation (Pliocene Epoch)
- Dockum Group (Triassic Period)
- Permian Quartermaster Formation (Permian Period) where the Dockum Group is not present.

The vertical dimensions of the geologic units are summarized in Table A-1. More detailed information regarding the local geology is presented in the *Subsurface Modeling Report* (BWXT Pantex and SAIC, 2004).

The Blackwater Draw, the uppermost hydrostratigraphic unit (HSU) consists of eolian silts and sands with an approximately 20-foot (6-m) thick lower unit composed of silty sand and caliche. The upper surface of the Blackwater Draw is defined by surface topography. Numerous depressions representing the playa basins are apparent on the land surface. These depressions range from a few feet to more than 46 feet (14 m) in relief and from several hundred feet to 1 mile (1.6 km) or more in diameter (ANL and BMI, 1995). Sediments beneath the playas contain thick sequences, roughly 16 to 60 ft (5 to 18 m), of lake sediments that are highly variable in lateral and vertical extent (Hovorka, 1995). The lake sediments interfinger with the Blackwater Draw sediments near the edges of the playa basins. The Blackwater Draw Formation and the availability of water control infiltration and recharge, especially to perched groundwater.

Underlying the Blackwater Draw Formation is the Ogallala Formation. The Ogallala sediments consist of coarse-grained fluvial sequences that fill the floors of paleovalleys and fine upward from gravel to fine sand. The fining-upward sequences contain channel sands and gravels overlain by finer overbank deposits (Gustavson, 1994). Fine-grained eolian deposits overlie the coarse fluvial sediments. Regionally, the thickness of the Ogallala Formation ranges from a few feet to over 900 feet (274 m). A massive caliche caprock layer generally defines the top of the Ogallala Formation (and the base of the Blackwater Draw Formation); however, it is not continuous in extent below Pantex Plant. Where present, the caprock layer consists of a hard, dense, finely crystalline caliche.

Underlying the Ogallala Formation is the Dockum Group. Where present, the Dockum Group is estimated to be approximately 200 feet (61 m) thick in the Plant area (Johns, 1989). Identification of the Dockum Group from the Ogallala Formation is more difficult than the identification of the Permian Redbeds or the Quartermaster Formation. The Quartermaster Formation is made up of red shale or clay with sandstone, dolomite, or gypsum. The Permian Redbeds have very low permeability values; therefore, there are limited permeable pathways between the Ogallala and Permian rocks (Nativ, 1988).

A.3. GROUNDWATER RESOURCES

A.3.1 Ogallala Aquifer

The principal source of groundwater for the region is the Ogallala Aquifer, the primary unit of the High Plains Aquifer, comprising the highly permeable basal sediments of the Ogallala Formation throughout the Southern High Plains. The Ogallala Aquifer provides water for municipal water supplies, crop irrigation, livestock operations, and industry and is the sole water source for Pantex Plant.

The High Plains Aquifer has been developed extensively with more than 96% of the total withdrawal used for irrigation (McGuire, 2004). During 2000, approximately 121,000 acre-feet of water were pumped from the aquifer in Carson County (PGCD, 2003). About 97,300 acre-feet, or 80%, were withdrawn for irrigation (PWPG, 2005). Because this volume of discharge greatly exceeds the amount of recharge, water levels in the aquifer are declining. Water level changes in the High Plains Aquifer from the time prior to substantial ground-water irrigation development (about 1950) to 2003 are illustrated in Figure A-1. In this figure, declines in western Carson County near Pantex Plant range from about 25 ft (7.6 m) to more than 150 feet (46 m). According to the Panhandle Groundwater Conservation District, the average water level in Carson County declined 31 feet (9.4 m) from 1964 to 2004 (PGCD, 2004). Beneath the northern part of Pantex Plant, water levels have dropped more than 130 feet (40 m) since 1942 and are currently declining at rates greater than 1 foot (0.3 m) per year.

The Ogallala Aquifer in Carson County was estimated to contain about 17.5 million acre-feet of groundwater in 1960 (Knowles, et al., 1984). In 2000, the volume in storage had declined to about 15.3 million acre-feet (PWPG, 2005). It is the stated goal of the Panhandle Groundwater Conservation District to conserve and preserve the limited supply of groundwater in the district while maintaining the economic viability of all resource user groups. To meet this goal, the District has instituted a conservation management policy to retain 50% of the 1998 groundwater supply in 2048 (PCGD, 2003). According to Groundwater Availability Modeling conducted as part of regional water planning, about 65% of the year 2000 groundwater supply in Carson County is projected to remain in 2050 (PWPG, 2005).

Regionally, the Ogallala water table slopes from northwest to southeast, generally following the regional topographic surface. In the vicinity of Pantex Plant, however, the water table slopes from southwest to northeast, as shown in Figure A-2, in response to extensive pumping from the City of Amarillo Carson County well field located north of Pantex Plant. Figure A-3, showing the approximate saturated thickness of the Ogallala Aquifer near Pantex, indicates an area of limited saturation in the aquifer on the eastern side of the Texas Tech University (TTU) property. As water levels in the aquifer continue to decline, this area of limited saturation will expand. Figure A-2 includes the locations of Ogallala Aquifer monitoring wells in the vicinity of Pantex Plant. This monitoring network was used to determine the water levels and potentiometric surface of the Ogallala Aquifer beneath the Plant.

A.3.2 Perched Groundwater

Localized bodies of perched groundwater occur above the Ogallala Aquifer throughout the Southern High Plains (Mullican, 1997). These localized zones occur where focused recharge from playa lakes has ponded on top of an aquitard, referred to as the fine-grained zone (FGZ). Figure A-4 includes the locations of perched groundwater monitoring wells in the vicinity of Pantex Plant. This monitoring network was used to determine the water levels and potentiometric surface of perched groundwater beneath the Plant. Three primary areas of perched groundwater beneath Pantex Plant are shown in Figure A-5. The largest area of perched groundwater underlying Pantex Plant is associated with natural recharge from Playas 1, 2, and 4, treated wastewater discharge to Playa 1, and historical releases to the ditches draining Zones 11 and 12. Smaller areas of perched groundwater are associated with Playa 3 (near the Burning Ground) and Pratt Playa (near the northeast corner of Pantex Plant).

Perched groundwater does not discharge to the surface, is not a source of drinking water for Pantex Plant, nor is it used for any Pantex Plant industrial operations. Treated water from the perched groundwater pump and treat system, and treated wastewater meeting Pantex Plant permitted discharge requirements, is used for subsurface irrigation onsite. Because perched groundwater is the shallowest water-bearing zone in the area, it is the first groundwater unit affected by the migration of constituents released from Pantex Plant Solid Waste Management Units (SWMUs). Units impacted by constituents at the surface are separated from groundwater in either the perched zone or the Ogallala Aquifer by a 200- to 500-foot (61- to 153-m) thick unsaturated zone. Vertical flow between perched groundwater and the Ogallala Aquifer is limited by the FGZ. In areas where perched groundwater is present, a second unsaturated zone occurs between the perched groundwater and the Ogallala Aquifer. Because of the thin saturated thickness of perched groundwater, flow in the perched zone is controlled by the topography of the FGZ and by localized sources of recharge, such as Playa 1. As a result, groundwater flow directions in the perched groundwater vary spatially in response to local topography and recharge. Perched groundwater northeast of Playa 1 is limited to Pantex Plant because of the limited extent of the perched groundwater in that area.

As a result of historical waste management practices that occurred at Pantex Plant from the early 1950s to approximately the late 1980s, portions of the main perched groundwater are impacted by contaminants, primarily in the areas beneath and downgradient of Zones 11 and 12 and Playa 1. The most prevalent contaminant in perched groundwater is Research Development Explosive compound cyclo-trimethylene trinitramine (RDX), a high explosive (HE) compound used at Pantex Plant since it began operations in the early 1950s. The approximate extent of RDX impacts in perched groundwater at Pantex Plant is shown in Figure A-6. In this figure, the highest concentrations of RDX are observed south of the Plant boundary on TTU property, and along the eastern Plant boundary. Current concentrations observed are much lower near the known source areas (WMG 6/7, SWMU 5-13c, and Playa 1). The lower concentrations near the source areas indicate that influx of RDX to perched groundwater was much greater in the past, the observed nature and extent of RDX impacts are a result of historical releases, and improved waste management practices have mitigated continuing influx of RDX to the perched groundwater. The *Groundwater RFIR* (Stoller, 2004) provides a complete discussion of the nature and extent of constituents in perched groundwater.

A.4. SOIL CHARACTERISTICS

Surficial soils at Pantex Plant are predominantly Pullman clay loams. Subsurface soils are considered part of the Blackwater Draw and Ogallala Formations. The Pullman clay loam series dominates the upland, and Randall clay dominates the playa bottoms. Lazbuddie and Lofton soils occur on the playa benches, and Pep and Estacado soils occur on the playa side slopes.

A.5. METEOROLOGY AND CLIMATOLOGY

The climate in the Texas Panhandle is typical of continental interiors. It is mainly semi-arid, with mild winters and hot, dry summers and is characterized by large variations in daily temperature extremes, low relative humidity, and irregular rainfall of moderate amounts. Thunderstorms occur approximately 49 days per year and can produce tornadoes (DOC, 1997). Pantex Plant is in a windy area and in a moderate- to high-hazard zone for tornadoes.

Based on National Weather Service (NWS) records, average annual precipitation for Amarillo is 19.9 inches (50.5 cm). The average annual temperature is 57.1ºF (13.9ºC), with a normal low temperature in January of 21.2ºF (-6.0ºC) and a normal high temperature in July of 91.7ºF (33.2ºC). Average wind speeds at the Amarillo NWS station are 13.1 mph (21.1 kph) based on a 33-year period of record (BPX/MHC, 1998). The prevailing wind direction is from the south for May through September and from the southwest for the remainder of the year (DOC, 1997). Analysis of NWS meteorological data for 1990 indicates local winds were predominantly from the south and southwest directions approximately 41% of the time with an average wind speed of 13.4 mph (21.6 kph). The gross lake-surface evaporation rate averages 73 inches (185 cm) per year, as measured from 1950 through 1975 (BPX/MHC, 1997).

A.6. SURFACE WATER

The principal surface water features of the Southern High Plains are the numerous shallow playas and small stream valleys or draws. Stream drainage patterns are poorly developed because of the low relief of the plains. Streams occur as long, shallow draws following the general slope of the land surface at widely spaced intervals. The drainage areas of the streams and draws are limited to narrow belts of land. Playa basins drain the larger, interfluvial areas and generally do not contribute runoff to streams. The perennial surface water feature closest to Pantex Plant is the Canadian River, located approximately 17 miles (27 km) to the north. The river flows in a generally eastward direction into Lake Meredith, a constructed reservoir. A few smaller streams are located south and east of Pantex Plant along the High Plains Escarpment. These streams are tributaries of the Red River and include 1) the Salt Fork of the Red River, about 20 miles (32 km) southeast of Pantex Plant; 2) the Prairie Dog Town Fork of the Red River, 25 miles (40 km) southwest of Pantex Plant; and 3) Sweetwater Creek, about 50 miles (80 km) east of Pantex Plant. During flood events at Pantex Plant, surface water may flow to offsite playas but runoff from Pantex Plant does not flow into the Canadian River, Lake Meredith, or any of the smaller streams.

Three playas are located at Pantex Plant, as shown on Figure A-4. Playa 1 is north of Zone 12, Playa 2 is west-northwest of Zone 11, and Playa 3 is included in the Burning Ground WMG. Playa 4 is located on TTU property, south of Zone 11. A large playa basin is located on Pantex Lake property, 2.5 miles (4 km) northeast of the Pantex Plant boundary. Other playas are present in the area and each constitutes a separate drainage basin with no surface drainage outlets. Most surface water runoff from Pantex Plant flows into the onsite playas. Historically, treated and untreated industrial wastewater was discharged directly to the ditches and flowed to the playas. Waste management practices were improved in the 1980s and all industrial discharges to the ditches were eliminated by 1999. Additionally, Playa 1 and Pantex Lake have received treated wastewater from the Old Sewage Treatment Plant (OSTP) and the current Wastewater Treatment Facility (WWTF). The treated wastewater discharge is currently routed to a subsurface irrigation system in accordance with permit requirements. Occasionally, treated wastewater is discharged to Playa 1 in compliance with permit requirements. Playas 2 and 3 and Pantex Lake receive only storm water runoff.

