National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020

July 30, 2014

Reply to Attn of: RE-14-089

Mr. John E. Kieling, Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: NASA WSTF Remediation System Monitoring Plan Annual Update

Enclosed is the NASA WSTF Remediation System Monitoring Plan (RSMP) Annual Update for 2014 as required by SectionVI.F.1 of the NASA Hazardous Waste Permit No. NM8800019434. The updated plan provides monitoring requirements for the Mid-plume Interception and Treatment System and the Plume Front Treatment System. This submittal includes an Executive Summary as Enclosure 1, a complete bound paper copy of the RSMP as Enclosure 2, and a CD-ROM with the complete RSMP in PDF as Enclosure 3.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for known violations.

If you have any questions or comments concerning this submittal, please contact Mike Zigmond at 575–524–5484.

Radel Bunker-Farrah
Chief, Environmental Office

3 Enclosures

cc:
Mr. Dan Comeau
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Executive Summary

This NASA Johnson Space Center White Sands Test Facility (WSTF) Remediation System Monitoring Plan (RSMP) includes updated information relative to the operation and monitoring of the Plume Front Treatment System (PFTS) and Mid-plume Interception and Treatment System (MPITS) as of July 2013. PFTS monitoring is conducted in accordance with NASA WSTF's Hazardous Waste Permit (Permit), issued by the New Mexico Environment Department (NMED) in November 2009 (NMED, 2009). Permit Section VII.F requires that NASA develop a PFTS Monitoring Plan to set forth detailed methods, procedures, and schedules for groundwater monitoring to determine the progress and effectiveness of the PFTS. The Permit requires that NASA submit updates to the PFTS Monitoring Plan annually on or before August 1. MPITS monitoring was previously conducted in accordance with the MPITS Monitoring Plan submitted to NMED on October 30, 2008 (NASA, 2008) and a variety of internal NASA documentation. The 2012 RSMP consolidated monitoring requirements for both active groundwater remediation systems into one document. This plan is used in conjunction with WSTF Groundwater Monitoring Plan (GMP; NASA, 2010a) to ensure adequate monitoring of groundwater remediation systems at WSTF.

This Plan supersedes the WSTF Plume Front Stabilization Work Plans (NASA, 1999; 2002), WSTF Plume Front Stabilization Project Plans (NASA, 1994; 1996), WSTF Mid-plume Interception and Treatment System Monitoring Plan (NASA, 2008), and Plume Front Treatment System Monitoring Plan (NASA, 2010b), including updates.

Significant activities at the PFTS and changes that impacted the PFTS since the 2012 RSMP Update was submitted on July 31, 2012 include the following.

- Beginning in November 2012, NASA discontinued pumping at PFE-7 because contaminant concentrations had dropped below cleanup levels at that location and continued extraction diluted contaminant concentrations in the PFTS influent. Intermittent pumping of PFE-7 continued through July 2013 to ensure adequate plume capture. The evaluation of intermittent pumping continues.
- NASA performed a series of characterization tests at the PFTS to determine the UV requirements for complete NDMA destruction at varying UV output and flow rates. Results indicate that complete groundwater treatment can be achieved with lower UV output than currently utilized. NASA may consider reducing UV output at the PFTS to reduce electrical power consumption.
- NASA performed routine scheduled maintenance of the PFTS during February 2013.
- NASA investigated the potential for replacing the pressure activated Cla-Val valves in the injection wells with electrically actuated positioning valves in order to improve injection well backwashing capabilities and to minimize air entrainment during injection. NASA expects to implement this change in mid to late 2013.
- Throughout 2012 and 2013 NASA continued efforts to upgrade the control and communication systems at the PFTS.

During the past year the MPITS has operated at varying flow rates. Significant activities performed during this time include the following.

- In September 2012 NASA completed installation of extraction wells MPE-8 and MPE-9 and connected the wells to the treatment system. The two wells were pumped intermittently between September and December 2012 when they were shut down to perform an aquifer recharge test.
- NASA continued working with Envirogen Technologies to operate a pilot scale bioreactor in the MPITS building to study the feasibility for bioremediation of NDMA-contaminated groundwater at WSTF. In June 2012 the bioreactor operated at a flow rate of approximately 0.7 gallons per minute (gpm) of NDMA-contaminated groundwater. The flow rate was increased to 1.4 gpm in August 2012, 2.2 gpm in September 2012, 2.4 gpm in October 2012, and 4.4 gpm in November 2012. The first phase of testing, in which influent only contained NDMA, was completed in December 2012 and the feed of contaminated groundwater was discontinued to prepare for the second phase of testing. In January 2013, the bioreactor was restarted and treatment of groundwater contaminated with both NDMA and volatile organic compounds was initiated. The pilot scale test was completed in March 2013 and the bioreactor and associated hardware was shipped off-site in April 2013. Data collected during the pilot scale test indicate a significant reduction in the concentration of NDMA in the treated groundwater. Final results are pending.
- In late March 2013 NASA shut down the MPITS to clean the UV reactor and remove flow meters for calibration at an off-site facility. The system was shut down through July 2013, during which time NASA completed flow meter calibrations, performed a variety of software upgrades to the MPITS control system, and performed numerous hardware upgrades to enhance system operational capabilities.

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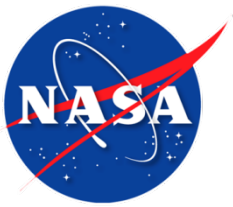

National Aeronautics and
Space Administration

Remediation System Monitoring Plan

July 2014

NM8800019434
NASA Johnson Space Center White Sands Test Facility
12600 NASA Road, Las Cruces, New Mexico 88012

NASA Johnson Space Center White Sands Test Facility

Remediation System Monitoring Plan

July 2014

Certification Statement

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for known violations.

Radel Bunker-Farrah
Chief, NASA Environmental Office

7-30-14
Date

Executive Summary

This NASA Johnson Space Center White Sands Test Facility (WSTF) Remediation System Monitoring Plan (RSMP) includes updated information relative to the operation and monitoring of the Plume Front Treatment System (PFTS) and Mid-plume Interception and Treatment System (MPITS) as of July 2014. PFTS monitoring is conducted in accordance with NASA WSTF's Hazardous Waste Permit (Permit), issued by the New Mexico Environment Department (NMED) in November 2009 (NMED, 2009). Permit Section VII.F requires that NASA develop a PFTS Monitoring Plan to set forth detailed methods, procedures, and schedules for groundwater monitoring to determine the progress and effectiveness of the PFTS. The Permit requires that NASA submit updates to the PFTS Monitoring Plan annually on or before August 1. MPITS monitoring was previously conducted in accordance with the MPITS Monitoring Plan submitted to NMED on October 30, 2008 (NASA, 2008) and a variety of internal NASA documentation. The 2012 RSMP consolidated monitoring requirements for both active groundwater remediation systems into one document. This plan is used in conjunction with the updated WSTF Groundwater Monitoring Plan (GMP; NASA, 2014) to ensure adequate monitoring of groundwater remediation systems at WSTF.

This Plan supersedes the monitoring-related sections of the WSTF Plume-Front Stabilization Work Plans (NASA, 1999; 2002), WSTF Plume-Front Treatment System Project Plans (NASA, 2004; 2006), WSTF Mid-plume Interception and Treatment System Monitoring Plan (NASA, 2008), and the Plume Front Treatment System Monitoring Plan (NASA, 2010b), including updates.

Significant activities at the PFTS and changes that impacted the PFTS since the 2013 RSMP Update was submitted on July 31, 2013 include the following.

- In November 2013, NASA eliminated all mechanical connections in the PFTS fiber optics communication network by welding all fiber optic connections. This change improved system communications and significantly reduced communication errors and related shutdowns.
- NASA performed routine scheduled maintenance of the PFTS during November 2013 and July 2014.
- In March 2014, NASA replaced obsolete variable frequency drives in both PFTS air strippers.
- NASA planned and performed a characterization test at the PFTS in May 2014 to determine if ultraviolet (UV) lamps from an alternate supplier provided adequate treatment of NDMA in WSTF groundwater. Analytical data confirmed that the lamps treated NDMA to levels comparable to those with manufacturer-supplied lamps. NASA initiated use of the alternate lamps in June 2014, which significantly reduced the cost of UV lamp replacement while maintaining PFTS performance at expected levels.
- Throughout 2013 and 2014, NASA continued efforts to upgrade the control and communication systems at the PFTS.

During the past year, the MPITS has operated at varying flow rates. Significant activities performed during this time include the following.

- In July 2013, MPITS instrumentation was damaged significantly by lightning. NASA investigated the damage and performed the required repairs in July and August 2013. During subsequent months, NASA installed a passive lightning protection system at potentially vulnerable locations in the MPITS.

- In August 2013, NASA reconfigured the MPITS to allow automated cleaning of the UV reactor when UV irradiance drops below specified levels and activated extraction well MPE-8 following its rehabilitation.
- Well MPE-9 was brought online in January 2014, slightly increasing the system flow rate. The pump in MPE-10 was also replaced in January 2014 to better match the pumping rate with well production.
- In April 2014, well the motor in well MPE-11 failed, causing the well to be taken out of service. Repairs are planned for August 2014.

Table of Contents

Abbreviations and Acronyms

µg/L	Micrograms per liter
µm	Micrometer
AMSL	Above mean sea level
bgs	Below ground surface
CCB	Communications control board
COC	Contaminant of concern
DP	Discharge Permit
EPA	Environmental Protection Agency
gal	Gallon
GMP	Groundwater Monitoring Plan
gpm	Gallons per minute
HDPE	High-density polyethylene
HMI	Human-machine interface
HWB	Hazardous Waste Bureau
km	Kilometer
LRG	Lower Rio Grande
MPCA	Mid-plume Constriction Area
MPE	Mid-plume extraction
MPITS	Mid-plume Interception and Treatment System
NASA	National Aeronautics and Space Administration
NDMA	N-Nitrosodimethylamine
ng/L	Nanograms per liter
NMED	New Mexico Environment Department
PCE	Tetrachloroethene
PFE	Plume front extraction
PFI	Plume front injection
PFTS	Plume Front Treatment System
PLC	Programmable logic controller
PMR	Periodic Monitoring Report
ppb	Parts per billion
ppt	Parts per trillion
psid	Pounds per square inch, differential
psig	Pounds per square inch, gauge
PVC	Polyvinyl chloride
QA	Quality assurance
RSMP	Remediation System Monitoring Plan
SCADA	Supervisory control and data acquisition
scfm	Standard cubic feet per minute
SLC	Small logic controller
T-C	Time-concentration
TCE	Trichloroethene
UV	Ultraviolet
VOC	Volatile organic compound
WSTF	NASA Johnson Space Center White Sands Test Facility

History of Revisions and Related Documents

Date	Revision or Document
January 20, 1999	Plume Front Stabilization Work Plan (PFSWP) submitted to NMED
March 15, 2000	PFSWP approved by NMED
May 16, 2002	Modification of PFSWP submitted to NMED - Plan was not approved by NMED
March 3, 2004	Plume Front Treatment System Project Plan (PFTSPP) submitted to NMED - Plan discussed technical issues raised in NMED Request for Supplemental Information dated April 4, 2003
July 15, 2004	Revised PFTSPP submitted to NMED
November 8, 2006	Revised PFTSPP submitted to NMED
May 14, 2007	Revised PFTS approved by NMED - Approval also included March 3, 2004 submittal
October 30, 2008	Mid-plume Interception and Treatment System Monitoring Plan submitted to NMED
June 8, 2010	Plume Front Treatment System Monitoring Plan submitted to NMED
August 26, 2010	PFTSMP approved by NMED
July 29, 2011	Scheduled 2011 update of PFTSMP submitted to NMED
September 22, 2011	PFTSMP 2011 update approved by NMED
July 31, 2012	Remediation System Monitoring Plan submitted to NMED - RSMP includes monitoring requirements for the Mid-plume Interception and Treatment System
September 11, 2012	RSMP approved by NMED
July 31, 2013	2013 RSMP Update submitted to NMED
September 27, 2013	2013 RSMP Update approved by NMED

1.0 Introduction

The White Sands Test Facility (WSTF) currently operates as a field test installation under the National Aeronautics and Space Administration (NASA) Lyndon B. Johnson Space Center. WSTF is a restricted access site and all activities are industrial in nature. Although the primary purpose of the facility is to provide test services and support to NASA for the United States space program, services are also provided for the Department of Defense, Department of Energy, private industry, and foreign government agencies. WSTF operates several laboratory facilities that conduct simulated use tests for space vehicles and space station materials and compatibility testing.

WSTF is located approximately 18 miles (29 km) northeast of Las Cruces, New Mexico. Figure 1.1 provides a vicinity map that shows the general location of WSTF relative to other dominant features and major properties in southern Doña Ana County. Groundwater at WSTF is contaminated as a result of historical operations at the site. Currently, there are no complete exposure pathways or human or ecological receptors. Downgradient public and WSTF water supply wells comprise potential future pathways for exposure to groundwater contamination. Under current conditions the nearest downgradient water use wells are WSTF water supply Well J (Lower Rio Grande [LRG] 06369 S), WSTF water supply Well K (LRG 06369 S-2), and a private water well (LRG 06393) located down-gradient of the plume and outside the westernmost WSTF boundary. Routine sampling of drinking water from Wells J and K indicate that the WSTF water supply wells have not been impacted by WSTF groundwater contaminants. NASA has constructed and currently operates two voluntary interim measures that were designed to stabilize migration of the groundwater plume and to remove hazardous constituents from the groundwater. Figure 1.2 shows the conceptualized trichloroethene (TCE) and N-Nitrosodimethylamine (NDMA) plumes (the most extensive contaminants in WSTF groundwater) in relation to relevant site features.

The Plume Front Treatment System (PFTS) is a voluntary interim measure implemented to control threats to human health and the environment through stabilization and mass removal of groundwater contamination encountered at the leading (westernmost) edge of the WSTF groundwater contaminant plume. The plume is approximately four miles long and one mile wide at its widest point, and has an average depth of 700 ft. The PFTS is an ex-situ pump and treat system that uses five Plume Front extraction (PFE) wells and four Plume Front injection (PFI) wells. The five extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-7) are located within and immediately west of the Western Boundary Fault Zone that separates the fractured bedrock pediment aquifer (east) from the Jornada del Muerto Basin alluvial aquifer (west). Groundwater from the extraction well system is treated by air stripping to remove volatile organic compounds (VOCs), filtration for particulate removal, and ultraviolet (UV) photolysis for NDMA oxidation. Remediated groundwater is injected using four PFI wells (PFI-1, PFI-2, PFI-3, and PFI-4) located to the west and south of the contaminant plume in accordance with Discharge Permit DP-1255, issued by the NMED Ground Water Quality Bureau on September 26, 2011 (NMED, 2011). The injection well locations are designed to mitigate future southern migration of the plume by creating a localized groundwater mound. This groundwater mound supports confinement of the groundwater plume to the northeast, and counteracts the effects of drawdown from current and planned domestic and municipal supply wells to the south. Figure 1.2 shows the location of PFTS components in relation to facility and geological features at WSTF.

The Mid-plume Interception and Treatment System (MPITS) is also a voluntary interim measure. The objective of the MPITS is to intercept and treat contaminated groundwater moving from the source areas in the WSTF industrial area toward the Plume Front area. The MPITS is installed within the Mid-plume Constriction Area (MPCA), a unique hydrogeological feature that constricts the flow of contaminated groundwater between the source areas and the Plume Front. The MPITS is an ex-situ pump and treat system that operates with up to five Mid-plume extraction (MPE) wells (MPE-1, MPE-8, MPE-9, MPE-

10, and MPE-11) to remove contaminated groundwater from a series of bedrock fractures in the MPCA. Extracted groundwater is treated by air stripping to remove VOCs, filtration for particulate removal, and UV photolysis for the oxidation of NDMA. Remediated groundwater is discharged to an infiltration basin located near the PFI wells in accordance with DP-1255. Figure 1.2 shows the location of MPITS components in relation to facility and geological features at WSTF.

2.0 Treatment System Regulatory Requirements

This RSMP was developed and will be updated annually in accordance with Section VII.F of NASA's Hazardous Waste Permit (Permit), issued by the New Mexico Environment Department (NMED) in November 2009 (NMED, 2009). The Permit requires that NASA develop a PFTS Monitoring Plan to set forth detailed methods, procedures, and schedules for groundwater monitoring to determine the progress and effectiveness of the PFTS. In July 2012 NASA revised the PFTS Monitoring Plan to include the necessary elements to direct monitoring of other remediation systems. That updated plan was approved by NMED on September 11, 2012 (NMED, 2012). The Permit and relevant subsequent NMED correspondence provide the regulatory criteria for the development and regular update of a monitoring plan for NASA's groundwater remediation systems.

NMED-issued DP-1255 (NMED, 2011) provides the regulatory requirements for discharging treated groundwater from WSTF groundwater remediation systems. DP-1255 specifies the treatment standards for groundwater contaminants of concern (COCs): NDMA, TCE, tetrachloroethene (PCE), and chloroform. Table 1.1 provides the groundwater treatment standards specified in DP-1255 that must be achieved prior to the discharge of treated groundwater to the PFI wells or MPITS infiltration basin.

3.0 Treatment System Descriptions

3.1 Plume Front Treatment System

The PFTS was designed to pump and treat VOC and nitrosamine-contaminated groundwater. Original design flow rates for each extraction well were determined based on groundwater modeling that estimated the lowest sustained groundwater extraction rate capable of containing the plume and preventing significant movement in the westward direction. Original design injection well flow rates were determined in the same manner. Subsequent refinements to the groundwater model have shown that the response of the aquifer to continued pumping may justify lower extraction flow rates than those identified during PFTS design. NASA may consider lower extraction well flow rates in the future to optimize system performance.

The system currently utilizes five extraction wells to remove contaminated groundwater. The PFE wells are secured in concrete vaults with associated piping, equipment, and instrumentation. Appendix A provides the completion diagrams for the active PFE wells. Contaminated groundwater is transported from the PFE wells to the treatment plant via sub-grade, dual-wall, high-density polyethylene (HDPE) piping. A leak detection system monitors the annular space of the dual-wall piping, the well vaults, and the pipeline manholes. This system notifies operators with a local alarm and initiates a system shutdown if a water leak is detected.

The HDPE carrier pipeline transitions to single-wall carbon steel piping at the PFTS facility (Building 650). A scale control chemical (polyphosphate) is injected at this point to inhibit scale formation in the process equipment. The groundwater flow is split equally into the two air strippers for VOC removal. Water is pumped from each air stripper sump and combined into a single steel header, which conveys the water through a cartridge filter set and then through the UV reactor to remove NDMA.

Following UV photolysis, the treated effluent is conveyed to the Injection Manifold Building (Building 651) via single walled HDPE pipe. There the flow is split into four individual streams that carry it to each of the respective injection well heads. Like the PFE wells, the PFI wells are secured in concrete vaults with associated piping, equipment, and instrumentation. Appendix A provides the completion diagrams for the active PFI wells.

Building 650 is designed with a dropped floor and a floor sump that will contain significant leakage (approximately 9,120 gal) from the piping, components, and/or treatment skids that could occur under emergency conditions. A float switch in the sump triggers a system shutdown and operator notification in the event of leakage. A rupture disc is installed in the piping upstream of the UV reactor to protect it from over-pressurization.

The following sections provide specific information about individual PFTS components or elements. The general PFTS layout is represented in Figure 3.1. The location of primary PFTS components relative to other features at WSTF is shown in Figure 3.2.

3.1.1 Air Stripper Information

The PFTS consists in part of two sieve tray air strippers that operate in a parallel configuration to treat VOCs in WSTF groundwater. A single air stripper is used when the system operates at half design flow or less. Both air strippers are used when the system runs at higher than half of the design flow capacity. Air enters the sump and travels upward through trays and water, exiting the top cover through a condensate trap. The air is discharged through vent stacks on the roof of Building 650. The air strippers must maintain an air flow rate between 3,600 standard cubic feet per minute (scfm) and 4,680 scfm in accordance with manufacturer's recommendations to ensure treatment of VOCs. Design parameters and target treatment goals are presented in Table 3.1. Historical monitoring has shown that all VOCs of interest, including those not regulated by DP-1255, are effectively removed by the air strippers.

A scale cleaning system exists for use with both of the air strippers. This can be used for periodic removal of scale from the interior surfaces of the air strippers when the units are not processing groundwater. The spent cleaning solution is discharged into an above-ground polyethylene tank located outside of the PFTS building. This tank sits on a concrete pad with spill containment. The scale cleaning operations are generally completed twice a year, during scheduled PFTS maintenance events. Spent solution is managed as indicated in Section 5.0.

3.1.2 Water Filtration Unit

The water filtration unit consists of a pair of cylindrical stainless steel vessels mounted on a skid located between the air strippers and the UV reactor in the treatment process. The filter vessels are operated using one micrometer (µm) filter elements. Each of the two filter vessels includes its own isolation valves and can accommodate full design flow of the plant. A single filter is in operation at any given time while the other remains isolated but ready for operation. Pressure transducers upstream and downstream of the water filters measure the pressure drop. A system shutdown occurs if the pressure drop exceeds 35 psid.

3.1.3 UV Reactor Information

The PFTS includes a Rayox®[1] UV reactor that uses UV photolysis to destroy semi-volatile organics (specifically NDMA) in groundwater. The UV reactor is a vertical, cylindrical, stainless steel vessel with

[1] Rayox® is a registered trademark of Calgon Carbon Corporation.

12 horizontally oriented UV lamps. It is designed to operate at a minimum hydraulic flow rate of 200 gpm and a maximum flow rate of 3,000 gpm. Contaminated groundwater enters at the bottom of the vessel, flows upward past the UV lamps, and exits the top of the reactor. The UV reactor contains four irradiance sensors placed at different elevations to measure irradiance in the vessel. The sensors initiate an alarm and then a shutdown if the average of these four irradiance sensor values drops below a specified set point at which complete treatment is known to occur. UV reactor design parameters are presented in Table 3.2. Historical monitoring has demonstrated that NDMA concentrations in groundwater are effectively reduced to levels below the DP-1255 treatment standards by the UV reactor.

3.1.4 Instrumentation and Control System – getting updated

The treatment system is operated and monitored using a supervisory control and data acquisition (SCADA) system. The human-machine interface (HMI) consists of a Rockwell Automation RSView®[2]32 software program running on a Windows®[3] workstation. The system displays equipment and system operation information, allows operator manipulation of operational set points and configuration (with administrative privileges), provides alarm notifications, and performs data logging and reporting. Each programmable small logic controller (SLC) on the control network is programmed in relay ladder logic to control independent operations of a particular skid or subset of the treatment system. Conventional hand controls are located on equipment skids, at well vaults, and in the injection manifold building for emergency and maintenance purposes. The control system also includes electrical power monitoring and metering capabilities. A summary of specific features, components, and operational capabilities is provided in Appendix B.

3.1.5 Alarms

The system is also equipped with numerous self-monitoring functions and alarm conditions to identify and control malfunctions or anomalous events. Depending on the severity of the situation, the system may go into an amber or red alarm mode. During the amber alarm mode, the treatment system continues to function with the alarm condition(s) displayed. In the red alarm mode, a system shutdown is immediately initiated. Amber alarm conditions can transition into red alarm conditions based on the duration and alarm set points configured for the sensors. PFTS alarm conditions are presented in Appendix C.

3.2 Mid-plume Interception and Treatment System

The MPITS is a pump and treat facility designed to provide efficient groundwater contaminant mass removal of the relatively high concentration of NDMA between the WSTF source areas and the Plume Front. The removal of the contaminants at the MPCA is intended to minimize migration of contaminants from the source areas to the Plume Front area. The MPITS consists of groundwater extraction, treatment (for VOCs and NDMA), and infiltration.

The system utilizes up to five extraction wells to remove contaminated groundwater from the MPCA. Appendix A provides the completion diagrams for the available MPE wells, which are secured in above-ground enclosures. Contaminated groundwater is transported from the MPE wells to the MPITS facility (Building 655) through sub-grade dual-wall polyvinyl chloride (PVC) piping. A leak detection system monitors the annular space of the dual-wall piping, the well vaults, and the pipeline manholes. This system notifies operators with a local alarm and initiates a system shutdown if a water leak is detected.

[2] RSView® is a registered trademark of Rockwell Automation, Inc.
[3] Windows® is a registered trademark of Microsoft Corporation.

The PVC pipeline continues into the facility, where it transitions to single-wall piping. A scale control chemical (polyphosphate) is injected into the influent in proportion to the flow rate and a static mixer is used to blend the polyphosphate with the groundwater. The flow is then directed to a surge tank that buffers the flow prior to filtration. After passing through the filtration unit, the groundwater flow is routed through the air stripper to remove VOCs and then to the UV reactor to destroy NDMA. Treated groundwater is pumped from the UV reactor to the infiltration basin through a single-wall HDPE pipeline.

Building 655 is designed in such a manner as to provide secondary containment for a volume equivalent to that in the treatment equipment and tanks installed in the building. In addition, the finished floor elevation is higher than the elevation of ground immediately outside the building to prevent water runoff into the building. A float switch in the building's overflow trench triggers a system shutdown and operator notification in the event of leakage.

The following sections provide specific information for individual MPITS components or elements. The general MPITS layout is represented in Figure 3.3. The location of primary MPITS components relative to other features at WSTF is shown in Figure 3.2.

3.2.1 Air Stripper Information

The MPITS includes a sieve tray air stripper designed to treat VOCs of concern in WSTF groundwater. Air enters the sump and travels upward through trays and water, exiting the top cover through a condensate trap. The air is discharged through a vent stack on the roof of Building 655. Design parameters of the air stripper and its target treatment goals are presented in Table 3.3. Historical and ongoing monitoring shows that all VOCs of interest, including those not regulated by DP-1255, are effectively removed by the air stripper.

A scale cleaning system is used to clean the air stripper as needed. Potable water is mixed with citric acid in a 710-gal mixing tank. The scale cleaning solution is transferred by pump to the air stripper sump where it is circulated through the air stripper for cleaning by the UV reactor feed pumps. The spent cleaning solution is discharged to a spent solution tank inside Building 655. Spent solution is managed as indicated in Section 5.0.

3.2.2 Water Filtration Unit

The MPITS includes three water filtration units. One is used to filter investigation derived waste, such as untreated groundwater, before it is placed in the MPITS surge tank and processed through the system. This unit consists of a single coated steel filtration canister with a 20 µm filter element. The flow of groundwater through the MPITS is filtered twice by pairs of inline filter units. First, the flow is directed through a 5 µm filter located between the surge tank and air stripper. After passing through the air stripper, groundwater is filtered by a 1 µm filter located between the air stripper and the UV reactor. Each of the two process filter units consist of a pair of coated steel filter canisters. Only one of the filters in each pair is used at a time. Groundwater flow is automatically switched to a clean filter when the pressure differential between filter influent and filter effluent exceeds preset limits.

3.2.3 UV Reactor Information

The MPITS includes a Trojan®[4] UV reactor that uses UV photolysis to destroy semi-volatile organics (specifically NDMA) in groundwater. The UV reactor is a horizontal, cylindrical, stainless steel vessel

[4] Trojan® is a registered trademark of Trojan Technologies.

with 72 horizontally oriented UV lamps. It is designed to operate at a minimum hydraulic flow rate of 20 gpm and a maximum flow rate of 125 gpm. The UV reactor contains one irradiance sensor to measure irradiance in the vessel. The UV system monitors physical parameters (flow, irradiance, transmissivity, ballast power, number of operational lamps, age of lamps, etc.) to perform calculations that characterize NMDA destruction. The UV system can be operated in manual mode by adjusting the percentage of UV output or in automatic mode where the control system automatically adjusts UV output to achieve adequate NMDA oxidation. UV reactor design parameters are presented in Table 3.4. Historical and ongoing monitoring has demonstrated that NDMA concentrations in groundwater are effectively reduced to levels below the DP-1255 treatment standards by the UV reactor.

3.2.4 Instrumentation and Control System

The treatment system is operated and monitored using a Rockwell Automation SCADA system. The HMI consists of a Rockwell Automation FactoryTalk®[5] software program running on a Windows workstation. The system displays equipment and treatment system operation information, allows operator manipulation of a limited range of operational set points and configuration, provides alarm notifications, and performs data logging. The main programmable logic controller (PLC) on the control network is programmed in Rockwell Automation RSLogix™[6] 5000 relay ladder logic to control all functions of the process and interact with any subset of the treatment system even if the HMI is off line. Separate site-specific software applications and equipment are used to monitor electrical power. A summary of specific features, components, and operational capabilities is provided in Appendix D.

3.2.5 Alarms

The system is configured to monitor the process and activate an alarm when events outside of control parameters occur. Depending on the severity rating of the events, the system will log minor, major, or critical status with the process responding appropriately. All alarms are displayed on the HMI in addition to an event log that is used to troubleshoot the alarms and related sequence of events. A system shutdown is immediate when a major or critical alarm is activated. All other alarms provide advanced warning of an out of operational range event that requires attention but does not immediately affect treatability. MPITS alarm conditions are presented in Appendix E.