Table A-1. Vertical Dimension of Geologic Features within Pantex Plant Boundary[a]

Geologic Features		High		Low		Average[b]	
		ft	m	ft	m	ft	m
Elevation[c]	Topographic Elevation (Top of Blackwater Draw Formation)	3594.6	1095.6	3501.2	1067.2	3553.6	1083.1
	Topographic Slope (ft/ft)	0.07	0.07	0.00005	0.00005	0.006	0.006
	Elevation of Base of Blackwater Draw Formation (Top of Ogallala Formation and Caprock Caliche)	3532.9	1076.8	3436.9	1047.6	3480.6	1060.9
	Elevation of the Base of the Caprock Caliche	3522.4	1073.6	3426.3	1044.3	3470.5	1057.8
	Elevation of the Perched Water Table Surface	3321.9	1012.5	3257.4	992.8	3283.4	1000.8
	Elevation of the Top of the FGZ	3341.5	1018.5	3111.1	948.3	3277.5	999.0
	Elevation of the Base of the FGZ	3309.6	1008.8	3031.5	924.0	3226.3	983.4
	Top of Ogallala Water Table	3210.4	978.5	2677.2	816.0	3115.6	949.6
	Elevation of the Base of the Ogallala Formation (Top of the Dockum Group and Redbeds)	3152.4	960.9	2679.2	816.6	2895.9	882.7
Depth below ground surface (bgs)	Depth bgs to Base of Blackwater Draw Formation (Top of Ogallala Formation and Caprock Caliche)	105.0	32.0	33.6	10.2	72.9	22.2
	Depth bgs to Base of Caprock Caliche	115.0	35.0	43.6	13.3	83.0	25.3
	Depth bgs to Perched Water Table Surface	297.9	90.8	195.1	59.5	256.7	78.2
	Depth bgs to Top of FGZ	321.7	98.1	223.5	68.1	276.0	84.1
	Depth bgs to Base of FGZ	431.1	131.4	267.5	81.5	327.1	99.7
	Depth bgs to Ogallala Water Table Surface	507.5	154.7	343.5	104.7	437.9	133.5
	Depth bgs to Base of Ogallala Formation (Top of the Dockum Group and Redbeds)	888.9	270.9	390.9	119.2	657.6	200.4
Thickness	Thickness of Blackwater Draw Formation	105.5	32.2	33.6	10.2	72.8	22.2
	Thickness of Caprock Caliche	23.2	7.1	0.5	0.2	7.1	2.2
	Saturated Thickness of Perched Groundwater	79.4	24.2	0.0	0.0	22.0	6.7
	Thickness of FGZ	157.1	47.9	8.7	2.6	51.1	15.6
	Lower Ogallala Unsaturated Thickness	221.1	67.4	0.0	0.0	110.8	33.8
	Saturated Thickness of Ogallala Aquifer	406.2	123.8	29.0	8.8	219.7	67.0
	Thickness of Ogallala Formation (Total)	821.6	250.4	316.4	96.5	584.7	178.2

Note: Water surface information is based on April 2000 measurements collected from monitoring, investigation, municipal, private, and extraction wells (See Table 2-3 of Subsurface Modeling Report [BWXT Pantex and SAIC, 2004] for list of wells included).
[a]Table taken from the Subsurface Modeling Report (BWXT Pantex and SAIC, 2004)
[b]Averages were calculated as the arithmetic mean of the interpolated surfaces within the Pantex Plant boundary.
[c]Elevation data is amsl.

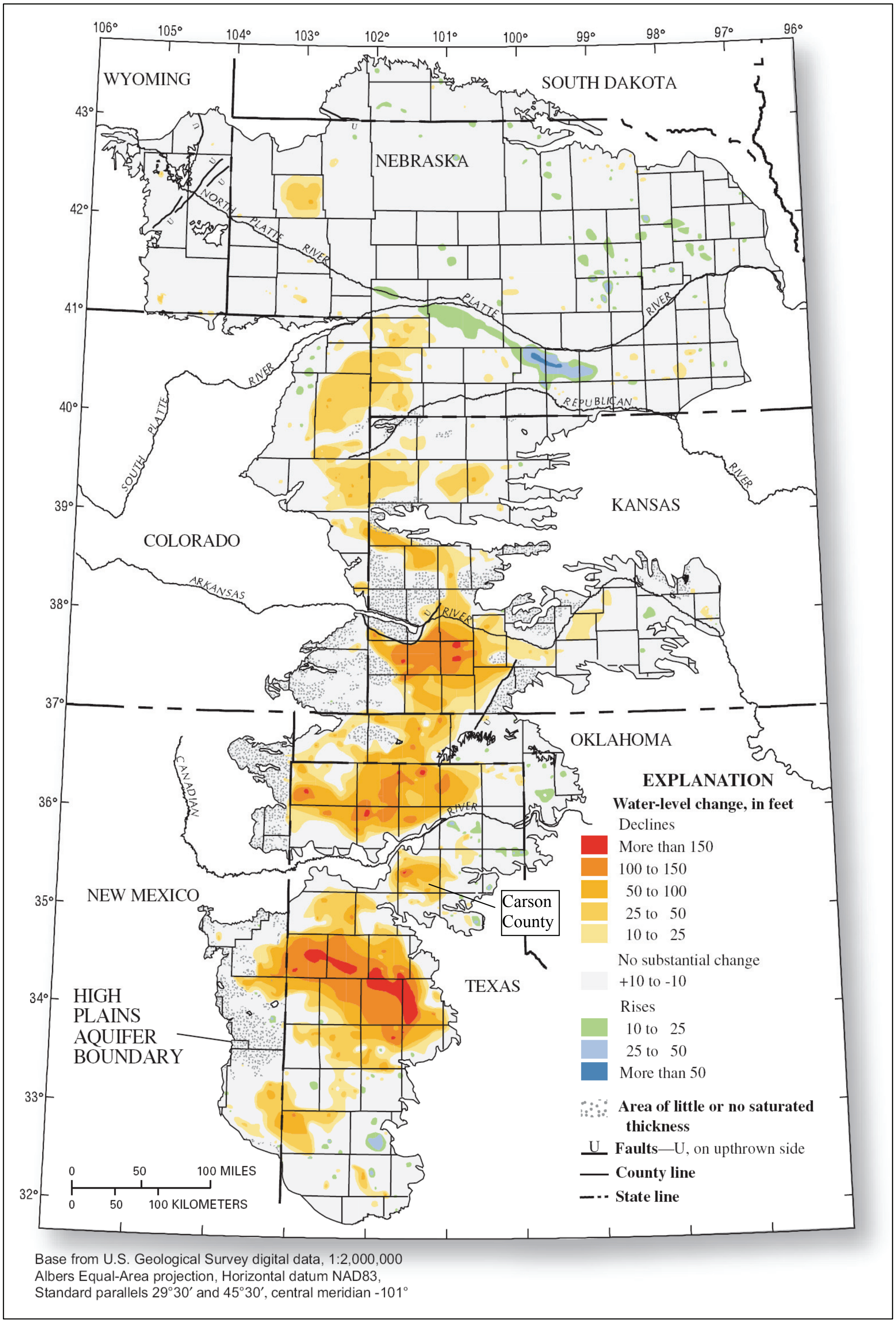

Figure A-1. Water-Level Changes in the High Plains Aquifer, Predevelopment to 2003 (Modified from Mcguire, 2004)