4.0 Remediation System Operational Procedures

The procedures for the operation of the PFTS and MPITS are contained in site-specific procedural documents. These documents contain instruction for routine start-up, operation, inspection, and maintenance of the facilities, as well as emergency shutdown and contingency procedures. The documents are updated regularly to reflect changes in operation due to lessons learned during system operations, updated system configurations or control system upgrades, and to add or remove information to keep the documents current. Remediation system operations, anomalies, and related information are recorded in the appropriate system logs and retained as part of the operational record. All documents and records are managed in accordance with established NASA procedures.

5.0 Waste Management Practices

Wastes generated by the PFTS and MPITS include both hazardous and non-hazardous waste. All wastes are managed in accordance with applicable federal, state, and local regulations. Additionally, the

[5] FactoryTalk® is a registered trademark of Rockwell Automation, Inc.
[6] RSLogix is a registered trademark of Rockwell Automation, Inc.

procedures for waste management contained in the most current and applicable NASA procedures will be strictly adhered to. Any off-site contractor-generated wastes will be managed in accordance with site waste management practices. New waste streams will be evaluated and managed prior to generation, in accordance with site waste management practices.

The basic management practices for current hazardous waste streams are provided below.

- Contaminated groundwater (prior to treatment) is stored in a less than 90-day area in accordance with 40 CFR 262.34 or an appropriate process container before being transported to and processed through the MPITS or PFTS.
- Gloves, wipes, and other debris that has contacted contaminated groundwater is managed as hazardous waste. Contaminated debris is stored in satellite accumulation areas pending off-site shipment and disposal.
- Spent water filters exposed to VOC-contaminated groundwater are managed in a less than 90-day area and subsequently shipped off-site for disposal.
- Spent UV lamps are managed as universal waste for eventual off-site disposal.

Non-hazardous wastes generated at the remediation systems are managed as described below.

- Spent scale cleaning solution is subject to elementary neutralization under 40 CFR 260.10 prior to disposal in a WSTF wastewater lagoon. NASA expects to connect WSTF to the City of Las Cruces Municipal Wastewater Treatment System in 2014 or 2015. After connection, neutralized spent scale cleaning solution will be discharged to that system.
- Spent water filters not exposed to VOC-contaminated groundwater are allowed to air dry prior to disposal as solid waste.
- Water produced during backflushing or other maintenance activities at remediation system locations downstream of the treatment process has been treated by the systems or extracted from the uncontaminated aquifer. This water may be discharged to grade in accordance with DP-1255 or other regulatory approval documents.

6.0 Treatment System Monitoring

The following sections describe monitoring activities that are used to characterize the performance of the PFTS and MPITS and to demonstrate their effectiveness.

6.1 Treatment System Well Performance

The instrumentation and control systems for the PFTS and MPITS continually monitor and intermittently log pertinent operational parameters related to the performance of the extraction and injection wells. These parameters include extraction and injection volumetric flow rates, extraction pump power-related parameters (including current and voltage), and the water level in each extraction and injection well. The specific capacity for each extraction and injection well is calculated utilizing water levels and flow rates. The long range trending of the specific capacities are reviewed and evaluated as an indicator of overall extraction and injection well health. Decreases in specific capacity that cannot be corrected by simple backflushing operations may warrant consideration of well rehabilitation or replacement.

6.1.1 Well Operational Parameters

Extraction and injection well performance and conditions are monitored periodically using two primary methods:

- Flow rate versus drawdown or mounding measurements (specific capacity).
- Power parameters related to the operation of pumps (current, voltage).

6.1.2 Miscellaneous "On Demand" Parameters

When operational problems occur, additional operations may be performed to better diagnose the nature of the problems and to determine subsequent remedial actions. For example:

- Downhole video logs may be performed (when practical) to provide visual verification of a well's condition.
- Physicochemical parameters may be collected to predict scaling and corrosive conditions and plot environmental change (when practical).
- Impromptu water level measurements may be obtained from groundwater monitoring wells and/or piezometers to help determine the impact of the remediation systems on the surrounding aquifer.
- Biological testing may be performed to determine the nature and abundances of microorganisms associated with biofouling.

6.2 Extraction and Injection Well Maintenance and Rehabilitation

During normal operations, clogging of the aquifer around the wellbore may occur due to alignment of formation fines, buildup of biological encrustations or slimes, air entrainment (injection wells), or scaling (injection wells). Backflushing is used at the injection wells to break up and/or dislodge these blockages. This is accomplished by taking the well off line and backflushing with the dedicated pump installed in the well. Backflushing requires a day or less to perform per well and typically results in only short-term benefits. Backflushing addresses only the area in the wellbore immediately adjacent to the pump intake; however, it has shown to be an effective means of maintaining well capacity in between more comprehensive well rehabilitation events. Backflushing, or over-pumping, at the extraction wells has not been necessary because clogging of the aquifer around the extraction wells has not been detected. This technique may be utilized at extraction wells in the future to alleviate clogging, if necessary.

When well backflushing maintenance ceases to be effective in restoring production capabilities due to more widespread or intense aquifer clogging, well rehabilitation may be required. Well rehabilitation involves removing the existing piping, equipment, and pumps from an affected well so that specialized equipment can be utilized to impact the aquifer throughout the entire screened section of the well. This more intense maintenance typically requires several days to weeks to perform and utilizes a specialized set of rehabilitation equipment supplied and operated by subcontractors.

6.3 MPITS Infiltration Basin Maintenance

Major scheduled maintenance is not required at the MPITS infiltration basins. Visual inspection of sediment accumulation, slope stability, and overall basin condition is conducted on a monthly basis. Trash and debris is removed and periodic weed control is performed when required. Solid removal and scarification may be conducted if ponding reaches unacceptable levels.

6.4 Remediation System Groundwater Monitoring

To ensure adequate treatment of contaminated groundwater as specified in this Plan and DP-1255, groundwater is sampled at various points in the PFTS and MPITS and analyzed for appropriate COCs. The overall performance of the systems is monitored by collecting and analyzing groundwater samples from the remediation system influent and effluent, PFE wells, and MPE wells.

6.4.1 Remediation System Influent and Effluent

The PFTS and MPITS are equipped with sampling ports to facilitate the collection of groundwater samples at various points in the treatment processes. At both systems, influent sampling ports (B650-INF-1 and B655-INF-1, respectively) are located on the influent piping immediately upstream of the air strippers to monitor influent characteristics. Effluent sampling ports (B650-EFF-1 and B655-EFF-2, respectively) are located immediately downstream of the UV reactors to monitor effluent characteristics. These sampling points are located directly on the process piping and consist of stainless steel manual valves with stainless steel discharge tubing. Remediation system influent and effluent are sampled monthly for the analysis of NDMA and VOCs by the most appropriate analytical method as described in the Groundwater Monitoring Plan (GMP).

6.4.2 Remediation System Extraction Wells

Individual extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-7 at the PFTS and MPE-1, MPE-8, MPE-9, MPE-10, and MPE-11 at the MPITS) are also equipped with sampling ports, which are constructed in a manner similar to the influent and effluent ports. Extraction well sampling ports are installed on the process piping in the PFE well vault or MPE well housing downstream of the wellhead. PFE and MPE wells are sampled at least quarterly for the analysis of NDMA and VOCs by the most appropriate analytical method as described in the GMP. More frequent sampling may be performed during periods of system reconfiguration, troubleshooting, or other testing to monitor system performance and ensure adequate treatment of contaminated groundwater.

6.5 Related Groundwater Monitoring

Groundwater monitoring is also performed outside the PFTS and MPITS as part of NASA's comprehensive groundwater monitoring program. This sampling supports remediation system monitoring and evaluation. Groundwater monitoring is directed by the GMP, which identifies the groundwater monitoring wells, the frequency of sampling, and the analyses to be performed.

6.5.1 Groundwater Monitoring Wells

Groundwater monitoring wells used to support characterization and effectiveness of the PFTS and MPITS are described in detail in the GMP. Plume Front and sentinel monitoring wells/zones are sampled at varying frequencies depending on their location in the plume, proximity to the PFTS, and intended use in the groundwater monitoring and remediation program. Most MPCA monitoring wells/zones are sampled at least semi-annually in accordance with the GMP. As with PFE and MPE wells, more frequent sampling may be performed during periods of system reconfiguration, troubleshooting, or other testing to monitor system performance and ensure adequate groundwater treatment. At a minimum, groundwater monitoring wells used for PFTS and MPITS monitoring are sampled for the analysis of NDMA and VOCs by the most appropriate analytical method as described in the GMP.

6.5.2 Groundwater Elevations

Groundwater elevations measured at monitoring wells and piezometers provide information required to evaluate changes in the potentiometric surface, contaminant plume geometry, and groundwater model calibration. Groundwater elevations collected from monitoring wells at the westernmost edge of the monitoring well network also provide information that is used to evaluate the potential impact of regional aquifer pumping that may affect WSTF groundwater contaminant plume migration. At a minimum, groundwater elevations are measured each time a monitoring well is sampled. Additional measurements are collected as required to ensure adequate groundwater elevation data are available to support ongoing remediation system monitoring and performance evaluation.

Groundwater elevations are used to generate a potentiometric surface map that is used to interpret the effects of remediation system pumping on the Plume Front alluvial aquifer and the localized MPCA fractured rock aquifer. Potentiometric surface maps are also utilized to support the evaluation of the overall response of the aquifer to remediation system pumping. Individual extraction well drawdown and radii of influence are evaluated when the remediation system operational configuration allows for the collection of the data required to perform this analysis.

Additional information related to the collection and use of groundwater elevations for evaluating remediation system performance is provided in the GMP.

7.0 Remediation System Performance Evaluation

Remediation system performance is evaluated on a regular basis to assess effectiveness of contaminant capture and plume stabilization and to determine whether adjustments to operational parameters and configurations are warranted to maintain or improve system operation. In general, performance will be evaluated as recommended in Environmental Protection Agency (EPA) guidance stressing “multiple lines of evidence” (EPA, 2002 and 2008). A summary of plume capture evaluation exercises is provided in routine Periodic Monitoring Reports (PMR) as specified in Section 8.0. A more detailed evaluation of plume capture is provided in the comprehensive PMR, submitted annually to the NMED Hazardous Waste Bureau (HWB).

7.1 Interim Measures Treatment System Goals

The goal of the PFTS is the stabilization of contaminant plume migration and COC mass reduction. Numerical flow and transport modeling extrapolated for over 40 years has indicated that further migration of the plume can be arrested. Due to the anticipated duration of this corrective action, NASA has not yet formulated a specific exit strategy. Future progress will assist in the formulation of an effective strategy based on contemporary operational data.

The current primary objective of the MPITS is to intercept and treat contaminated groundwater moving from the source areas in the WSTF industrial area towards the Plume Front area, effectively cutting off the continued supply of contaminated groundwater to the Plume Front. The MPITS is also used to treat and dispose of IDW generated during well sampling and testing activities. Operation of the MPITS is transitioning out of a developmental stage and into a steady operational configuration. Data from MPITS operation thus far indicates that a hydraulic sink has been created in the area near the MPITS extraction wells. This is evident by measured water level elevations downgradient of the extraction wells that have declined up to 30 ft. since MPITS operation began. This presence of this hydraulic sink is favorable evidence that the MPITS is intercepting and treating contaminated groundwater at the MPCA.

NASA initiated a tracer test in the MPCA in June 2014, which is scheduled to continue through 2016. The five MPITS extraction wells will continue to operate in their current or optimized configuration

throughout the duration of this test. Long-term objectives and future operational strategy for the system will be addressed after results from the tracer test are available and considered. In the short term, NASA will continue to operate the system and perform any necessary upgrades or enhancements required to achieve the current system objectives.

7.2 Definition of Capture Zone

The three-dimensional target capture zone for the COCs that drive the Plume Front health-risk assessment is primarily defined by the location of the TCE plume, which is the most extensive groundwater contaminant at WSTF. The target plume capture zone used for the design of the PFTS was defined as the 0.5-ppb TCE and 10-ppt NDMA iso-concentration lines conceptualized in 1998. The revised target plume capture zone within the 2002 PFTS Project Plan was defined as the 5-ppb TCE iso-concentration line conceptualized in 2001. PFE well pumping was modeled from approximately 330 to 800 ft below ground surface (bgs), while simulated particles were tracked from approximately 330 to 1,200 ft bgs. Based on that modeling, TCE and NDMA plume capture was predicted using the proposed PFE well configuration at the prescribed flow rates.

Over time, the dimensions and extent of the TCE plume will change due to operation of the PFTS and to offsite pumping effects on the groundwater gradient. As the plume evolves, the target capture zone may be adjusted to prevent increases in risk to human health and the environment. As part of this process, ongoing analyses and potentiometric surface evaluations are performed to maintain current estimates of plume position, contaminant mass, and rates of removal.

7.3 Remediation System Effectiveness

PFTS and MPITS effectiveness is evaluated by comparing the results of effluent sampling and analysis described in Section 6.3, to the DP-1255 treatment standards in Table 1.1. Fundamentally, the PFTS is considered effective if effluent concentrations meet discharge requirements and a plume capture evaluation indicates continued stability of the contaminant plume. The MPITS is considered effective if effluent concentrations meet treatment standards and a plume capture evaluation indicates a reduction in the transport of groundwater contaminants through the MPCA toward the Plume Front.

In addition to direct comparisons of analytical data to treatment standards, contaminant mass removal is estimated by comparing average influent and effluent concentrations for select COCs over time. Average concentrations in the influent and effluent will be combined with the measured volume of treated groundwater to estimate mass removal during a specific time interval. Although not a specific measurement of remediation system effectiveness, concentrations of COCs in groundwater samples collected from individual extraction wells and system influent are also periodically evaluated as an indicator of plume dynamics.

Several techniques are utilized to determine the effects of the operation of the remediation systems on the aquifer and contaminant plume. These techniques include a comprehensive evaluation of groundwater elevations through the use of potentiometric surface maps, a thorough assessment of groundwater chemical analytical data using time-concentration plots and plume iso-concentration maps, the preparation and interpretation of a numerical groundwater model, and where practical, the evaluation of tracer test results. These tools are described in the sections below.

7.3.1 Potentiometric Surface Map

Measured groundwater depths are converted to piezometric elevations and plotted on a base map for the purpose of evaluating the effect of extraction wells on local groundwater flow paths. Piezometric

elevations are determined for selected PFTS and MPITS groundwater monitoring wells by manually measuring the water level in conventional monitoring wells and calculating the piezometric elevation of target monitoring zones within Westbay®[7] multiport wells based on the groundwater formation pressures measured at those zones. Groundwater elevations from Westbay wells are calculated using pressure data from the uppermost sampling ports proximal to the water table using Westbay pressure profile equipment. These operations are conducted in accordance with the site-specific procedural documentation previously identified. If a remediation system and the related area of the aquifer are in a state of equilibrium, extraction well elevations may also be used to develop the potentiometric surface map.