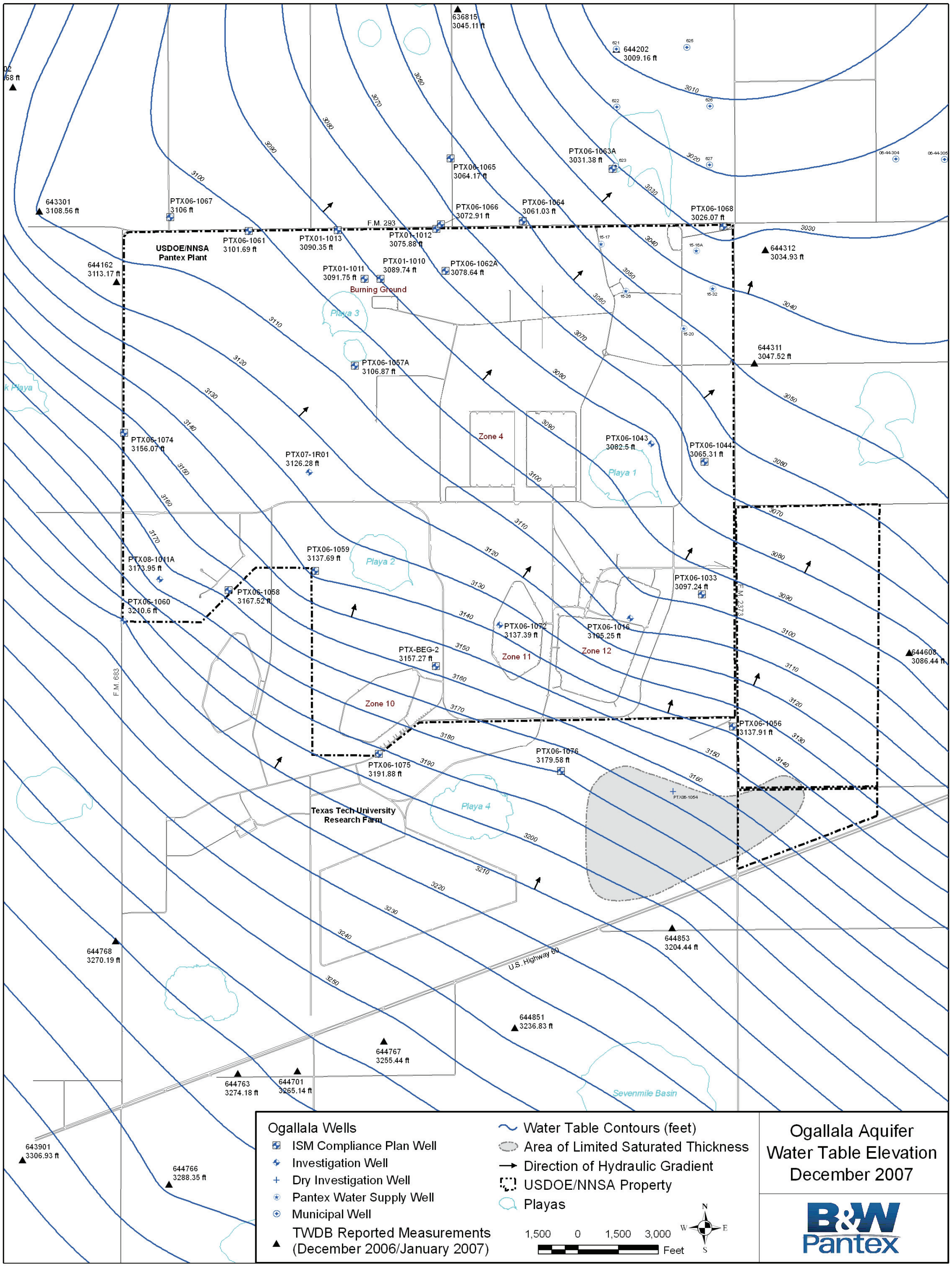

Figure A-2. Ogallala Aquifer Water Levels at Pantex Plant, December 2007

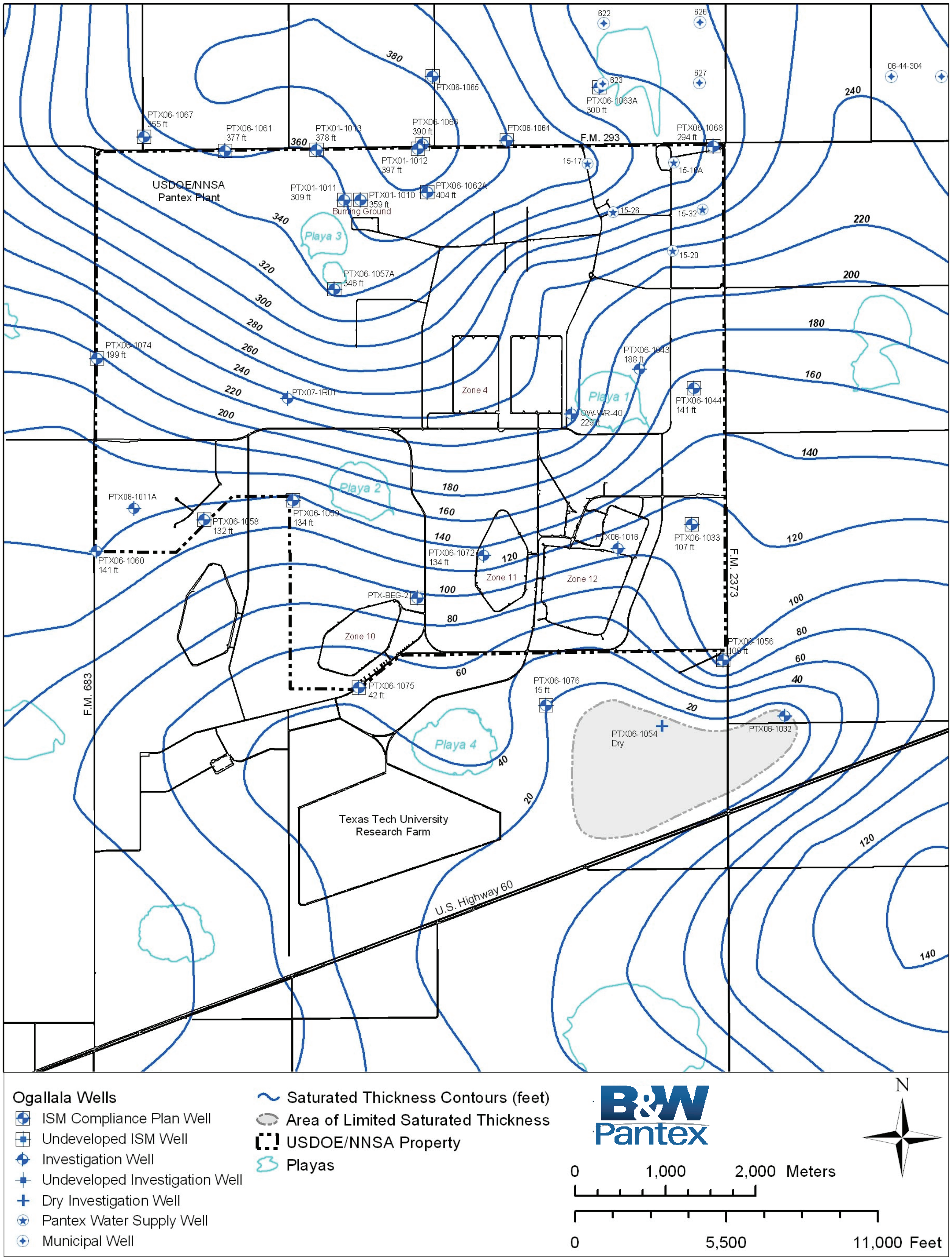

Figure A-3. Approximate Saturated Thickness of the Ogallala Aquifer, December 2004

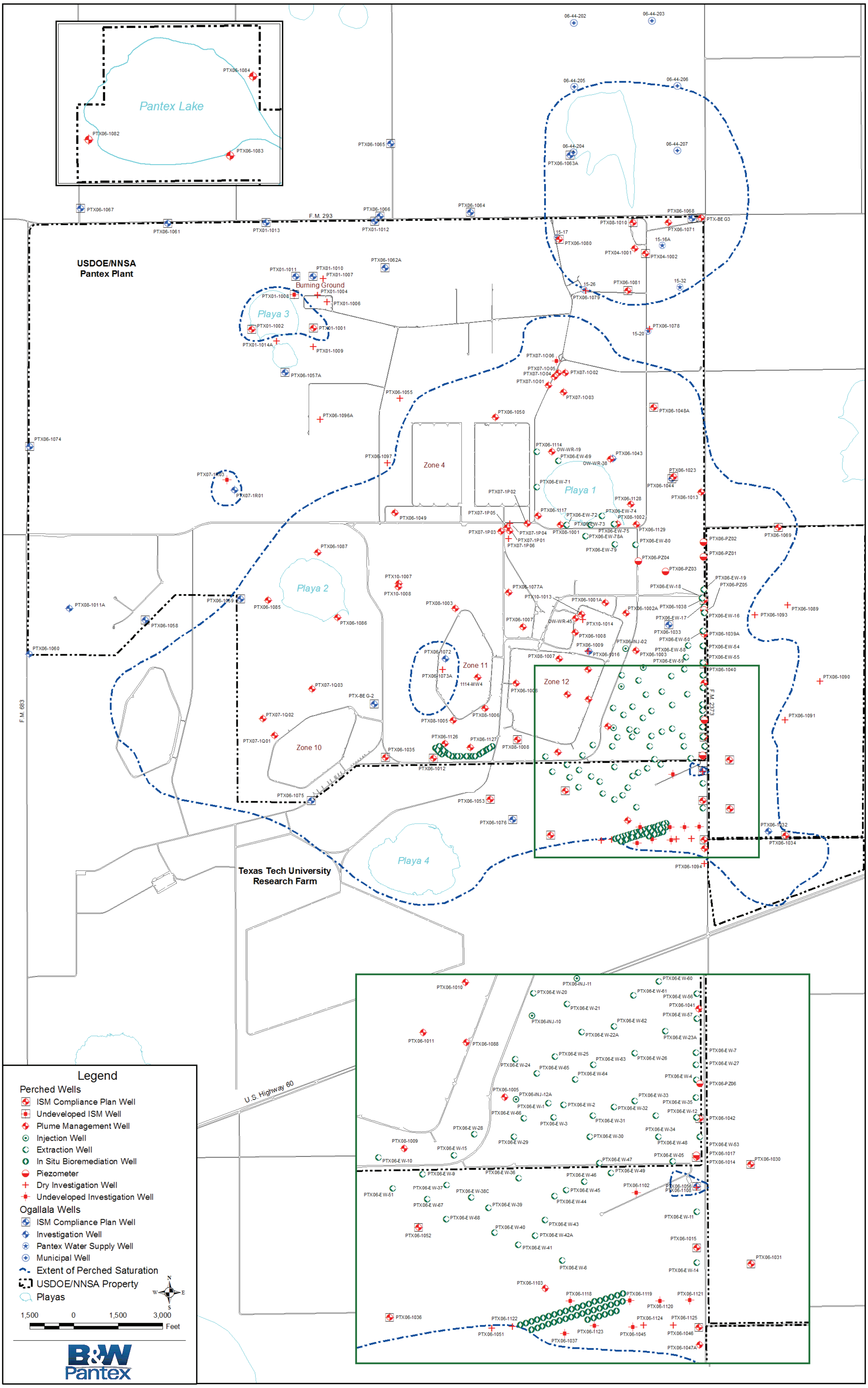

Figure A-4. Well Location Map

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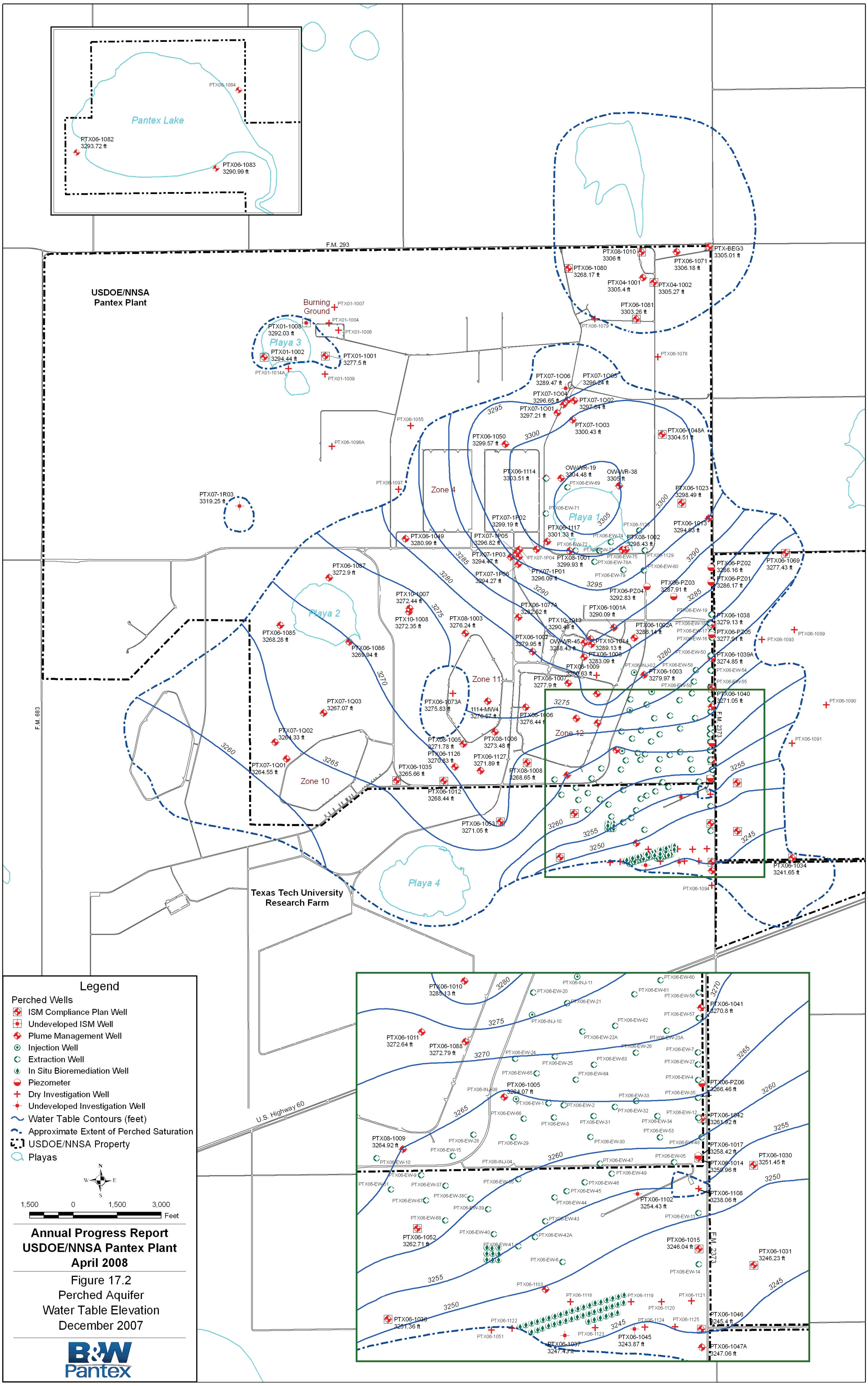