The potentiometric surface map is hand contoured by a qualified geologist. Automated contouring software may also be used to develop the map. The results of the automated method are analyzed and modified or replaced by hand contouring if appropriate. The method used to produce the potentiometric surface is identified on the potentiometric surface map.

7.3.2 Time-Concentration Plots

Groundwater analytical data are presented as time-concentration (T-C) plots for targeted groundwater monitoring wells or zones in the Plume Front area or MPCA. Historical analytical data used to populate the time concentration plots are available through the WSTF groundwater analytical database. The following guidelines and considerations will be observed during the construction of T-C plots:

- Groundwater monitoring wells used for the development of T-C plots are designed in accordance with the applicable EPA/NMED point source monitoring guidance.
- T-C plots for the monitoring wells use each sampling dataset collected following installation of the well through the most recent available data.
- Analytical data are typically evaluated for hazardous constituents regulated under DP-1255.
- The selection protocol for analytical data includes using the highest concentration for qualifying samples collected during a sampling event at each well. Analytical results for use in a T-C plot are selected giving priority to analytical methods with greater accuracy, and consider any qualified data.
- Non-detect results are reported at one half of the method detection limit concentration.

Due to changes in the off-site laboratory utilized to analyze groundwater samples, method detection limits for some analytes may change over reporting periods. Some of the subtle fluctuations in T-C plots may be the result of changing analytical technology. Other trends in contaminant concentrations may be identified as irregular responses to WSTF operations. Trends or patterns in the data will meet the general criteria that: several T-C plots (using data from several sampling events) supported the trend; the change in concentration is significant (typically an order of magnitude); and several contaminants within the location responded with similar trends. Irregularities in T-C plots that are not identified as responses to operations typically require additional data points and a greater change between recent concentrations and historical data.

7.3.3 Plume Iso-concentration Maps

Iso-concentration maps for contaminants of concern are primarily developed manually, but may also use automated contouring software with the most recent analytical data available for each well. Automated

[7] Westbay® is a registered trademark of Schlumberger Limited.

contouring methods are not used for maps generated for the MPCA. Hand drawn contour maps are provided for the MPCA to allow for technical interpretation of hydrogeological features. Consideration of hydrogeological conditions, such as differing hydrostratigraphic units or significant structural features that cause the juxtaposition of variable hydraulic conductivities, may provide a more realistic representation of the contaminant plume.

Guidelines recommended for the selection and presentations of analytical data are as follows:

- The analytical data from MPCA monitoring wells are reviewed for the analytes regulated by DP-1255. NDMA data are evaluated at the ng/L concentration level based on its toxicity and importance relative to health risk evaluation. The remaining contaminants will be evaluated at the µg/L concentration level.
- Data processed by the WSTF quality assurance (QA) system during each reporting period are utilized for contouring. Priority is given to analytical methods with greater accuracy, and flagged data points are considered individually. The selection protocol uses the highest concentration for qualifying samples.
- The most recent analytical results available are utilized for contouring (including any wells for which no analytical data were available during the reporting period).
- When duplicate samples or multiple sampling results are available for a specific monitoring well or sampling point, the maximum concentration is utilized in accordance with WSTF convention for contouring using the most conservative approach.
- For Westbay multiport monitoring wells, the maximum contaminant concentration from any sampling zone within the well is used in accordance with WSTF convention for contouring using the most conservative approach.
- For conventional well clusters or closely adjacent monitoring wells, the most recent maximum contaminant concentration for the well group is used in accordance with WSTF convention for contouring using the most conservative approach.
- Analytical data from extraction wells may be considered for the plume evaluation even though these wells are non-compliant for point source monitoring purposes due to the extended screened intervals. In general though, data obtained from extraction wells are utilized for engineering purposes only.
- Automated and manually constructed maps utilize the same analytical data sets.
- Contaminant plume iso-concentration plots do not represent a single horizontal layer or horizon within the contaminant plume, but a cumulative representation of the maximum values recorded over the sampling period at all depths.

7.3.4 Groundwater Modeling

Groundwater modeling simulations comprise an essential component of presenting the conceptual model of the contaminant plume, and supporting estimates of contaminant mass extraction at the PFTS. Particle tracking analyses are conducted for NDMA and TCE to evaluate the ability of the PFTS to achieve its design objectives. Particle tracking is performed using MODPATH software in conjunction with the WSTF groundwater flow model.

Due to the complexity of fractured bedrock and the proximity between flow pathways, the flow model was not developed to support the design of the MPITS relative to optimizing remediation well placement and system flow rates. However, it can be utilized to obtain generalized information on the effect of the

MPITS as it relates to the behavior of the conceptualized plume on a larger scale at WSTF. With respect to the MPCA and MPITS operation, the WSTF groundwater model is used primarily as a support tool that assists with understanding large scale plume behavior and contaminant movement through the fractured bedrock aquifer.

7.4 Activity and Changes at Sentinel Wells

Monitoring wells utilized as sentinel wells for evaluation of plume capture are described in the GMP. As indicated in that plan, routine monitoring supports the evaluation of PFTS effectiveness. Anomalies detected at sentinel wells may trigger additional sampling for confirmation purposes. If contaminant increases are verified through multiple sampling events, then changes to PFTS operation or even additional extraction wells to arrest plume migration will be considered. Due to the slow rate of groundwater migration in the Plume Front area, actions provoked from contaminant increases at sentinel wells will proceed after thorough consideration and consultation with NMED.

7.5 Plume Capture Evaluation Methodologies

A comprehensive plume capture evaluation is performed annually to determine if the remediation systems are achieving the overall objectives of plume stabilization and interception. An effective plume capture evaluation is based on the six steps described in "Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems" (EPA, 2008). These include:

- Review site data, site conceptual model, and remedy objectives.
- Define site-specific Target Capture Zone(s).
- Interpret water levels.
- Perform calculations and groundwater modeling.
- Evaluate concentration trends.
- Interpret actual capture based on steps 1-5, compare to Target Capture Zone(s), and assess uncertainties and data gaps.

The scope of the EPA document is limited to evaluating capture in porous media (PFTS) and not necessarily fractured rock (MPITS), but the methods and techniques described in the EPA guidance are applied towards the evaluation of the effectiveness of MPITS contaminant interception, where possible. NASA anticipates that the results from the ongoing MPCA tracer test will provide more substantial evidence of MPITS contaminant interception effectiveness. Tracer test results will be incorporated into plume capture presentations as it becomes available. The results of plume capture evaluations are provided in the comprehensive PMR described below.

8.0 Reporting

Information related to remediation system operation and monitoring is provided to NMED in the scheduled correspondence described below. The GMP provides the schedule for the submittal of these reports, along with more detailed descriptions.

- Monthly Environmental Activity Report, which summarizes remediation system operation, maintenance, and significant activities.
- "Routine" PMR, which includes chemical analytical data that were processed through the WSTF QA system during the reporting period (calendar quarter). These PMRs also include brief

discussions of groundwater monitoring and remediation activities, and summarize the results of groundwater and remediation system monitoring.

- Comprehensive PMR, which includes additional data and a more comprehensive evaluation of corrective measures. This PMR includes a complete evaluation of contaminant plume capture and detailed results of remediation system monitoring.

9.0 Schedule for Review and Revision of the Plan

The RSMP will be reviewed and revised annually. Annual revisions will be submitted to the HWB on or before August 1 and are not considered Permit modifications.

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Tables

Table 1.1
DP-1255 Treatment Standards

Contaminant	Standard
NDMA	4.2 ng/L
TCE	5 µg/L[1]
PCE	1.1 µg/L
Chloroform	1.9 µg/L

[1] Although the DP-1255 treatment standard for TCE is 5 µg/L, the current NMED-required cleanup level for TCE is 2.6 µg/L. NASA's groundwater remediation systems both achieve the cleanup level.

Table 3.1
PFTS Air Stripper Performance Specifications

Criteria	Specification	
Total Hydraulic Flow Rate	1,250 gpm	
Hydraulic Flow Rate per Air Stripper	625 gpm	
Maximum Run Time	24 hours per day 365 days per year	
Design Life	>15 years	
Air Temperature	Minimum Annual Average Maximum	-13 ºC 17 ºC 44 ºC
Influent Water Temperature	15 to 20 ºC	
Site Elevation	4,500 feet above mean sea levels (AMSL)	
Expected Influent Concentrations	TCE PCE Chloroform	130 µg/L 4.2 µg/L <1 µg/L
Effluent Standards	See Table 1.1	

Table 3.2
PFTS UV System Performance Specifications

Criteria	Specification
Total Hydraulic Flow Rate	1,150 gpm

Table 3.2
PFTS UV System Performance Specifications

Criteria		Specification
Minimum Flow Rate		200 gpm
Maximum Run Time		24 hours per day 365 days per year
Design Life		>15 years
Maximum System Pressure		100 psig
Maximum Pressure Drop		10 psig
Site Elevation		4,500 feet AMSL
Expected Influent Concentrations	NDMA	2,000 ng/L
Effluent Standards	NDMA	See Table 1.1

Table 3.3
MPITS Air Stripper Performance Specifications

Criteria		Specification
Total Hydraulic Flow Rate		20-125 gpm
Maximum Run Time		24 hours per day 365 days per year
Design Life		>15 years
Air Temperature	Minimum Annual Average Maximum	-13 ºC 17 ºC 44 ºC
Influent Water Temperature		15 ºC
Site Elevation		4,500 feet AMSL
Expected Influent Concentrations	TCE PCE Chloroform	140 µg/L 6.4 µg/L <1 µg/L
Effluent Standards		See Table 1.1

Table 3.4
MPITS UV System Performance Specifications

Criteria	Specification
Total Hydraulic Flow Rate	20-125 gpm
Minimum Flow Rate	20 gpm
Maximum Run Time	24 hours per day 365 days per year

Table 3.4
MPITS UV System Performance Specifications

Criteria		Specification
Design Life		>15 years
Maximum System Pressure		65 psig
Maximum Pressure Drop		10 psig
Site Elevation		4,500 feet AMSL
Expected Influent Concentrations	NDMA	25,500 ng/L
Effluent Standards	NDMA	See Table 1.1

Figures

Figure 1.1 WSTF Location Map

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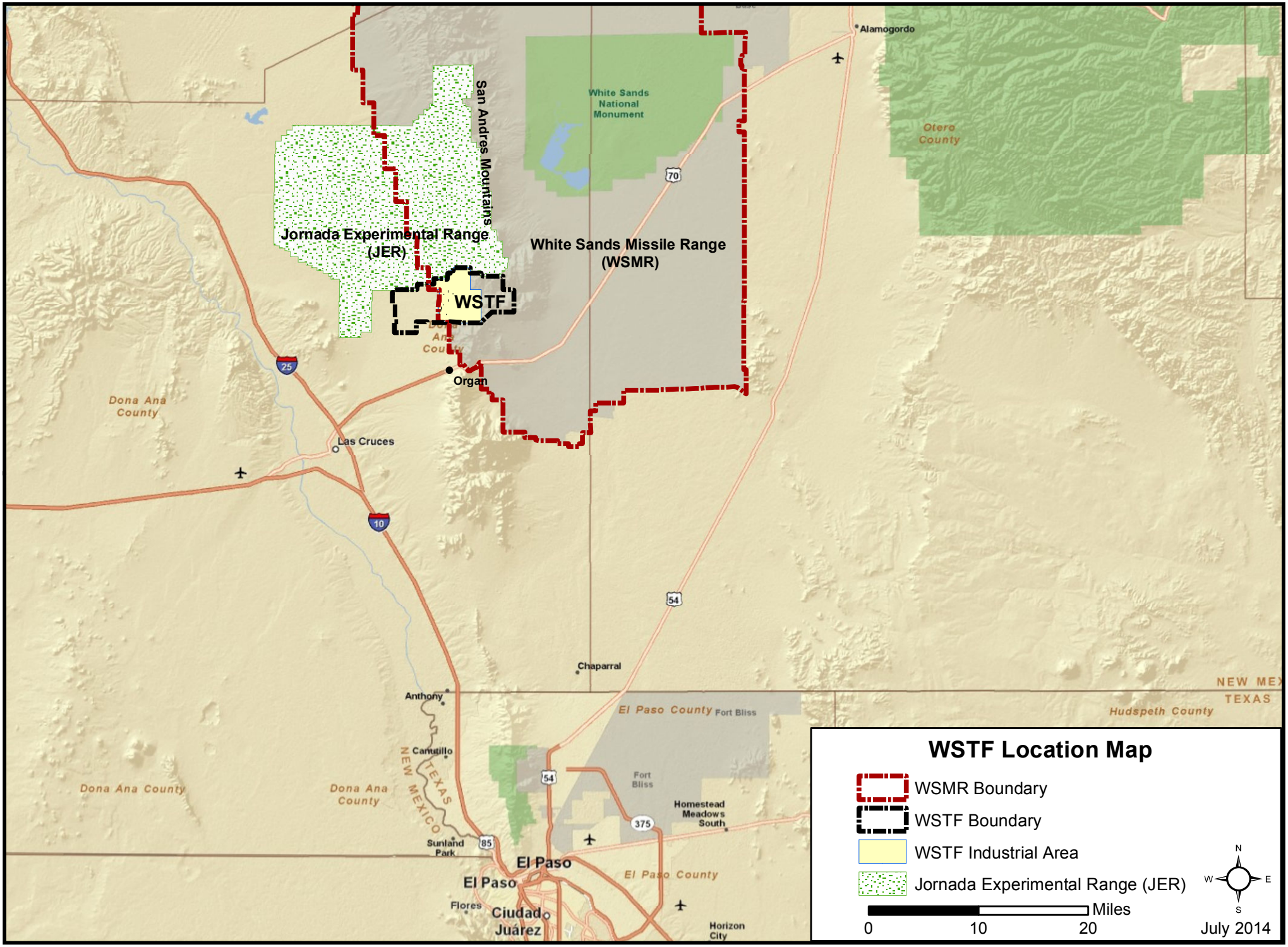
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WSTF
Organ
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Las Cruces
Chaparral
Anthony
El Paso County
Fort Bliss
Hudspeth County
TEXAS
Canutillo
NEW MEXICO
Dona Ana County
Homestead Meadows South
Sunland Park
El Paso
Flores
Ciudad Juárez
Horizon City
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25
10
54
375
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WSTF Location Map
WSMR Boundary
WSTF Boundary
WSTF Industrial Area
Jornada Experimental Range (JER)
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July 2014

Figure 1.2 WSTF Conceptualized TCE and NDMA Plumes and WSTF Features

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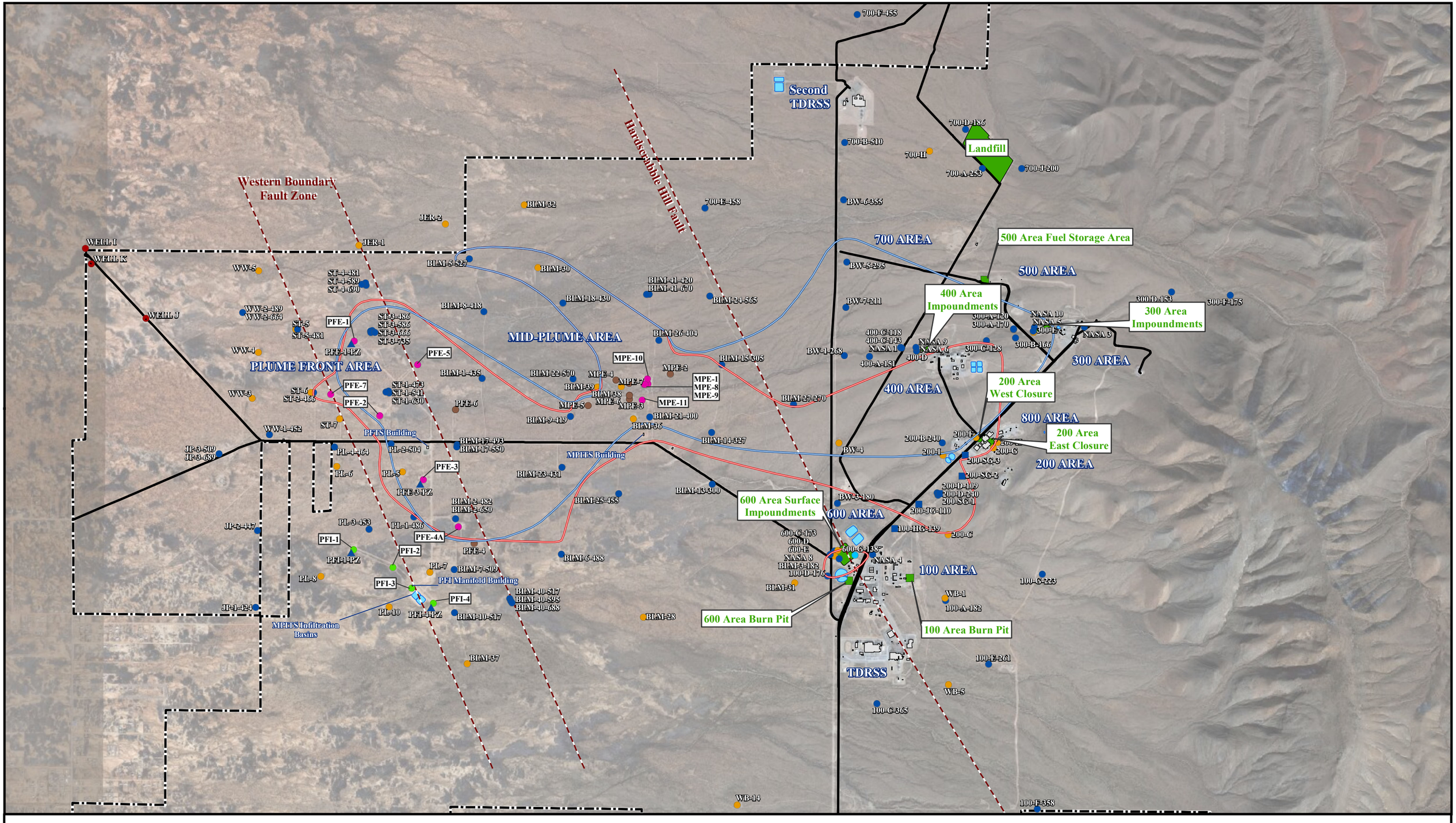
Western Boundary Fault Zone
Hardscrabble Hill Fault
Second TDRSS
Landfill
700 AREA
500 Area Fuel Storage Area
500 AREA
400 Area Impoundments
300 Area Impoundments
300 AREA
MID-PLUME AREA
PLUME FRONT AREA
400 AREA
200 Area West Closure
800 AREA
200 Area East Closure
200 AREA
600 Area Surface Impoundments
600 AREA
100 AREA
600 Area Burn Pit
100 Area Burn Pit
TDRSS
PFTS Building
MPITS Building
PFI Manifold Building
MPITS Infiltration Basins
WELL I
WELL K
WELL J
JER-1
JER-2
BLM-32
700-E-458
700-F-455
700-D-186
700-B-510
700-H
700-A-253
700-I-200
BW-6-355
BW-5-295
BW-7-211
BW-1-268
BLM-5-527
BLM-30
BLM-18-430
BLM-41-420
BLM-41-670
BLM-24-565
BLM-8-418
BLM-26-404
BLM-15-305
BLM-1-435
BLM-22-570
BLM-39
BLM-58
BLM-9-419
BLM-27-270
BLM-21-400
BLM-36
BLM-14-327
BLM-17-493
BLM-17-550
BLM-23-431
BLM-25-455
BLM-13-300
BLM-2-482
BLM-2-650
BLM-6-488
BLM-7-509
BLM-40-517
BLM-40-595
BLM-40-688
BLM-10-517
BLM-28
BLM-31
BLM-37
WB-14
WW-5
WW-2-439
WW-2-664
WW-4
WW-3
WW-1-452
ST-1-481
ST-1-589
ST-1-690
ST-5
ST-5-481
ST-3-486
ST-3-586
ST-3-666
ST-3-735
ST-6
ST-2-466
ST-1-473
ST-1-541
ST-1-630
ST-7
PFE-1
PFE-1-PZ
PFE-5
PFE-7
PFE-2
PFE-6
PFE-3
PFE-3-PZ
PFE-4A
PFE-4
PFI-1
PFI-1-PZ
PFI-2
PFI-3
PFI-4
PFI-4-PZ
MPE-10
MPE-4
MPE-2
MPE-7
MPE-1
MPE-8
MPE-9
MPE-5
MPE-6
MPE-3
MPE-11
PL-4-464
PL-2-504
PL-6
PL-5
PL-3-453
PL-1-486
PL-7
PL-8
PL-10
JP-3-509
JP-3-689
JP-2-447
JP-1-424
NASA 10
NASA 5
NASA 3
NASA 9
NASA 6
NASA 1
NASA 8
NASA 4
400-C-118
400-C-143
400-A-151
400-D
300-D-153
300-F-175
300-A-120
300-A-170
300-E
300-B-166
300-C-128
200-B-240
200-I
200-F
200-C
200-SG-3
200-SG-2
200-D-109
200-D-240
200-SG-1
200-IG-110
100-HG-139
600-G-173
600-D
600-E
600-G-138
100-D-176
100-G-223
WB-1
100-A-182
100-E-261
WB-5
100-C-365
100-F-358
WSTF Site Structures
Conventional Well
Perched Well
Multiport Well
MSVGM Well
Extraction Well
Injection Well
Piezometer
Exploration Well
Production Well
TCE Extent (2.6 ppb)
NDMA Extent (4.2 ppt)
Road
Fault
WSTF Boundary
Building
Impoundment
Feet
0
4,000
8,000
N
W
E
S
July 2014

Figure 3.1 General PFTS Layout

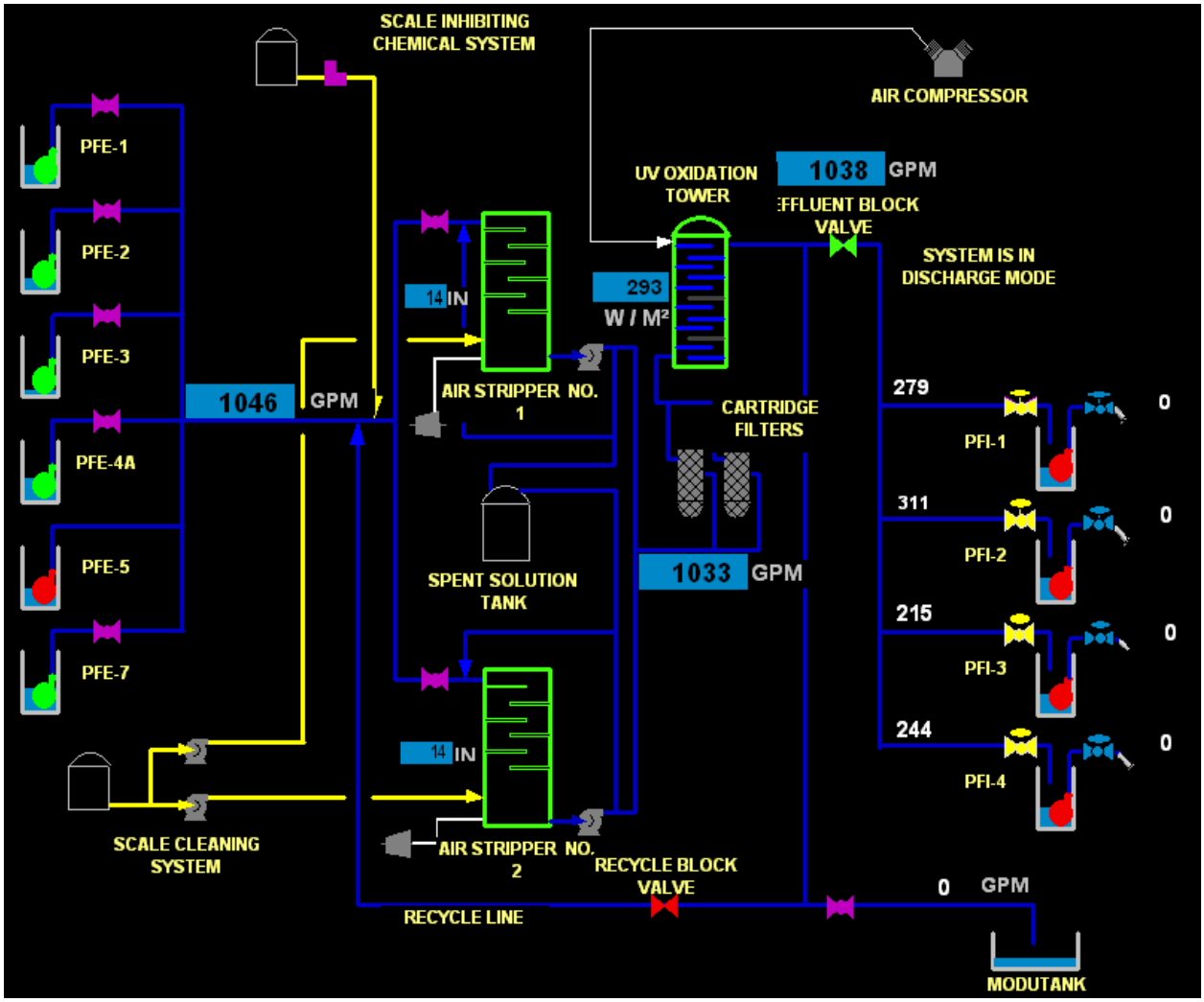

Figure 3.2 WSTF Remediation System Locations

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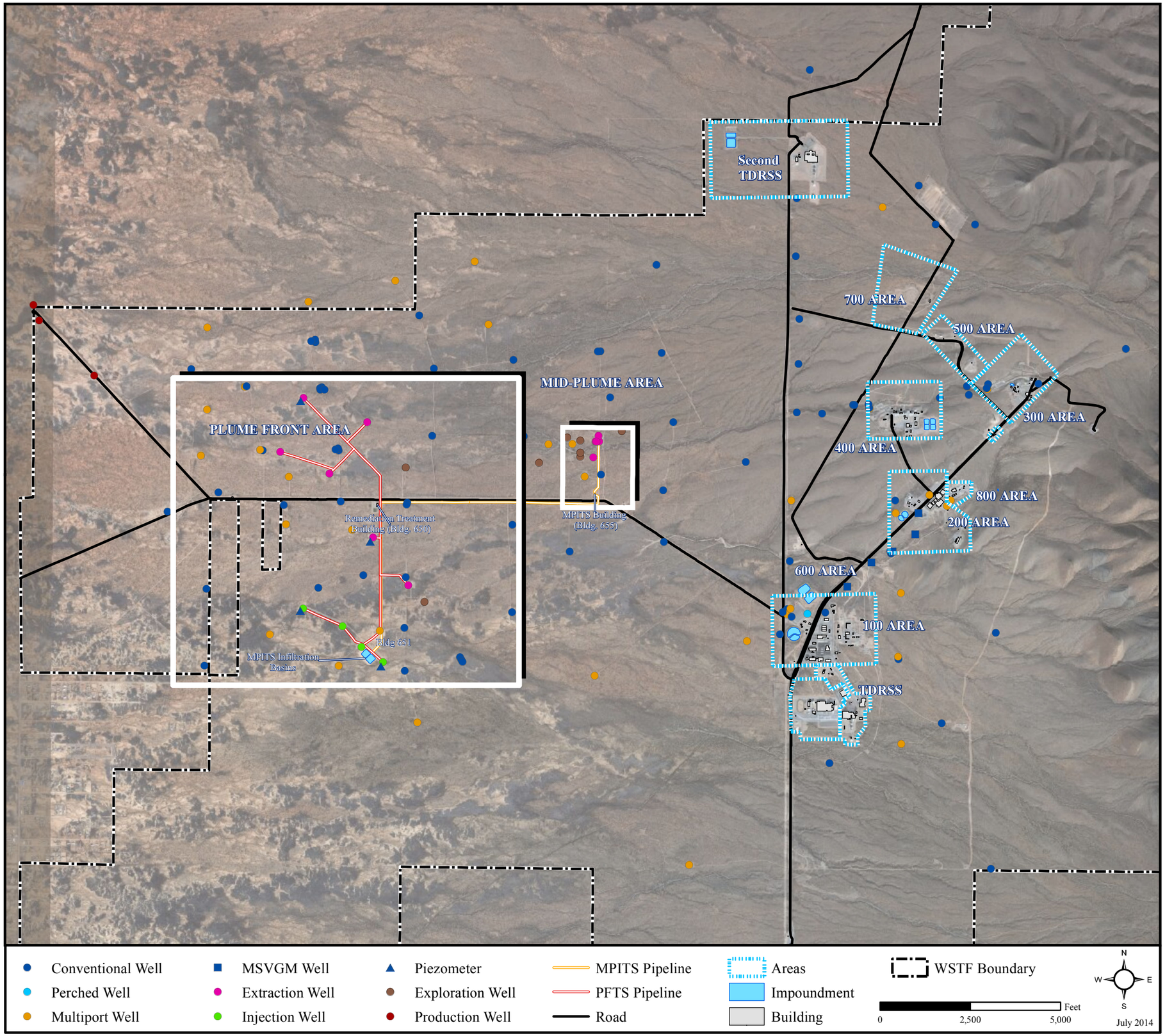
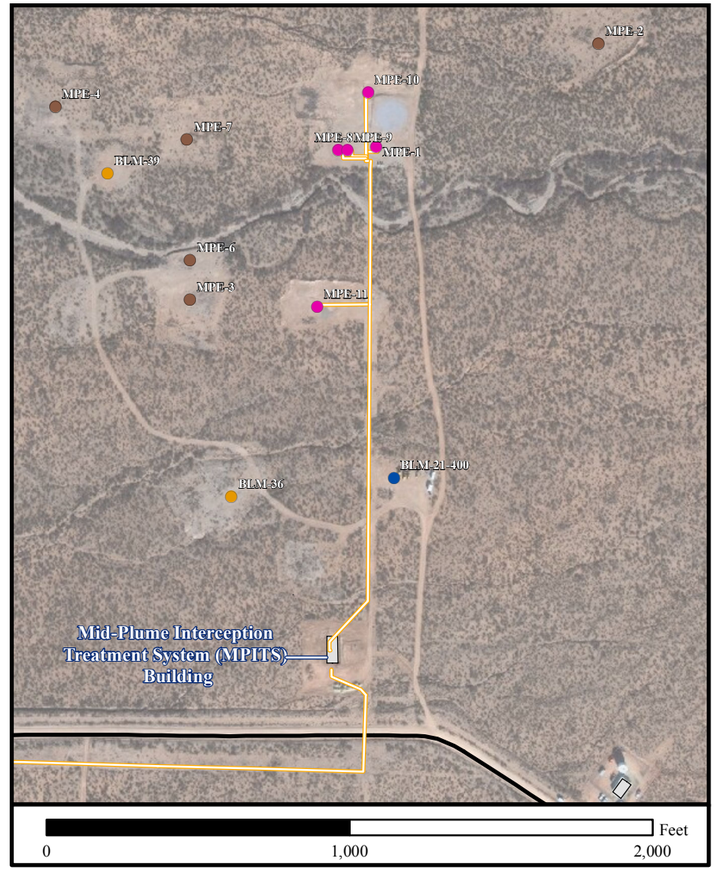