Figure A-5. Perched Groundwater Water Levels at Pantex Plant

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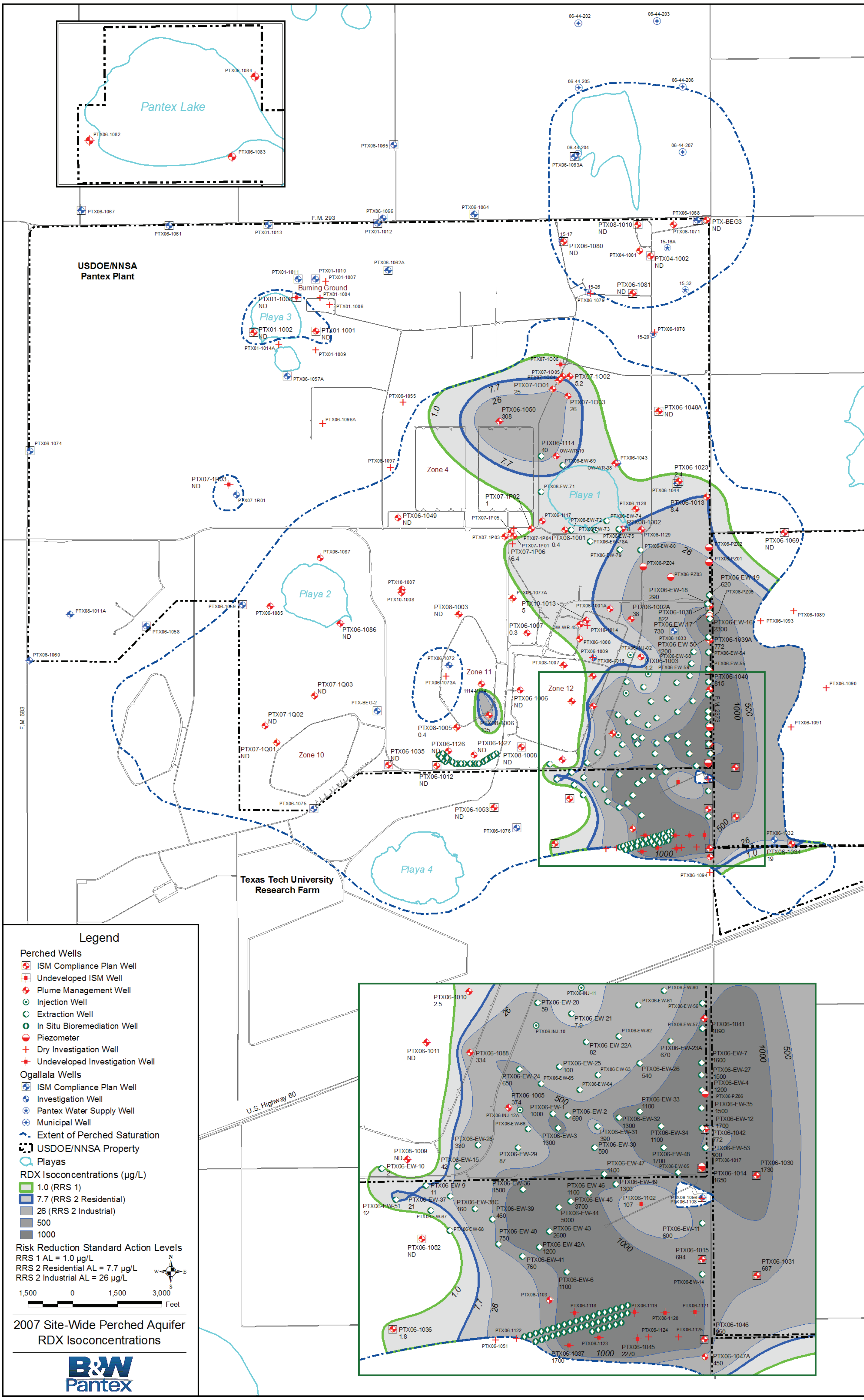

Figure A-6. Perched Groundwater RDX Isoconcentrations

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Appendix B

Groundwater Monitoring Network Optimization (GSI, 2008)

Optimization of Monitoring Well Placement for Breakthrough Detection in the Ogallala Aquifer (SAIC, 2008)

Analysis of Vertical Flow During Ambient and Pumping Conditions in Four Monitoring Wells at the Pantex Plant, Carson County, Texas, July—September 2008 (USGS, 2009)

APPENDIX C

<u>Chromium in Perched Groundwater Wells</u>

C.1. INTRODUCTION

Total chromium has been observed at concentrations above background in many of the perched groundwater monitoring wells constructed with stainless steel screens. Analysis of metals data in perched groundwater shows that a statistical relationship exists among the constituents found in stainless steel (specifically, chromium, manganese, molybdenum, and nickel) at wells with stainless steel screens. The correlation among chromium, manganese, molybdenum, and nickel concentrations indicates measured concentrations of these constituents do not relate to groundwater contamination, but rather to sample contamination contributed by stainless steel well construction materials. Although these wells may not be suitable for monitoring of total chromium and other constituents found in stainless steel (i.e., manganese, molybdenum, and nickel), the presence of chromium in the samples does not preclude the wells from providing representative samples for other constituents.

This appendix presents a summary of conclusions presented in the Baseline Human Health Risk Assessment (BHHRA) Report (BWXT Pantex, 2006) and Groundwater RFIR (Stoller, 2004) regarding water sample contamination caused by stainless steel well construction materials. In the BHHRA, a statistical analysis of metals data in perched groundwater was conducted to determine the relationship of stainless steel corrosion products in groundwater to well casing material. For the Groundwater RFIR, well screen corrosion was visually confirmed by downhole video in nine perched groundwater wells; analytical data for chromium, manganese, and nickel acquired from those wells were removed from the RFIR dataset and the rationale for removing those data was presented. Based on the statistical analysis and visual evidence, analytical data for chromium, manganese, molybdenum, and nickel from stainless steel wells were not included in the Baseline HHRA evaluation for perched groundwater.

C.2. CHEMICAL CHARACTERISTICS OF STAINLESS STEEL WELLS

Many studies have confirmed that groundwater quality data can be biased by the presence of well construction materials in the sample as a result of leaching, desorption, or volatization (USGS, 1997). According to EPA, when constituents are leached from well materials, “constituents that are not indicative of formation water quality may be detected in samples collected from the well” (1989). These “false positives” only indicate that the sample has been affected by the well casing material.

Because well screen materials have a large surface area exposed to groundwater, the screen is the part of a well most susceptible to corrosion and leaching of its constituents. In a ranking of well screen materials by potential to leach inorganic constituents, the USGS lists stainless steel among the most leaching of potential well construction materials even though stainless steel generally has high corrosion resistance (1997). Stainless steel type 316, the type used in most stainless steel wells at Pantex, is composed of 30 to 37 percent chromium, manganese, molybdenum, and nickel (USGS, 1997).

C.3. CHROMIUM IN PERCHED GROUNDWATER

Based on historical information and soil and groundwater sampling, two separate source areas of hexavalent chromium in Zone 12 South have impacted perched groundwater. The two plumes commingle southeast of Zone 12 and extend offsite beneath Texas Tech property south of Pantex. Chromium has been detected in samples from many stainless steel wells located either upgradient or far away from these plumes. These detections do not indicate the presence of chromium contamination in perched groundwater at these locations, but are related to corrosion of stainless steel well screens as shown by the statistical evaluation presented in the BHHRA. Further, it is not plausible that a widespread chromium plume could result from well casing corrosion because well casings do not contain sufficient mass of chromium.

As an example, consider an aquifer of 20-ft saturated thickness and porosity of 0.25 containing a circular (1,000-ft radius) plume of chromium with a uniform concentration of 1 mg/L. The mass of chromium in this volume of groundwater is about 980 lb (445 kg). By comparison, a 20-ft length of 4-inch stainless steel monitoring well casing weighs about 220 lb (100 kg) based on screen weight of 11 lb/ft and contains at most 40 lb (18 kg) of chromium. Therefore, at least 25 well screens would need to be completely dissolved in the groundwater to create the small plume in the aquifer. This rather extreme example illustrates that apparent water quality impacts caused by well screen corrosion affect only the water contained within the well bore and cannot measurably affect water quality in the aquifer away from the well.

As presented in Section I.3.1 of the BHHRA, the majority of chromium, manganese, molybdenum, and nickel action level exceedances occur at well locations with stainless steel screens, while no hexavalent chromium exceedances occur at stainless steel wells. The presence of elevated concentrations of total chromium without corresponding hexavalent chromium coupled with the high occurrence of exceedance among the other corrosion constituents suggests that corrosion of the stainless steel screens is likely the cause. A statistical correlation analysis supports this hypothesis. For this analysis, total and hexavalent chromium results for 3 stainless steel wells located downgradient of known total chromium and hexavalent chromium source areas were removed. Among non-stainless steel wells where corrosion would not be expected to occur, poor relationships between the corrosion constituents (chromium, manganese, molybdenum, and nickel) are observed. In addition, the statistically significant correlation between total chromium and hexavalent chromium indicates the observed chromium detections can be attributed to a source. Conversely, the relationship between the corrosion constituents from wells with stainless steel screens showed statistically significant correlations. These results among wells with stainless steel screens coupled with the poor correlation between total chromium and hexavalent chromium would suggest that the presence of the corrosion constituents is not indicative of source contamination.

C.4. SUMMARY AND CONCLUSIONS

In the BHHRA, metals data acquired for chromium, manganese, molybdenum, and nickel in wells constructed with stainless steel screens were removed from the groundwater datasets because measured concentrations of these constituents are only localized occurrences associated with wells exhibiting corrosion. Removal of this data is consistent with the data evaluation in the Groundwater RFIR and is supported by visual observations (by downhole video) of corroded well screens, the observed extent of chromium in perched groundwater from known source areas, statistical evaluations of total and hexavalent chromium, manganese, molybdenum, and nickel in perched monitoring wells, and published data from EPA and USGS. In addition, a simple calculation of the mass of chromium in a stainless steel well screen shows that well corrosion cannot measurably affect water quality in the aquifer away from the well.

Wells constructed with stainless steel screens may not be suitable for monitoring of total chromium and other constituents found in stainless steel (i.e., manganese, molybdenum, and nickel), but these wells can provide representative samples for other constituents. Aside from chromium, none of the other constituents found in stainless steel were identified as constituents of concern in perched groundwater. Chromium impacts to perched groundwater are associated with releases of hexavalent, not total, chromium, and a separate analytical method is used to quantify concentrations of hexavalent chromium. Therefore, it is recommended that the presence of chromium and other constituents found in stainless steel at elevated concentrations not be used in the determination of the need for well replacement without other information indicating that a particular well can no longer provide representative samples of perched groundwater quality, such as visual evidence of well screen deterioration obtained from downhole video or hydraulic data from slug or pump tests.

C.5. REFERENCES

BWXT Pantex, 2006. Baseline Human Health Risk Assessment Report for Zones 10, 11, and 12, Fire Training Area, Ditches and Playas, Independent Sites, and Groundwater. Prepared for Pantex Plant, Amarillo, Texas.

Stoller, 2004. Groundwater RCRA Facility Investigation Report. Prepared for Pantex Plant, Amarillo, Texas.

USEPA (L. Aller, T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nielson, and J.E. Denne), 1989. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, EPA/600/4-89/034.

USGS (W.W. Lapham, F.D. Wilde, and M.T. Koterba), 1997. Guidelines and Standard Procedures for Studies of Ground-Water Quality: Selection and Installation of Wells, and Supporting Documentation. U.S. Geological Survey Water-Resources Investigations Report 96-4233.

APPENDIX D

Table of Wells and Coordinates

Monitoring Wells and Coordinates

Well ID	Easting	Northing	Well ID	Easting	Northing
Ogallala Wells					
PTX01-1010	630576.88	3771397.26	PTX06-1064	635900.45	3773557.90
PTX01-1011	629986.45	3771397.29	PTX06-1068	643403.70	3773360.30
PTX01-1012	632664.21	3773264.13	PTX06-1072	635047.45	3758434.63
PTX01-1013	628976.89	3773218.25	PTX06-1076	637327.32	3752978.41
PTX06-1032	645981.41	3752592.58	PTX06-1137A	647900.89	3758635.67
PTX06-1033	642614.48	3759581.41	PTX06-1138	646285.31	3760503.82
PTX06-1043	640711.00	3765225.21	PTX06-1139	646768.73	3756376.08
PTX06-1044	642706.18	3764538.54	PTX06-1140	646959.38	3762807.67
PTX06-1056	643767.03	3754642.87	PTX06-1141	633445.44	3766872.94
PTX06-1057A	629630.04	3768142.23	PTX06-1143	639244.72	3770496.78
PTX06-1058	624894.00	3759747.11	PTX06-1144	640252.98	3773320.45
PTX06-1061	625651.61	3773186.59	PTX07-1R01	627914.28	3764159.91
PTX06-1062A	633017.18	3771685.22	PTX-BEG2	632652.49	3756906.56
Perched Wells					
1114-MW4	636151.93	3757809.40	PTX06-1093	645529.01	3759922.32
OW-WR-38	640645.32	3765201.69	PTX06-1094	643813.77	3751494.55
PTX01-1001	630592.95	3769641.90	PTX06-1095A	640634.87	3755598.65
PTX01-1002	628496.92	3769596.99	PTX06-1096A	630823.57	3766548.35
PTX01-1004	630729.82	3770768.71	PTX06-1097	633104.35	3765068.63
PTX01-1008	629942.97	3770782.89	PTX06-1098	640266.14	3753628.43
PTX01-1009	630594.67	3769018.50	PTX06-1100	640285.97	3753579.52
PTX04-1001	641458.10	3772334.66	PTX06-1101	640383.57	3753437.09
PTX04-1002	641818.01	3772165.27	PTX06-1102	642751.09	3754532.94
PTX06-1002A	641161.56	3759984.00	PTX06-1103	641228.13	3752946.88
PTX06-1003	641498.93	3758711.05	PTX06-1118	641644.92	3752736.07
PTX06-1005	640545.44	3756139.87	PTX06-1119	642646.10	3752739.01
PTX06-1006	637450.19	3757599.75	PTX06-1120	643152.43	3752735.03
PTX06-1007	637679.37	3759513.00	PTX06-1121	643645.57	3752750.09
PTX06-1008	639441.93	3759325.25	PTX06-1122	640677.35	3752308.74
PTX06-1010	639886.62	3758067.00	PTX06-1123	642051.96	3752319.94
PTX06-1011	639178.93	3757219.75	PTX06-1124	642877.91	3752327.45
PTX06-1012	634640.91	3755068.80	PTX06-1125	643377.53	3752331.14
PTX06-1013	643710.38	3764075.09	PTX06-1126	635034.72	3755562.85
PTX06-1014	643758.88	3755125.71	PTX06-1127	635901.90	3755432.03
PTX06-1015	643765.00	3753617.00	PTX06-1130	644270.36	3759745.02
PTX06-1023	642773.84	3764603.10	PTX06-1131	629371.66	3754232.94
PTX06-1030	644670.42	3755008.03	PTX06-1133A	645287.37	3751315.73
PTX06-1031	644674.92	3753348.03	PTX06-1134	635211.37	3754129.45
PTX06-1034	646555.62	3752434.98	PTX06-1135	638343.76	3753631.93
PTX06-1035	633027.45	3755092.64	PTX06-1136	634860.83	3766771.76
PTX06-1036	638615.43	3752455.56	PTX06-1146	645978.91	3757691.87
PTX06-1037	641549.25	3752194.06	PTX06-1147	645431.85	3753953.21
PTX06-1038	643802.04	3760426.35	PTX06-1148	636465.02	3754720.72
PTX06-1039A	643807.47	3759272.56	PTX06-1149	635896.51	3754720.72
PTX06-1040	643811.23	3758262.93	PTX06-1150	635234.30	3754720.72
PTX06-1041	643803.61	3757622.78	PTX06-1151	633935.95	3756123.62
PTX06-1042	643812.20	3755779.88	PTX06-1153*	641185.00	3752090.00
PTX06-1045	642697.65	3752300.00	PTX06-1154*	641865.00	3752290.00
PTX06-1046	643802.63	3752292.55	PTX06-1155*	634605.00	3755215.00

Well ID	Easting	Northing	Well ID	Easting	Northing
PTX06-1047A	643817.46	3752004.39	PTX06-1156*	636380.00	3755080.00
PTX06-1048A	642103.43	3766957.63	PTX07-1O01	638532.53	3767695.22
PTX06-1049	633343.53	3763376.96	PTX07-1O02	639106.56	3768117.46
PTX06-1050	636746.04	3766622.06	PTX07-1O03	639046.64	3767462.56
PTX06-1051	640332.91	3752279.10	PTX07-1O06	638814.40	3768536.81
PTX06-1052	639100.91	3753957.66	PTX07-1P02	637817.70	3763019.08
PTX06-1053	636576.74	3753672.06	PTX07-1P05	637136.13	3762886.83
PTX06-1055	633521.90	3767254.87	PTX07-1Q01	629274.83	3755836.12
PTX06-1069	646317.00	3762879.60	PTX07-1Q02	628876.97	3756408.66
PTX06-1071	642601.46	3773219.43	PTX07-1Q03	630542.61	3757408.87
PTX06-1073A	634963.34	3758072.00	PTX07-1R03	627664.39	3764501.80
PTX06-1077A	637201.80	3760689.50	PTX08-1001	638950.13	3762969.23
PTX06-1080	638901.00	3772643.95	PTX08-1002	640878.64	3763005.65
PTX06-1081	641222.41	3770912.33	PTX08-1003	635385.36	3760136.56
PTX06-1082	653856.27	3780321.59	PTX08-1005	635316.66	3756346.19
PTX06-1083	658643.46	3779777.76	PTX08-1006	636400.41	3756761.86
PTX06-1085	629059.82	3760418.31	PTX08-1007	638898.35	3758429.95
PTX06-1086	631411.81	3759843.32	PTX08-1008	637485.10	3755695.51
PTX06-1088	639902.10	3757059.42	PTX08-1009	638866.95	3755275.01
PTX06-1089	646637.32	3760258.95	PTX08-1010	641401.47	3773206.74
PTX06-1090	647727.51	3757684.39	PTX10-1013	639664.44	3759944.21
PTX06-1091	646554.01	3756363.40			

*Coordinates shown for these wells are for the proposed well locations and will differ slightly when drilled.

APPENDIX E

Modified Compliance Plan Attachment B Well Specifications

COMPLIANCE PLAN ATTACHMENT B
MODIFIED WELL DESIGN AND CONSTRUCTION SPECIFICATIONS

The following well design and construction specifications should be used as guidance when designing a groundwater Compliance Monitoring Program (Section XI.C.) or a Corrective Action Program (Section XI.D.). This guidance is provided to establish minimum well design and construction specifications for the Compliance Plan.

1. Well drilling methods that minimize potential adverse effects on the quality of water samples withdrawn from the well and that minimize or eliminate the introduction of foreign fluids into the borehole must be utilized.

2. All wells shall be constructed such that the wells can be routinely sampled with a pump, bailer, or alternate sampling device. Piping associated with recovery wells should be fitted with sample ports or an acceptable alternative sampling method to facilitate sampling of the recovered groundwater on a well by well basis.

3. Above the saturated zone the well casing may be two (2)-inch diameter or larger schedule 40 or 80 polyvinyl chloride (PVC) rigid pipe or stainless steel or polytetrafluoroethylene (PTFE or “teflon”) or an approved alternate material. The PVC casing must bear the National Sanitation Foundation logo for potable water applications (NSF-pw). Solvent cementing compounds shall not be used to bond joints and all connections shall be flush-threaded. In and below the saturated zone, the well casing shall be stainless steel or PTFE.

   PVC or fiberglass reinforced resin may be used as an alternate well casing material in and below the saturated zone provided that it yields samples for groundwater quality analysis that are unaffected by the well casing material.

4. Any well that has deteriorated due to incompatibility of the casing material with the groundwater contaminants or due to any other factors must be replaced if the well material interferes with the evaluation of groundwater against expected conditions.

5. Well casings and screens shall be steam cleaned prior to installation to remove all oils, greases, and waxes. Well casings and screens made of fluorocarbon resins shall be cleaned by detergent washing.

6. Screen lengths exceeding ten (10) feet may be installed in groundwater recovery or injection wells to optimize the groundwater remediation process in accordance with standard engineering practice. Monitoring well screen length shall be installed as noted below:
   - Perched – screen across the entire saturated thickness (less than 40 ft in most cases).
   - Ogallala – screen across the entire saturated interval with blank casing segments set across less transmissive zones and between each screen interval. The uppermost screen interval will be based on the anticipated rate of decline in the water table, but will be no greater than 40 feet. Subsequent screen intervals up to 40 feet will be continued to enable sampling near the top of the water table for 30 years after installation. Blank casing segments separating the screen intervals will be 15 feet long. Screening of the lower portion of the aquifer will be determined by evaluation of lithologies and geophysical logs.

7. The intake portion of a well shall be designed and constructed so as to allow sufficient water flow into the well for sampling purposes and minimize the passage of formation materials into the well during pumping. The intake portion of a well shall consist of commercially manufactured stainless steel or PTFE screen or approved alternate material. The annular space between the screen and the borehole shall be filled with clean siliceous granular material (i.e., filter pack) that has a proper size gradation to provide mechanical retention of the formation sand and silt. The well screen slot size shall be compatible with the filter pack size as determined by sieve analysis data. The filter pack should extend no more than three (3) feet above the well screen. A silt trap, no greater than one (1) foot in length, may be added to the bottom of the well screen to collect any silt that may enter the well. The bottom of the well casing shall be capped with PTFE or stainless steel or approved alternate material.

Groundwater recovery and injection wells shall be designed in accordance with standard engineering practice to ensure adequate well production and accommodate ancillary equipment. Silt traps exceeding one (1) foot may be utilized to accommodate ancillary equipment. Well heads shall be fitted with mechanical wellseals, or equivalent, to prevent entry of surface water or debris.

8. A minimum of two (2) feet of pellet or granular bentonite shall immediately overlie the filter pack in the annular space between the well casing and borehole. Where the saturated zone extends above the filter pack, pellet or granular bentonite shall be used to seal the annulus. The bentonite shall be allowed to settle and hydrate for a sufficient amount of time prior to placement of grout in the annular space. Above the minimum two (2)-foot thick bentonite seal, the annular space shall be sealed with a cement/bentonite grout mixture. The grout shall be placed in the annular space by means of a tremie pipe or pressure grouting methods equivalent to tremie grouting standards.

   The cement/bentonite grout mixture or TCEQ approved alternative grout mixture shall fill the annular space to within two (2) feet of the surface. A suitable amount of time shall be allowed for settling to occur. The annular space shall be sealed with concrete, blending into a cement apron at the surface that extends at least two (2) feet from the outer edge of the monitor well for above-ground completions. Alternative annular-space seal material may be proposed with justification and must be approved by the executive director prior to installation.

   In cases where flush-to-ground completions are unavoidable, a protective structure such as a utility vault or meter box should be installed around the well casing and the concrete pad design should prevent infiltration of water into the vault. In addition, the following requirements must also be met 1) the well/cap juncture is watertight; 2) the bond between the cement surface seal and the protective structure is watertight; and 3) the protective structure with a steel lid or manhole cover has a rubber seal or gasket.

9. Water added as a drilling fluid to a well shall contain no bacteriological or chemical constituents that could interfere with the formation or with the chemical constituents being monitored. For groundwater recovery and injection wells, drilling fluids containing freshwater and treatment agents may be utilized in accordance with standard engineering practice to facilitate proper well installation. In these cases, the water and agents added should be chemically analyzed to evaluate their potential impact on in-situ water quality and to assess the potential for formation damage. All such additives shall be removed to the extent practicable during well development.

10. Upon completion of installation of a well, the well must be developed to remove any fluids used during well drilling and to remove fines from the formation to provide a particulate-free discharge to the extent achievable by accepted completion methods and by commercially available well screens. Development shall be accomplished by reversing flow direction, surging the well or by air lift procedures. No fluids other than formation water shall be added during development of a well unless the aquifer to be screened is a low-yielding water-bearing aquifer. In these cases, the water to be added should be chemically analyzed to evaluate its potential impact on in-situ water quality, and to assess the potential for formation damage.

    For recovery and injection wells, well development methods may be utilized in accordance with standard engineering practice to remove fines and maximize well efficiency and specific capacity. Addition of freshwater and treatment agents may be utilized during well development or re-development to remove drilling fluids, inorganic scale or bacterial slime. In these cases, the water and agents added should be chemically analyzed to evaluate their potential impact on in-situ water quality and to assess the potential for formation damage. All such additives shall be removed to the extent practicable during well development.

11. Each well shall be secured and/or designed to maintain the integrity of the well borehole and groundwater.

12. The above-ground portion of the well must be protected by bumper guards and/or metal outer casing protection when wells are located in traffic areas or outside the secured plant area.

13. Copies of drilling and construction details demonstrating compliance with the items of this provision shall be kept on site. This record shall include the following information:

. name/number of well (well designation);
. intended use of the well(sampling, recovery, etc.);
. date/time of construction;
. drilling method and drilling fluid used;
. well location ($\pm$ 0.5 ft.);
. bore hole diameter and well casing diameter;
. well depth ($\pm$ 0.1 ft.);
. drilling and lithologic logs;
. depth to first saturated zone;
. casing materials;
. screen materials and design;
. casing and screen joint type;
. screen slot size/length;
. filter pack material/size;
. filter pack volume (how many bags, buckets, etc.);
. filter pack placement method;
. sealant materials;
. sealant volume (how many bags, buckets, etc.);
. sealant placement method;
. surface seal design/construction;
. well development procedure;
. type of protective well cap;
. ground surface elevation ($\pm$ 0.01 ft. MSL);
. top of casing elevation ($\pm$ 0.01 ft. MSL); and,
. detailed drawing of well (include dimensions).