Second TDRSS
700 AREA
500 AREA
300 AREA
400 AREA
800 AREA
200 AREA
600 AREA
100 AREA
TDRSS
MID-PLUME AREA
PLUME FRONT AREA
Remediation Treatment Building (Bldg. 650)
MPITS Building (Bldg. 655)
Bldg 651
MPITS Infiltration Basins
Conventional Well
Perched Well
Multiport Well
MSVGM Well
Extraction Well
Injection Well
Piezometer
Exploration Well
Production Well
MPITS Pipeline
PFTS Pipeline
Road
Areas
Impoundment
Building
WSTF Boundary
Feet
0
2,500
5,000
N
W
E
S
July 2014


MPE-2
MPE-10
MPE-4
MPE-7
MPE-SAMPLE-9
MPE-1
BLM1-39
MPE-6
MPE-3
MPE-11
BLM1-24-400
BLM1-36
Mid-Plume Intereception Treatment System (MPITS) Building
Feet
0
1,000
2,000

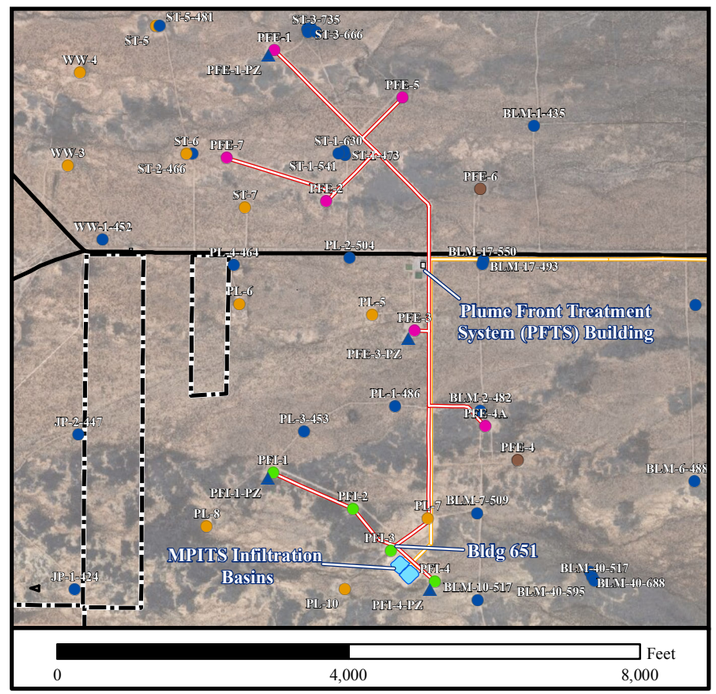
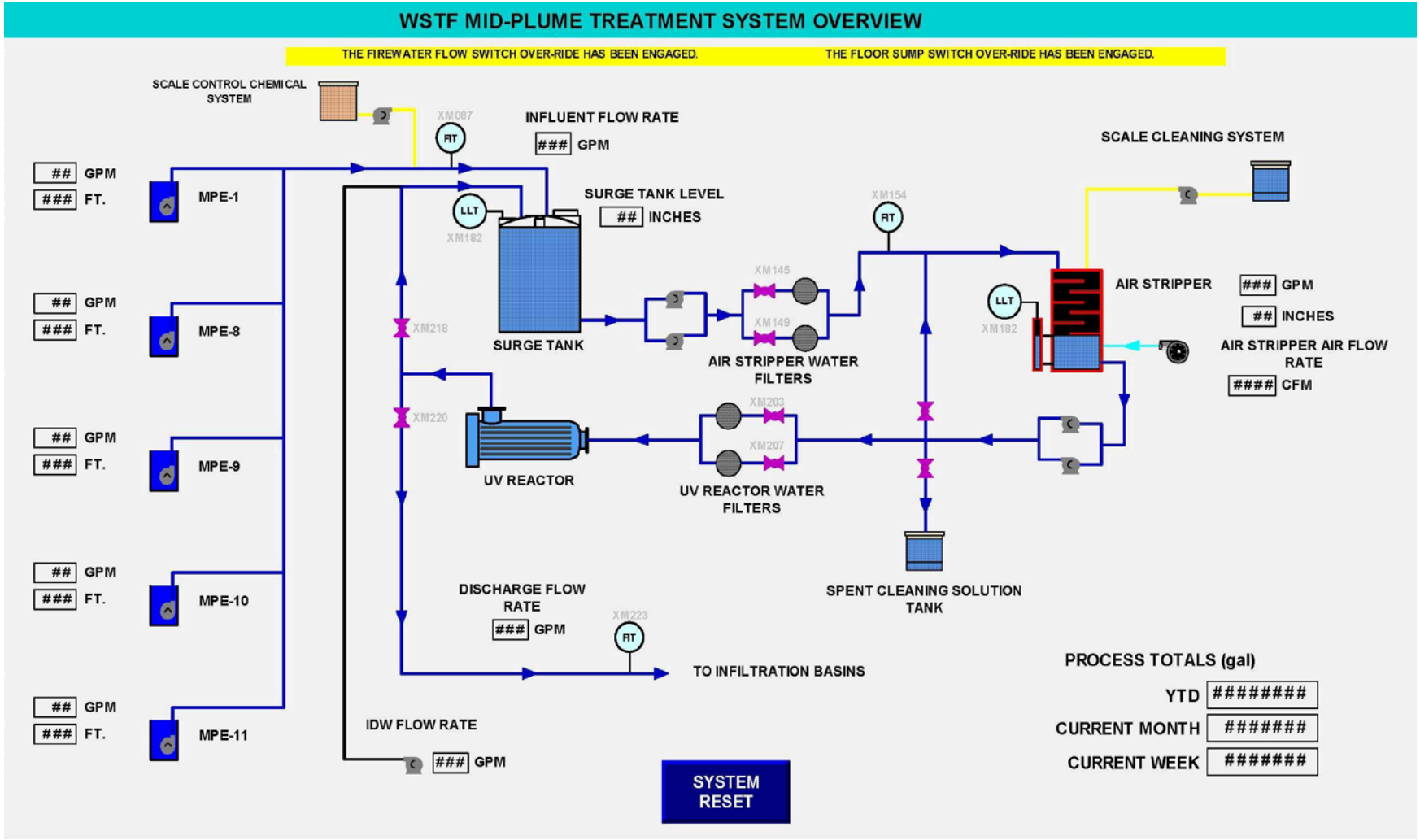

ST-5-481
ST-5-735
ST-3-666
ST-5
PFE-1
WW-4
PFE-1-PZ
PFE-5
BLM1-1-435
WW-3
ST-6
PFE-7
ST-1-630
ST-2-473
ST-3-466
ST-1-541
PFE-6
PFE-2
ST-7
WW-1-482
PL-2-503
BLM1-17-550
BLM1-17-493
PL-6
PL-5
PFE-3
Plume Front Treatment System (PFTS) Building
PFE-3-PZ
PL-1-486
BLM1-2-482
PFE-4A
TP-2-447
PL-3-453
PFE-4
PFE-1
BLM1-6-488
PFE-1-PZ
PFE-2
BLM1-7-509
PL-8
PFE-3
Bldg 651
MPITS Infiltration Basins
PFE-4
BLM1-40-517
BLM1-40-688
PL-1-494
BLM1-40-517
BLM1-40-595
PL-10
PFE-4-PZ
Feet
0
4,000
8,000

Figure 3.3 General MPITS Layout



Appendix A
Remediation System Well Completion Diagrams

WELL COMPLETION DIAGRAM

EXTRACTION

Location ID: **PFE-1**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4, SE 1/4, NW 1/4, Sec 32, T20S, R3E**
Site Coordinates: **169190.22 N/461691.33 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1368.84 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **Juan Aguilar**
Total Depth of Borehole (bgs): **788' (240.2 m)**
Borehole Diameter: **17 1/2" 0-100'; reamed 26"; 17 1/2" 100-788'**
Depth to Bedrock (bgs): **700' (213.4 m; Andesite)**
Depth to Groundwater: **422.63' (128.82 m)**
Total Depth Surface Casing (bgs): **96' (29.3 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **1/26/00-2/3/00**
Date(s) Well Developed: **2/9-10/00 bailing; 6/12/00-6/29/00 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **~768.4' (~234.2 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **9.31" min. ID; 10.75" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **~389-748.4' (~118.6-228.0 m)**
Comments: **Well completed as an extraction well below grade in a cement vault**

Casing Explanation:

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Conventional End Cap
10.75" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

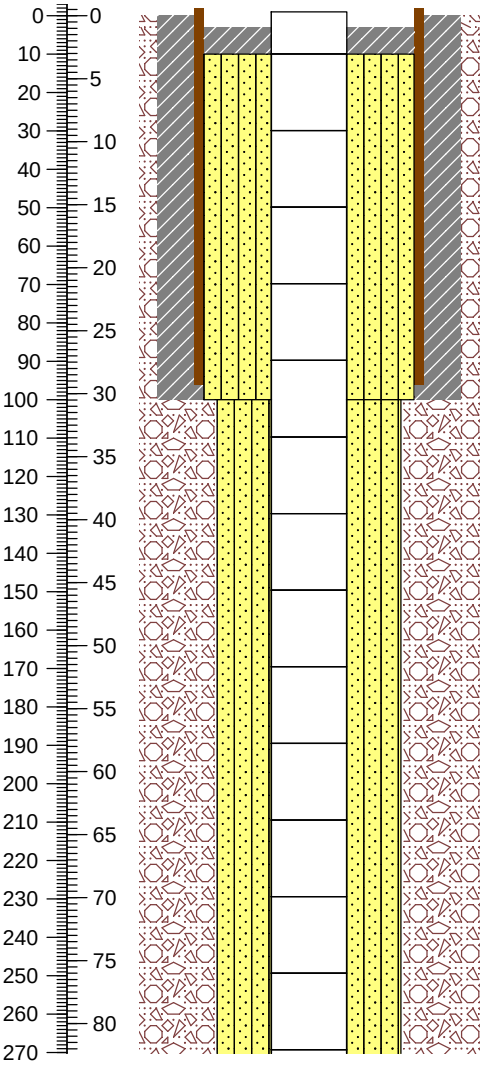
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough

1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand

10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.6 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

NOTE: Well casing was not measured at installation. 19.95' was assumed to be an average joint lengths based on measurements at PFE-4 installation

20" OD Carbon Steel Surface Casing Depth = 96' (29.3 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~3' (0.9 m)
Top of 4/8 Sand/Bentonite Mix = 10' (3.0 m)

Field Representatives: Mary Canavan; Geoff Giles; Lela Hunnicutt-Mack; Jack Kirby; John Pearson; Mark Rivera; and Ron Weaver

The formation is Santa Fe Group Alluvium from surface to 500' (152.4 m)

17 1/2" Borehole cemented to 100' (30.5 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