14. Construction or plugging and abandonment of each well shall be completed in accordance with the requirements of 16 TAC Chapter 76 and must be reported/certified to the TCEQ that such proper construction or plugging and abandonment has occurred following installation or plugging and abandonment. Well completion logs for each newly installed or replaced well shall be included with the report. The certification shall be prepared by a qualified geologist or geotechnical engineer. Each well certification shall be accompanied by a certification report, including an accurate log of the soil boring, which thoroughly describes and depicts the location, elevations, material specifications, construction details, and soil conditions encountered in the boring for the well. A copy of the certification and certification report shall be kept on-site, and a second copy shall be submitted to the executive director.

15. The well number must be clearly marked and maintained on each well at the site.

16. The elevation of the top of each well casing must be measured in feet above mean sea level to the nearest 0.01 foot.

17. Wells must be replaced at any time the well integrity or materials of construction or well placement no longer enable the well to yield samples representative of groundwater quality.

18. Soil test borings shall be plugged and wells removed from service with a cement/bentonite grout mixture so as to prevent the preferential migration of fluids in the area of the borehole. Certification of each plugging shall be reported in accordance with Provision 14. The plugging of wells shall be in accordance with 16 TAC Chapter 76 dealing with Well Drilling, Completion, Capping and Plugging.

19. A well's screened interval shall be appropriately designed and installed to meet the well's specific objective (i.e., either DNAPL, LNAPL, both, or other objective of the well). All wells designed to detect, monitor, or recover DNAPL must be drilled to intercept the bottom confining layer of the aquifer. The screened interval to detect DNAPL should extend from the top of the lower confining layer to above the portion of

the aquifer saturated with DNAPL. The screened interval for all wells designed to detect, monitor, or recover LNAPL must extend high enough into the vadose zone to provide for fluctuations in the seasonal water table. In addition, the sandpacks for the recovery or monitoring well's screened interval shall be coarser than surrounding media to ensure the movement of NAPL to the well.

APPENDIX F

Well Construction Diagrams and Approach to Construction of New Ogallala Aquifer Wells

F. WELL CONSTRUCTION DIAGRAMS AND APPROACH TO CONSTRUCTION OF NEW OGALLALA AQUIFER WELLS

Seven new wells are proposed in the Ogallala Aquifer as early detection wells near perched groundwater contamination and for uncertainty management. This section provides the diagrams and information for proposed well installations.

F.1. OGALLALA AQUIFER DRILLING AND WELL INSTALLATION DECISION PROCESS

Ogallala aquifer monitoring well drilling will progress in steps. An Air Rotary Casing Hammer (ARCH) drilling rig will initially be used to bore through the Blackwater Draw and upper Ogallala Formations to the FGZ, generally about 260 to 290 feet bgs. An 8-inch carbon steel conductor casing will then be set and permanently cemented from the FGZ to ground surface. The Portland cement used to grout the conductor casing will be allowed to cure a minimum of 24 hours before drilling operations continue. Mud rotary drilling then will be used to complete the borehole. This method includes a containment system that will hold all drilling fluids and cuttings until the well is completed. All grout will be segregated from this system. The borehole will be advanced to the Permian redbeds. At completion of drilling activities, a series of geophysical surveys will be run in the borehole. The geophysical logging suite will consist of natural gamma, spontaneous-potential, and resistivity. A video survey may also be completed on the Ogallala aquifer monitoring well. This survey will be completed after the well is developed and at the end of the drilling program in order to ensure clarity of the well. At the conclusion of logging activities and following evaluation of the geophysical and lithological logs by the field geologist, 5-inch, Schedule 10, Type 316, stainless steel screen and casing will be used to construct the well. This procedure will be used for any other Ogallala aquifer monitoring wells that may be installed during the project. Drilling activities are described in more detail below.

During all drilling operations, the lithology of the soil and rock cuttings will be described and logged on standard field forms. Lithologic descriptions will conform to USCS criteria. Munsell soil and rock color charts will be used to facilitate uniform naming of soil/rock colors. Additionally, the on-site geologist may conduct field sieve analysis of soil samples collected from selected intervals using a core barrel or split-spoon type sampler.

After installation of the conductor casing, drilling will continue with mud rotary methods through the Ogallala and Dockum Formations to the Permian redbeds. The Triassic/Permian contact beneath the site is often difficult to identify based solely on drill cuttings. It is necessary to penetrate the Permian formation at least ten feet in order to identify the correct natural gamma and resistivity curves on a geophysical log. Therefore, drilling will terminate when the field geologist has identified the contact based on lithology, penetration-rate, and inferred data from the nearest existing wells. This will occur at about ten to fifteen feet into the Permian formation.

The well will be constructed using a 5-inch, Schedule 10, Type 316 stainless steel riser and screen with a sump up to 5 feet in length. Well materials will either be pre-cleaned and packaged for environmental use by the manufacturer, or steam-cleaned at the decontamination pad prior to installation. Sand will be used to fill the bottom 10 to 15 feet of the over-drilled hole beneath the well. The bottom of the well screen will be set as close as possible to the Triassic/Permian contact. The top of the well screen will be set about five feet above the saturated interval of the Ogallala aquifer. A sand filter pack will be placed around the screened interval in the annulus between the well and borehole. The filter pack will extend from total depth of the well to at least three feet above the well screen. A five-foot thick bentonite seal will be placed in the annulus on top of the sand pack. The remaining annular space will be filled with Volclay or equivalent grout to the surface.

The surface completion of the Ogallala aquifer monitoring well will be constructed similarly to existing wells. Unauthorized access to the well will be restricted with a temporary cover until the permanent wellhead is constructed. The wellhead will consist of a 10-inch steel protective casing with a locking cover installed over the well and centered in a concrete pad. The concrete pad will have 25 square feet of surface area measuring 5 feet by 5 feet. The pad will be 8 inches thick with 6 inches below ground. Four 3-inch steel bollards will be placed exactly vertical within the concrete pad and equidistant from the edges of the pad and each other. The concrete pad and bollards will be oriented parallel to adjacent roads and/or fences. The wellhead will be painted to match existing wellheads. A brass plate stamped with the well number will be set in the surface of the pad to serve as the survey marker.

F.2. MULTIPLE WELL SCREEN INTERVAL DETERMINATION

The primary method for determination of the depth intervals for the different screen lengths and intervening blank casing sections is the interpretation of the geophysical logs. While there usually is sufficient and detailed information available from the field notes (provided in final form as lithologic logs), there can be a lag time for specific sediment intervals to be transported to the surface via the drilling mud/water solution. This lag time results in depth intervals for the various geologic strata (gravels, sands, clays) in the geologic field note descriptions being off slightly from those shown on the geophysical logs. Sometimes the discrepancy can be 20 feet or more. Therefore, the geophysical logs are used as the primary guidance for well construction.

Examination of well logs from two previously installed wells show clayey intervals that were “blanked-off” from the screened sections. Some of the clay intervals were not noted on the lithologic logs, but in general all significant sand and/or gravel zones were noted. These sediments are usually easier to identify when drilling with mud-rotary methods. The geophysical logs also help identify prominent sandy/gravelly zones.

Field methods utilized for well completion will be as described above for lithologic descriptions followed by conducting the geophysical logging as soon as the drill stem is removed from the borehole. Following the logging, a printout is made in the field and the geologist compares it to the notes made during drilling to determine the approximate lag time between observed depths of sediments and their actual depths. Once the entire saturated interval has been evaluated, a determination will be made if there are significant clayey layers that should be eliminated, or “blanked-off” from the screened section. Equally important is well construction that ensures screened intervals “capture” significant sand/gravel layers that may be preferentially transmissive zones. This information will be provided to the Pantex technical representative and upon agreement, conveyed to the drilling subcontractor and well construction started. The time interval between geophysical logging completion and well construction start-up should be as soon as possible (1 hour preferred) to prevent borehole collapse.

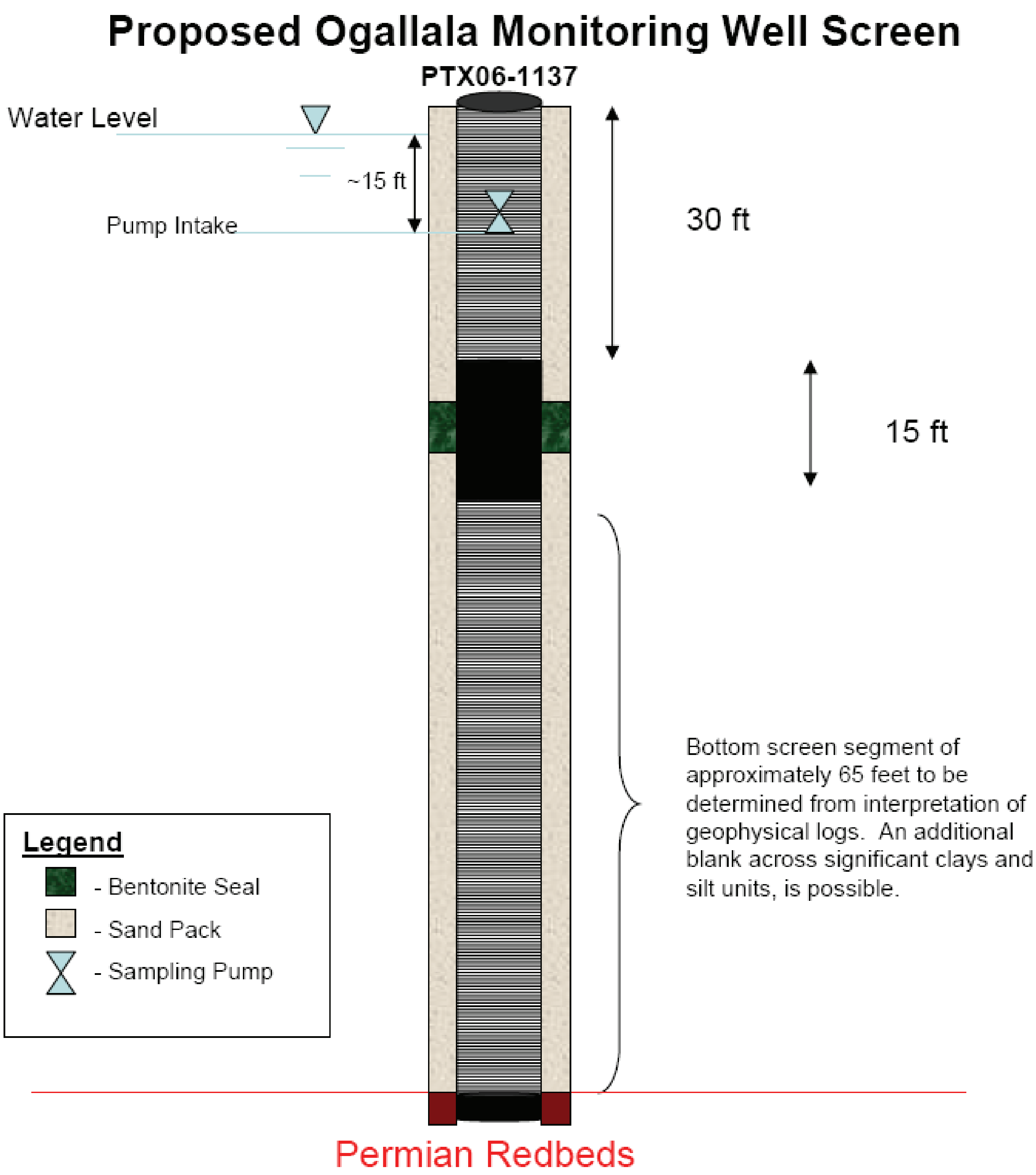
Table F-1. Proposed Screen Segments for New Ogallala Wells

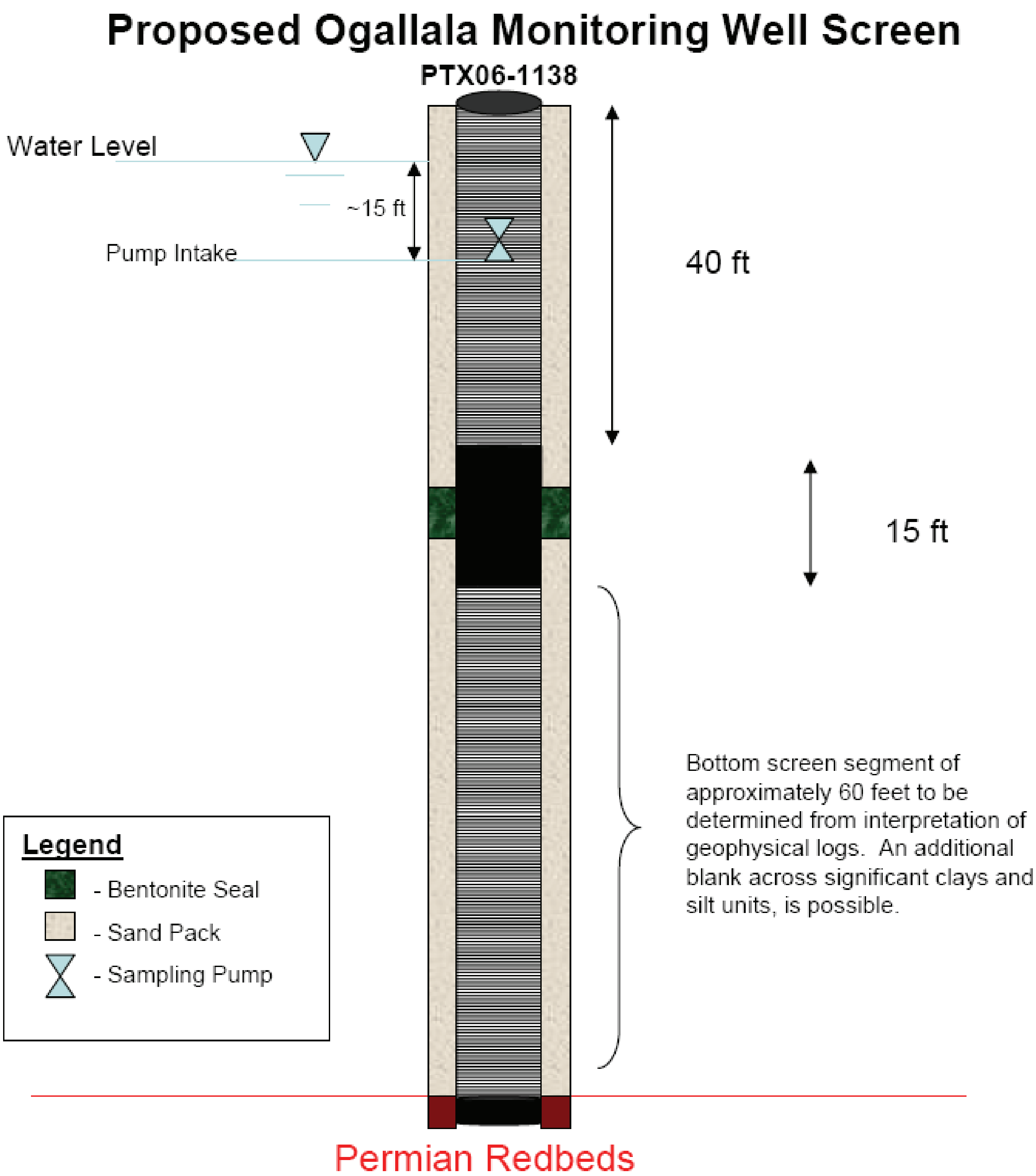
Well ID	Projected Saturated Thickness (ft)	Observed Rate of Decline (ft/yr)	Estimated 30-yr Decline[1] (ft)	First Screen Segment[2] (ft)	Second Screen Segment (ft)	No. of 15-ft Blank Segments	Bottom Screen Segment (ft)
PTX06-1137	105	0.9	27	30	N/A	1	63
PTX06-1138	107	1.1	33	40	N/A	1	59
PTX06-1139	70	0.7	21	30	N/A	1	34
PTX06-1140	145	1.2	36	40	30	2	49
PTX06-1141	282	1.2	36	40	40	2	176
PTX06-1143	272	2	60	40	40	2	172
PTX06-1144	315	2	60	40	40	2	215

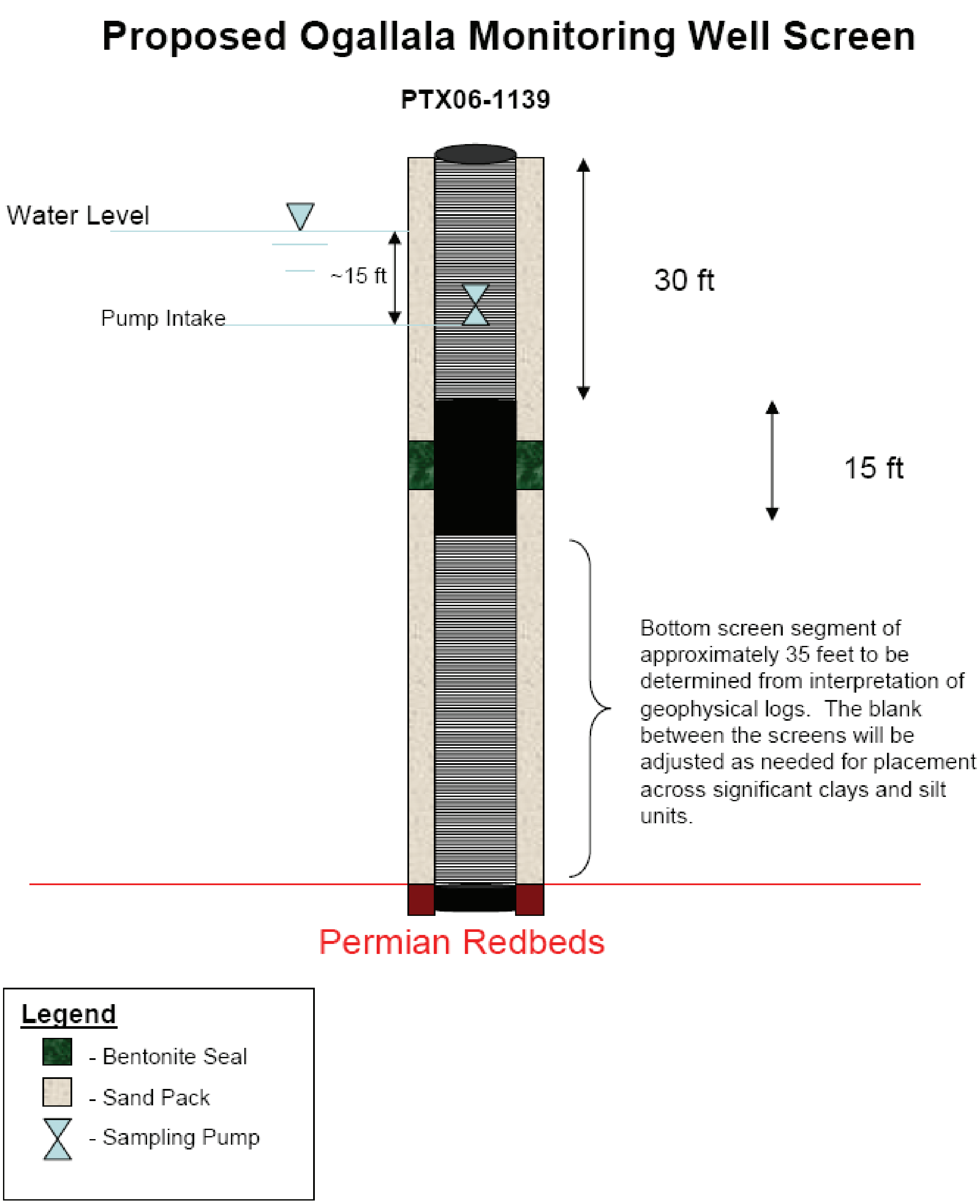
[1] Based on review of trends for the annual rate of water level decline in nearby Ogallala Aquifer monitoring wells.

[2] Accounts for screen above the top of water (between 3 and 10 feet); length of this segment limited to no more than 40 feet.

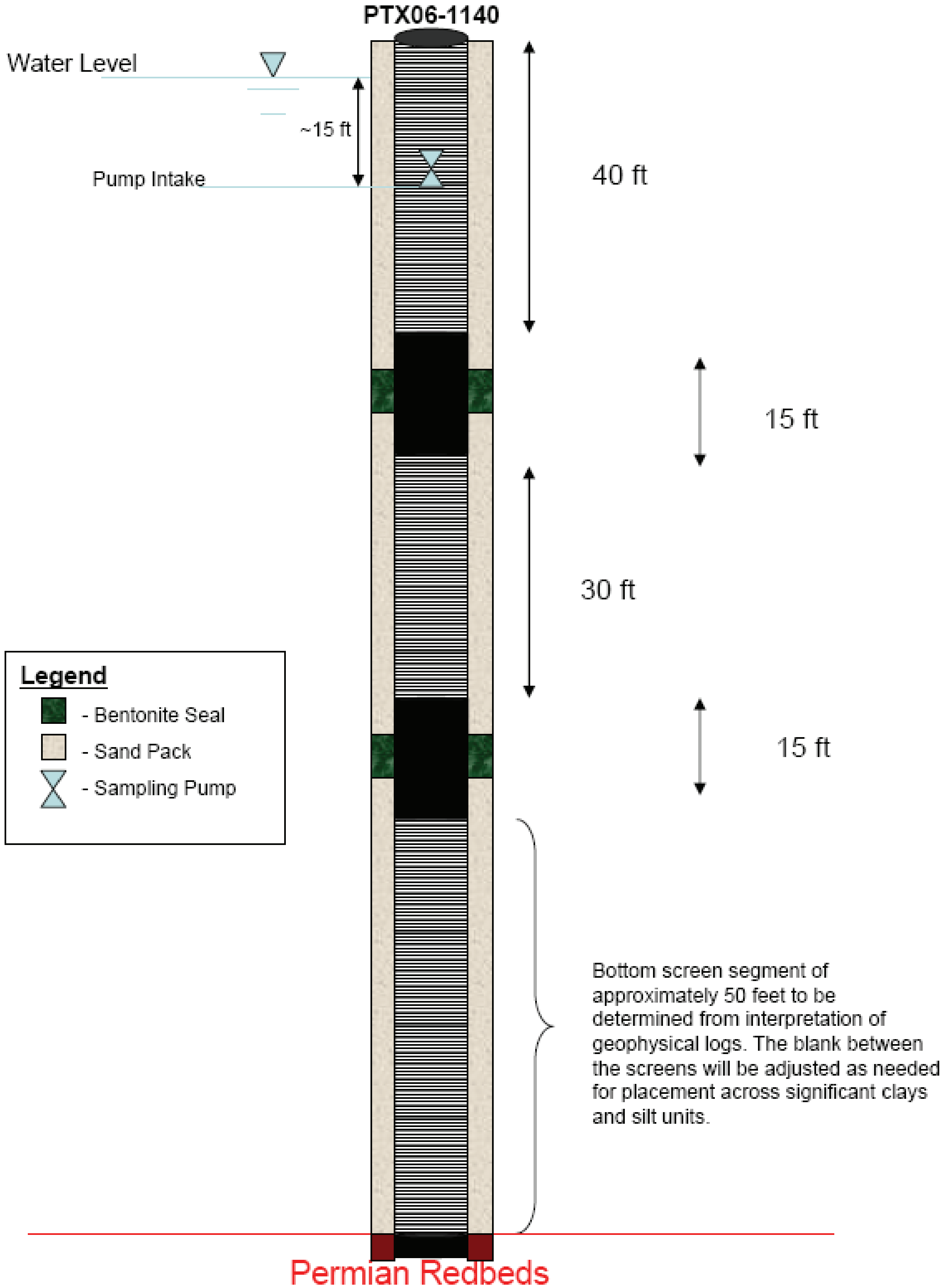
F.3. PROPOSED WELL CONSTRUCTION DIAGRAMS