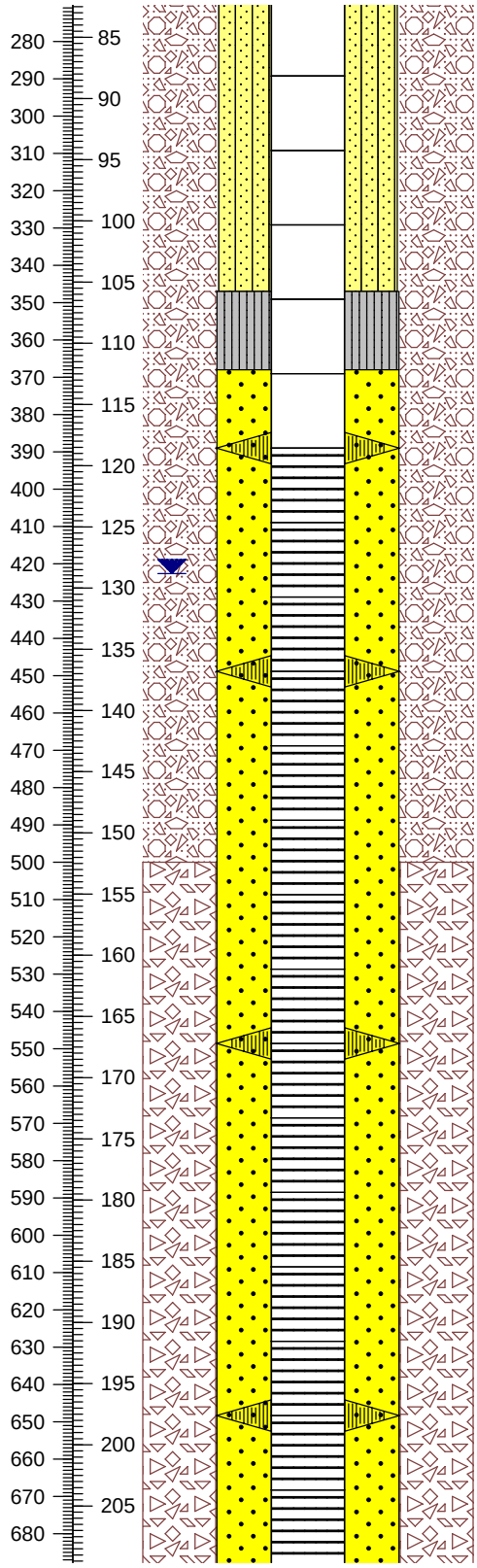
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Steel cage centralizer bolted together around casing coupling at ~389.0' (~118.6 m)

Top of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = ~389.0' (~118.6 m)

Water Table Depth = 422.63' (128.8 m; measured post-development date unknown)

Steel cage centralizer bolted together around casing coupling ~448.9' (~136.8 m)

Steel cage centralizer bolted together around casing coupling ~548.6' (~167.2 m)

Steel cage centralizer bolted together around casing coupling ~648.4' (~197.6 m)

Top of Upper Bentonite Seal = 347' (105.8 m)

Top of 4/8 Sand = 368' (112.2 m)

Volcanic-Rich Alluvium Depth = 500' (152.4 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

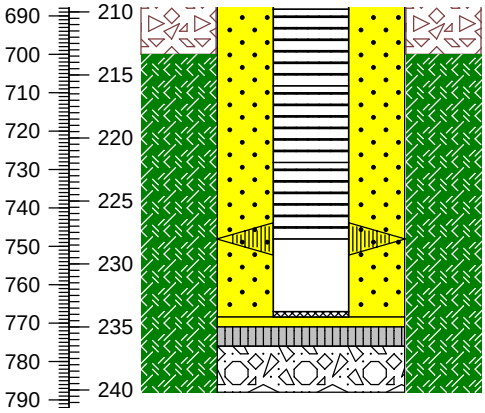
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Bottom of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = ~748.1' (~228.0 m)

Sump consists of 20' blank riser and end cap; end cap attached with spline

9.31" minimum ID; 10.75" OD CertainTeed SDR 17 PVC Casing TD = ~768.4' (~234.2 m)

Annular/Borehole Descriptions
All depths listed are bgs

Volcanic Andesite Bedrock Depth = 700' (213.4 m)

Top of Lower Bentonite Seal = 771' (235.0 m)

Top of Slough = 778' (237.1 m; from Geophysical Logs)

17 1/2" Borehole TD = 788' (240.2 m)

WELL COMPLETION DIAGRAM

EXTRACTION

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **PFE-2**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SW 1/4, SW 1/4, SE 1/4, Sec 32, T20S, R3E**
Site Coordinates: **168557.65 N/461907.38 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1372.40 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **Juan Aguilar**
Total Depth of Borehole (bgs): **912' (278.0 m)**
Borehole Diameter: **17 1/2" 0-100'; reamed 26"; 17 1/2" 100-912'**
Depth to Bedrock (bgs): **700' (213.4 m; Andesite)**
Depth to Groundwater: **434.02' (132.29 m; measured 7/21/00)**
Total Depth Surface Casing (bgs): **100' (30.5 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **2/20/00-2/22/00**
Date(s) Well Developed: **4/15-17/00 bailing; 7/11-12/00; 7/21/00 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **896.2' (273.2 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **9.31" min. ID; 10.75" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **397.5-875.8' (121.2-266.9 m)**
Comments: **Well completed as an extraction well below grade in a cement vault**
Flushed casing with clean water 2/23/00

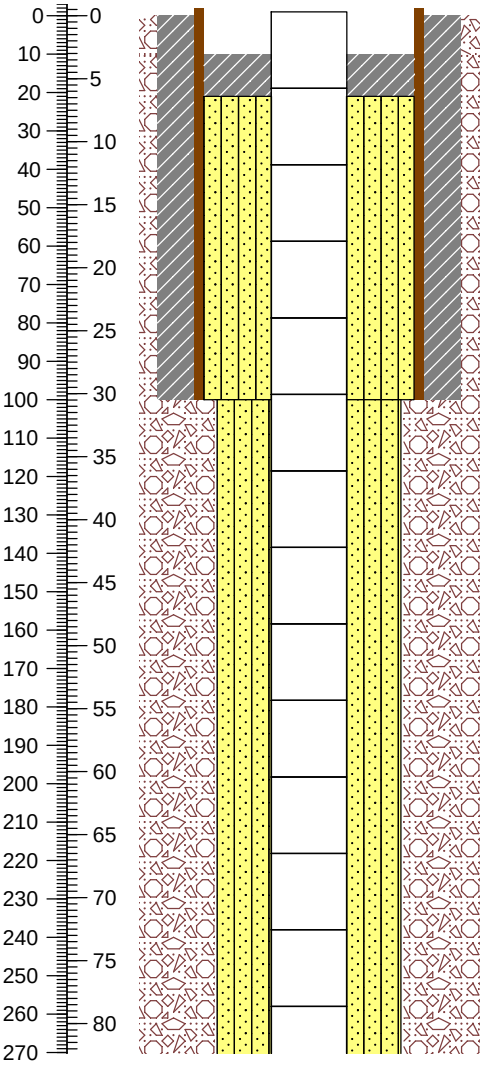
Casing Explanation:

- Surface Casing: **20" Carbon Steel**
- Conventional Casing: **10.75" OD CertainTeed PVC**
- Conventional Screen: **10.75" OD CertainTeed PVC 0.085"-Slot**
- Conventional End Cap: **10.75" OD CertainTeed PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 4/8 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.6 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

20" OD Carbon Steel Surface Casing Depth = 100' (30.5 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~10' (3.0 m)

Top of 4/8 Sand/Bentonite Mix = 21' (6.4 m)

Field Representatives: Mary Canavan; Geoff Giles; Lela Hunnicutt-Mack; Jack Kirby; John Pearson; and Murray Stepro

The formation is Santa Fe Group Alluvium from surface to 525' (160.0 m)

17 1/2" Borehole cemented to 100' (30.5 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

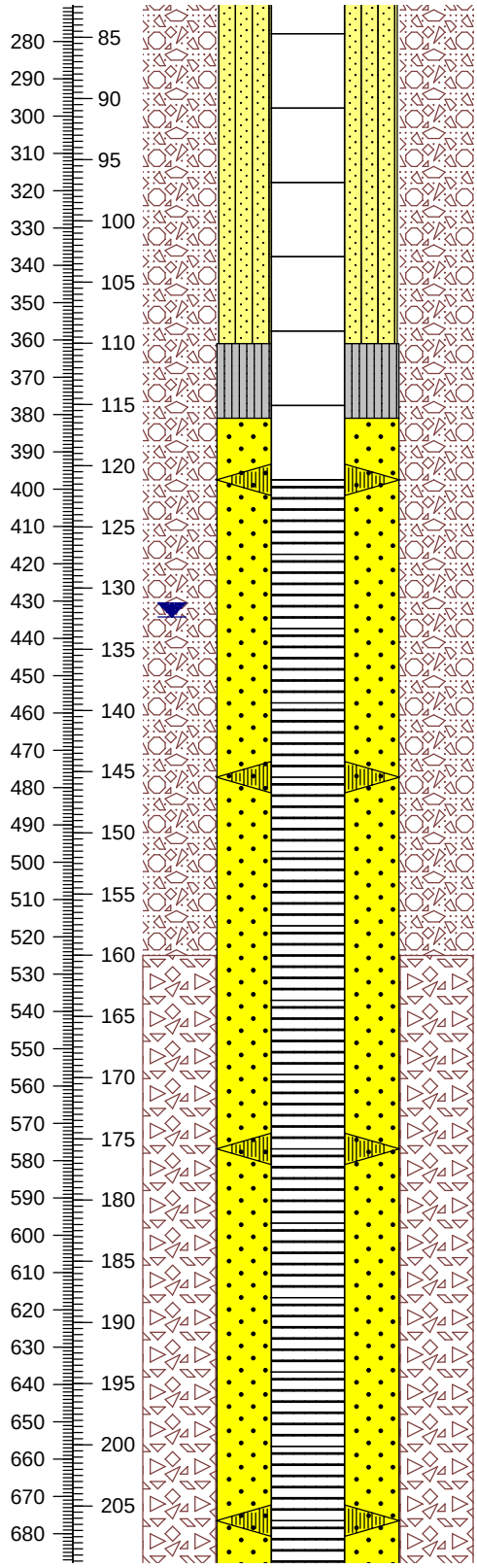
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Steel cage centralizer bolted together around casing coupling at 397.5' (121.2 m)

Top of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 397.5' (121.2 m)

Water Table Depth = 434.02' (132.29 m; measured during development 7/21/00)

Steel cage centralizer bolted together around casing coupling 477.2' (145.5 m)

Steel cage centralizer bolted together around casing coupling 576.8' (175.8 m)

Steel cage centralizer bolted together around casing coupling 676.5' (206.2 m)

Top of Upper Bentonite Seal = 361' (110.0 m)

Top of 4/8 Sand = 381' (116.1 m)

Volcanic-Rich Alluvium Depth = 525' (160.0 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

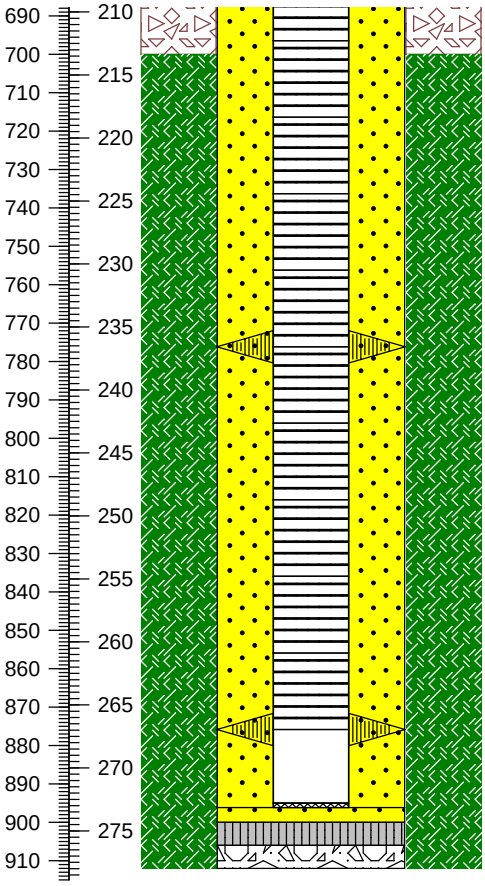
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Steel cage centralizer bolted together around casing coupling 776.2' (236.6 m)

Steel cage centralizer bolted together around casing coupling 875.8' (266.9 m)

Bottom of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 875.8' (266.9 m)

Sump consists of 20' blank riser and end cap; end cap attached with spline

9.31" minimum ID; 10.75" OD CertainTeed SDR 17 PVC Casing TD = 896.2' (273.2 m)

Annular/Borehole Descriptions
All depths listed are bgs

Volcanic Andesite Bedrock Depth = 700' (213.4 m)

Top of Lower Bentonite Seal = ~900' (~274.3 m) Depth not measured

Top of Slough = 906' (276.1 m; from Geophysical Logs)

17 1/2" Borehole TD = 912' (278.0 m)

WELL COMPLETION DIAGRAM

EXTRACTION

JSC - White Sands Test Facility, Las Cruces, New Mexico, USA

Location ID: **PFE-3**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SW 1/4 NE 1/4 NE 1/4 Sec 5, T21S, R3E**

NM State Plane Coordinates (NAD 83 in meters) **168015.96N 462277.63E**

Elevation (Brass Cap): **~1378.81 m AMSL (estimated ground level)**

Elevation (Top of Casing): **1379.35 m AMSL (prior to vault construction)**

Drilling Contractor: **Larjon Drilling Company**

Driller: **T. Crawford, J. Gower**

Total Depth of Borehole (bgs): **856' (260.91 m)**

Borehole Diameter: **16" 0 - 79'; 7 7/8" pilot; reamed 17 7/8" 79 - 856'**

Depth to Bedrock (bgs): **844' (257.25 m)**

Depth to Groundwater: **459' (139.9 m) 1/16/03**

Total Depth Surface Casing (bgs): **79.5' (temporary)**

Diameter and Type Surface Casing: **10" temporary steel casing (pulled 12/6/89)**

Date(s) Well Installed: **O = 12/19/89 - 1/5/90; I = 1/22/03 - 1/24/03**

Date(s) Well Developed: **O = 1/9/90 - 1/12/90, 3/29/90; I = 1/25/03 - 1/29/03**

Field Representative(s): **G. Contaldo, E. Morse, P. Egan, R. Cooper, J. Kirby**

Total Depth Outer Well Casing (bgs): **838.47' (255.57 m)**

Total Depth Inner Well Casing (bgs): **836.12' (254.84 m)**

Type of Casing(s): **O = Carbon Steel; I = CertainTeed PVC**

Diameter Well Casing(s): **O = 10.02 ID/10.5 OD; I = 6.13" ID/6.90" OD**

Casing Schedule(s): **O = Not Recorded; I = SDR 21**

Outer Casing Screened Zone (bgs): **507.7 - 828.4' (154.75 - 252.50 m) (alternate 20' Screens/10' blanks)**

Inner Casing Screened Zone (bgs): **477.1 - 816.0' (145.42 - 248.72 m) (alternating screens with blanks)**

Comments: **Well completed as an extraction well below grade in a cement vault; O = Outer Casing; I = Inner Casing Pump test performed 5/23/90. Step-drawdown test performed 6/4 - 6/17/90 (including recovery monitoring). S = screen; B = blank**

Casing Explanation:

- Surface Casing — **Nominal 10" Carbon Steel**
- **10" ID Carbon Steel**
- **10" ID Carbon Steel 0.080" - Slot Screen**
- **10" ID Carbon Steel End Cap**
- Water Table
- **6.05" ID CertainTeed PVC**
- **6.05" ID CertainTeed PVC 0.050" - Slot Screen**
- **6.05" ID CertainTeed PVC End Cap**
- **Welded Centralizers**

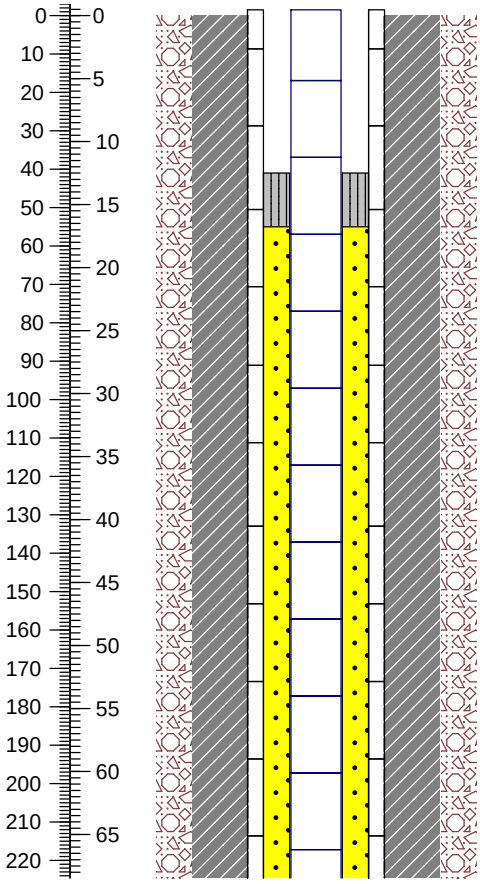
Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 10/20 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Lithology Explanation:

Alluvium, Volcanic-Rich Alluvium, Limestone, Sandstone, Shale, Andesite, Rhyolite, Undifferentiated Volcanics

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~11.4' (3.5 m) ags installed at installation. Cut to ~1.5' (0.5 m). Casing was later cut below ground surface and completed within a cement well vault.