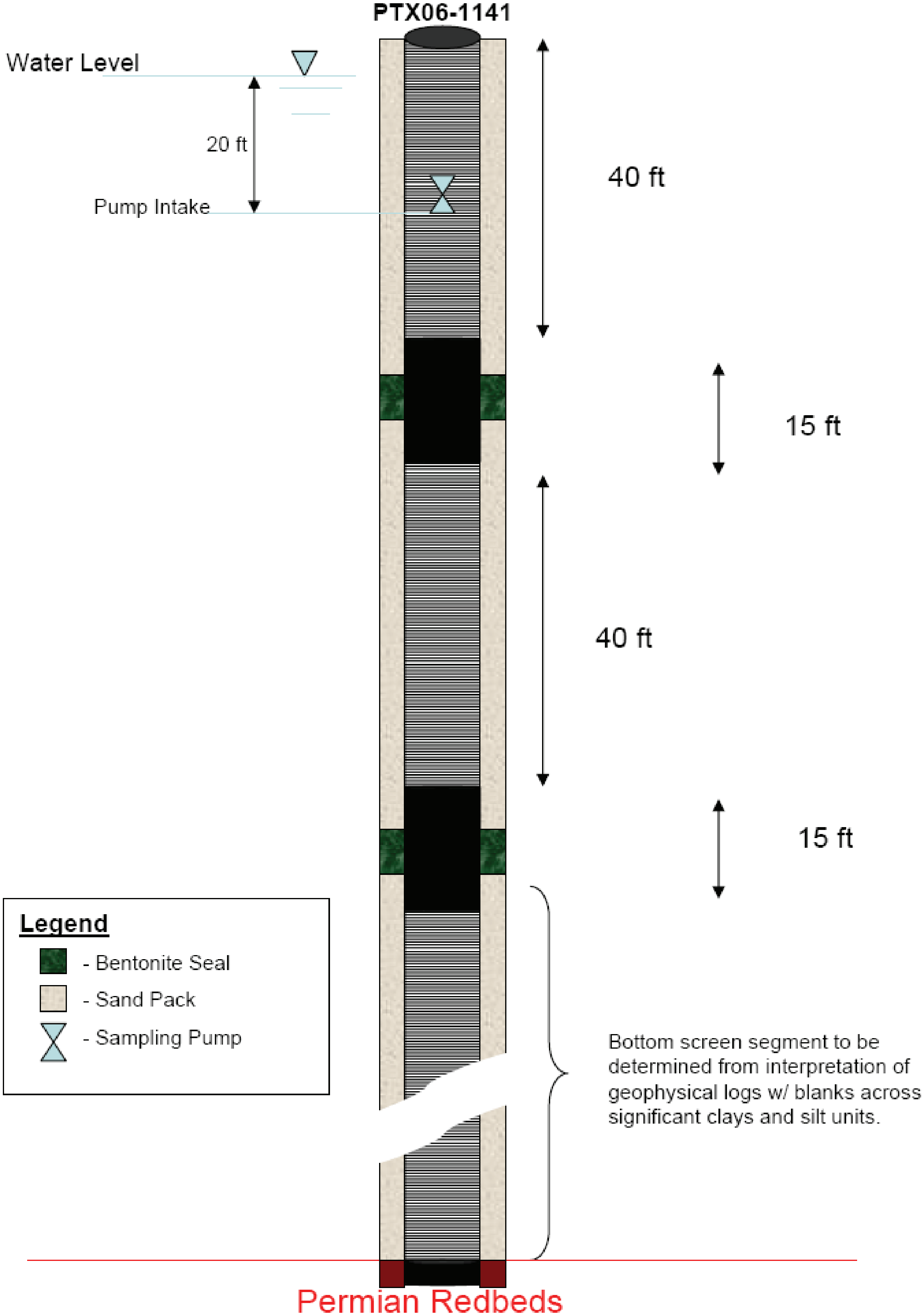

Proposed Ogallala Monitoring Well Screen
PTX06-1138
Water Level
~15 ft
Pump Intake
40 ft
15 ft
Bottom screen segment of approximately 60 feet to be determined from interpretation of geophysical logs. An additional blank across significant clays and silt units, is possible.
Legend
- Bentonite Seal
- Sand Pack
- Sampling Pump
Permian Redbeds


Proposed Ogallala Monitoring Well Screen
PTX06-1139
Water Level
~15 ft
Pump Intake
30 ft
15 ft
Bottom screen segment of approximately 35 feet to be determined from interpretation of geophysical logs. The blank between the screens will be adjusted as needed for placement across significant clays and silt units.
Permian Redbeds
Legend
- Bentonite Seal
- Sand Pack
- Sampling Pump

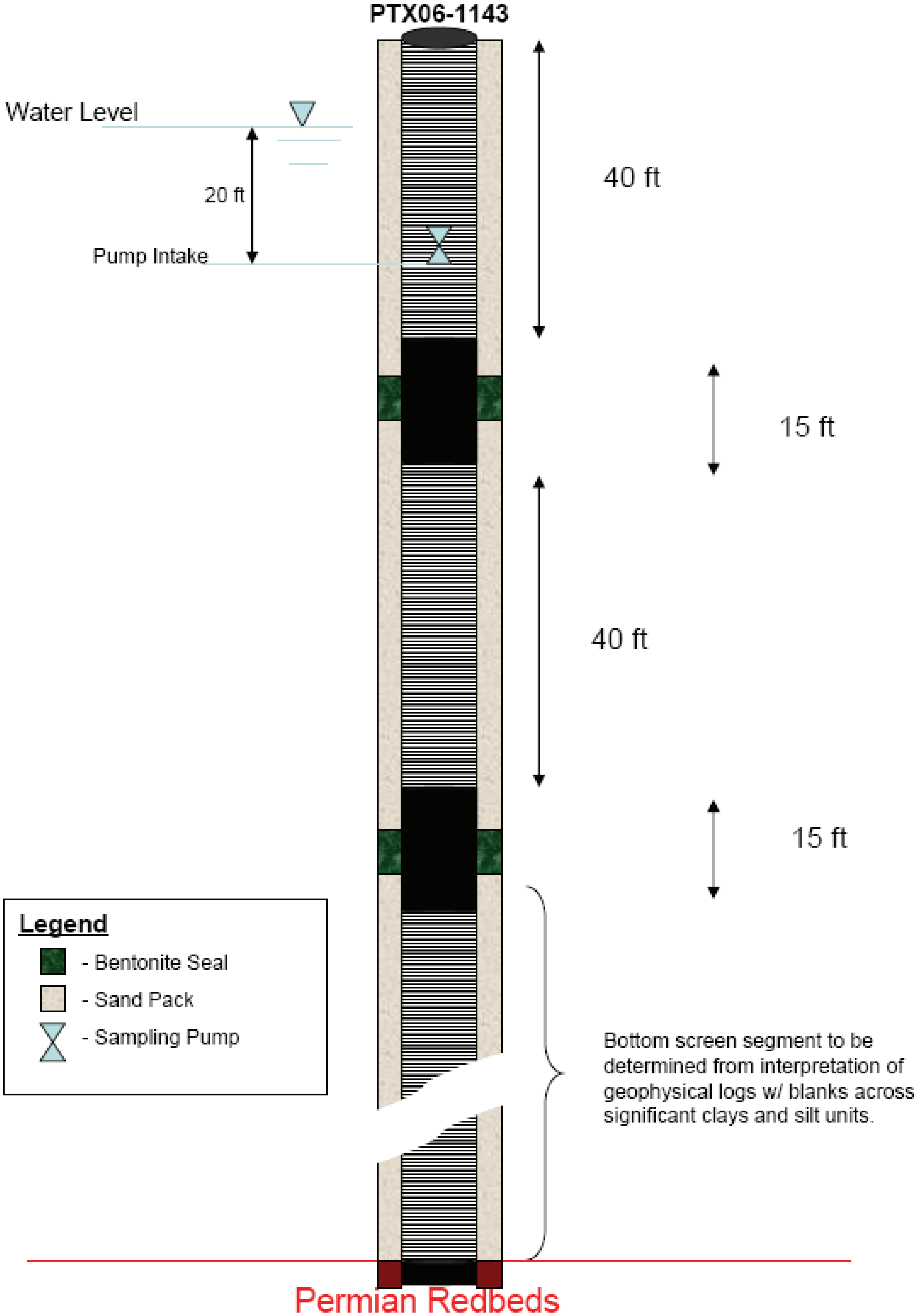
Proposed Ogallala Monitoring Well Screen

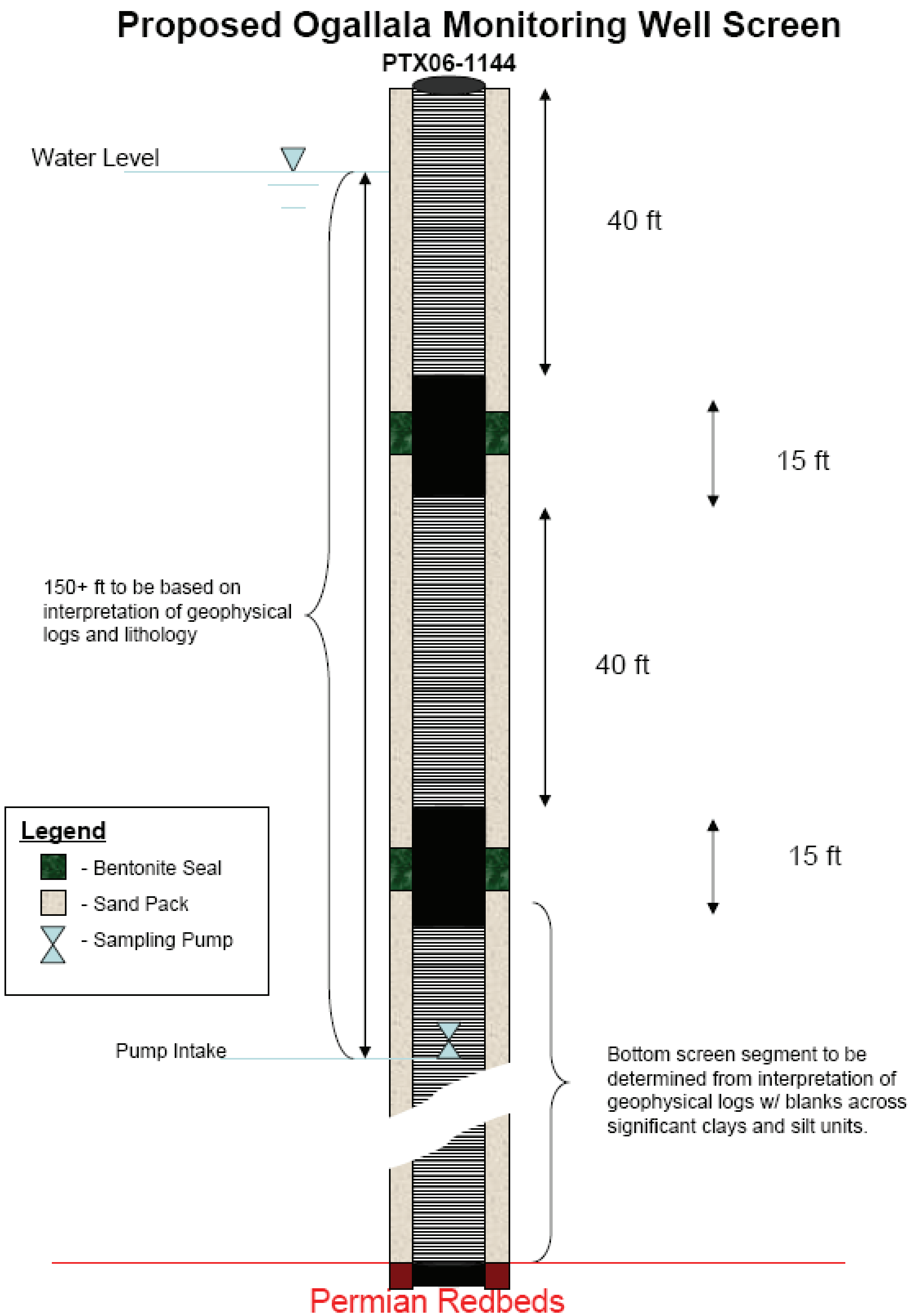


Proposed Ogallala Monitoring Well Screen



Proposed Ogallala Monitoring Well Screen




Proposed Ogallala Monitoring Well Screen
PTX06-1144
Water Level
40 ft
15 ft
150+ ft to be based on interpretation of geophysical logs and lithology
40 ft
Legend
- Bentonite Seal
- Sand Pack
- Sampling Pump
15 ft
Pump Intake
Bottom screen segment to be determined from interpretation of geophysical logs w/ blanks across significant clays and silt units.
Permian Redbeds