No Surface Casing

Stick-Up = 3.11' (0.9 m) ags installed at installation to sit level on flange of carbon steel well. Casing was later cut below ground surface and completed within a cement well vault.

Welded carbon steel casing (schedule of casing not recorded).

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = 0'

Formation is Santa Fe Group Alluvium from surface to 500' (152.4 m)

Casing Explanation:

- Surface Casing — **Nominal 10" Carbon Steel**
- **10" ID Carbon Steel**
- **10" ID Carbon Steel 0.080" - Slot Screen**
- **10" ID Carbon Steel End Cap**
- Water Table
- **6.05" ID CertainTeed PVC**
- **6.05" ID CertainTeed PVC 0.050" - Slot Screen**
- **6.05" ID CertainTeed PVC End Cap**
- **Welded Centralizers**

Annular Materials Explanation:

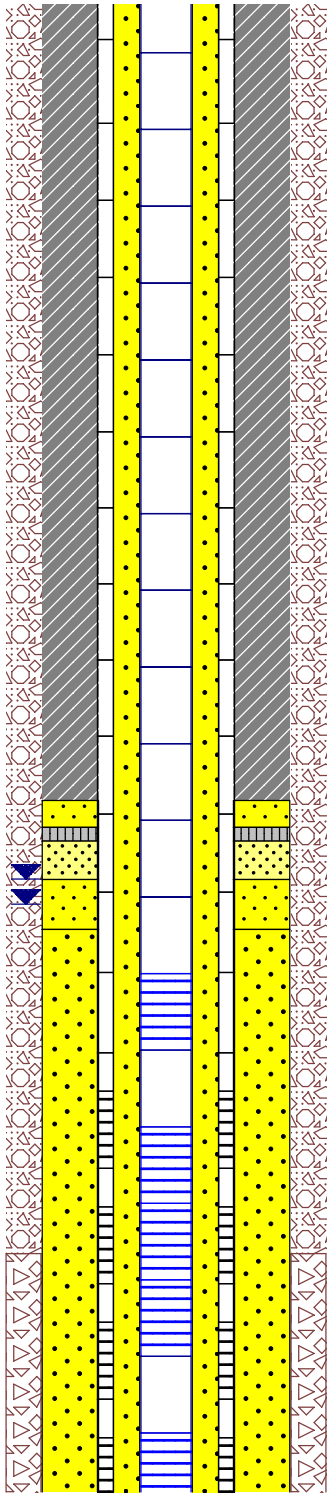
- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 10/20 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Lithology Explanation:

Alluvium, Volcanic-Rich Alluvium, Limestone, Sandstone, Shale, Andesite, Rhyolite, Undifferentiated Volcanics

Feet/Meters

230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610
70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185															



Well Descriptions
All depths listed are bgs (unless noted)

Water Table Depth = 452.44' (137.90 m TOC; measured, date unknown)

Water Table Depth = 459' (139.9 m bgs) per camera log counter 1/16/03.

6.9" OD PVC casing screened zone made up of one 20' screen, one 20' blank, then three 20' screens separated by 20' blanks.

Top of 6.13" minimum ID (6.05" ID measured); 6.9" OD CertainTeed SDR 21 0.050" - Slot PVC Screen = 477.1' (145.4 m)

10.02" ID Carbon Steel Screened zone made up of 20' screens welded to 10' blank sections.

Top of 10.02" ID; 10.75" OD Carbon Steel Continuous Wire Wound 0.080"-Slot Screen = 507.7' (154.7 m)

Annular/Borehole Descriptions
All depths listed are bgs

Note: Exact depths of annular materials not measured due to malfunctioning probe. Depths are approximate (~).

Top of 8/20 Sand = ~432' (~131.7 m)

Top of Bentonite Seal = ~439' (133.8 m)

Top of 16/40 Sand = ~442.6' (~134.9 m)

Top of 8/20 Sand = ~452.6' (~138.0 m)

Top of 4/8 Sand = 465.6' (141.9 m)

Volcanic-Rich Alluvium Depth = 550' (167.6 m)

Casing Explanation:

- Surface Casing — **Nominal 10" Carbon Steel**
- **10" ID Carbon Steel**
- **10" ID Carbon Steel 0.080" - Slot Screen**
- **10" ID Carbon Steel End Cap**
- Water Table
- **6.05" ID CertainTeed PVC**
- **6.05" ID CertainTeed PVC 0.050" - Slot Screen**
- **6.05" ID CertainTeed PVC End Cap**
- **Welded Centralizers**

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 10/20 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Lithology Explanation:

Alluvium | Volcanic-Rich Alluvium | Limestone | Sandstone | Shale | Andesite | Rhyolite | Undifferentiated Volcanics

Feet/Meters

Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
Three stainless steel centralizers welded to casing at 623.5' (190.0 m)	
Three stainless steel centralizers welded to casing at 713.5' (217.5 m)	
Three stainless steel centralizers welded to casing at 803.5' (244.9 m)	
Bottom of 6.13" minimum ID (6.05" ID measured); 6.9" OD CertainTeed SDR 21 0.050" - Slot PVC Screen = 816.0' (248.7 m)	
Bottom of 10.02" ID / 10.75" OD Carbon Steel Continuous Wire Wound 0.080" - Slot Screen = 828.4' (252.5 m)	
Sump consists of 20' blank riser with end cap attached with spline.	
Sump consists of 10' blank riser welded to tapered end cap.	Top of Slough = 838' (255.4 m) (Casing installed to top of slough 12/20/89)
6.13" minimum ID (6.05" ID measured); 6.9" OD CertainTeed SDR 21 PVC Casing TD = 836.1' (254.8 m)	Volcanic Andesite Bedrock Depth = 844' (257.3 m)
10.02" ID / 10.75" OD Carbon Steel Casing TD = 838.47' (255.57 m)	17 7/8" Borehole TD = 856' (260.91 m)

WELL COMPLETION DIAGRAM

EXTRACTION

Location ID: **PFE-4A** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SW 1/4, SW 1/4, NW 1/4, Sec 4, T21S, R3E**
Site Coordinates: **167616.47 N/462572.87 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1383.19 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **Davis Gaddy**
Total Depth of Borehole (bgs): **720' (219.5 m)**
Borehole Diameter: **17 1/2" 0-117'; reamed 26"; 17 1/2" 117-720'**
Depth to Bedrock (bgs): **630' (192.0 m; Andesite)**
Depth to Groundwater: **469.58' (143.13 m; measured 9/4/01)**
Total Depth Surface Casing (bgs): **117' (35.7 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **8/15/01-8/22/01**
Date(s) Well Developed: **8/23-24/01 jetted; 8/25/01-9/5/01 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **697.3' (212.5 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **9.31" min. ID; 10.75" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **398.0-677.3' (121.3-206.4 m)**
Comments: **Well completed as an extraction well below grade in a cement vault**

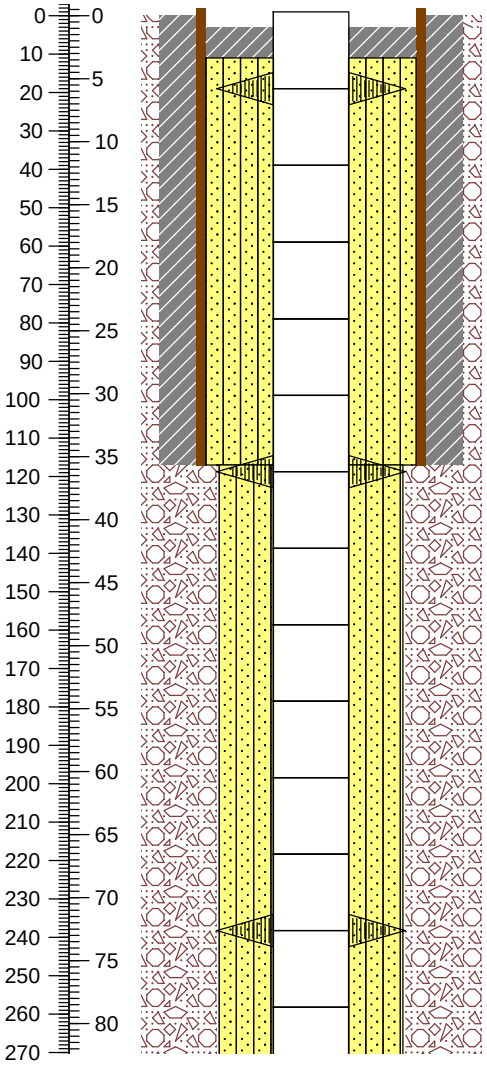
Casing Explanation:

- Surface Casing: **20" Carbon Steel**
- Conventional Casing: **10.75" OD CertainTeed PVC**
- Conventional Screen: **10.75" OD CertainTeed PVC 0.085"-Slot**
- Conventional End Cap: **10.75" OD CertainTeed PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 4/8 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.6 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

Steel cage centralizer bolted together around casing coupling at 19.0' (5.8 m)

20" OD Carbon Steel Surface Casing Depth = 117' (35.7 m)
Steel cage centralizer bolted together around casing coupling at 118.8' (36.2 m)

Steel cage centralizer bolted together around casing coupling at 238.3' (72.6 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~3' (0.9 m)

Top of 4/8 Sand/Bentonite Mix = 11' (3.4 m)

Field Representatives: Mary Canavan; Geoff Giles; Lela Hunnicutt-Mack; John Pearson; Murray Stepro; and Ron Weaver

The formation is Santa Fe Group Alluvium from surface to 480' (146.3 m)

17 1/2" Borehole cemented to 117' (35.7 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

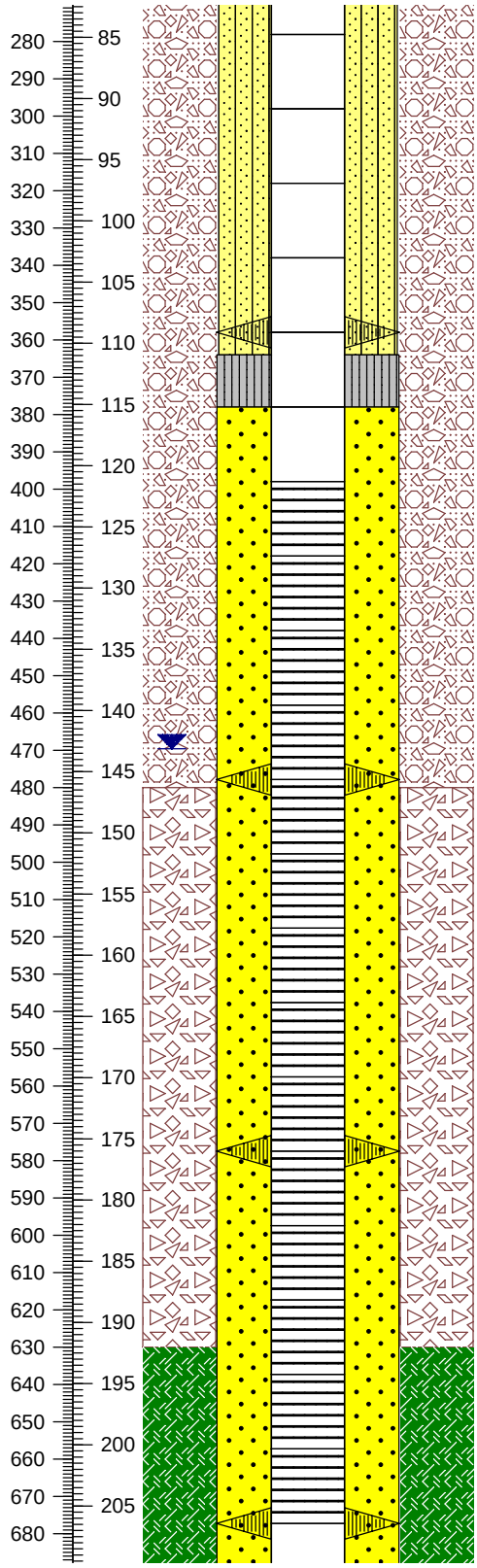
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Steel cage centralizer bolted together around casing coupling at 358.0' (109.1 m)

Top of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 358.0' (109.1 m)

Water Table Depth = 469.58' (143.13 m; measured during development 9/4/01)

Steel cage centralizer bolted together around casing coupling 477.8' (145.6 m)

Steel cage centralizer bolted together around casing coupling 577.5' (176.0 m)

Steel cage centralizer bolted together around casing coupling 677.3' (206.4 m)

Bottom of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 677.3' (206.4 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Upper Bentonite Seal = 364' (110.9 m)

Top of 4/8 Sand = 378' (115.2 m)

Volcanic-Rich Alluvium Depth = 480' (146.3 m)

Volcanic Andesite Bedrock Depth = 630' (192.0 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

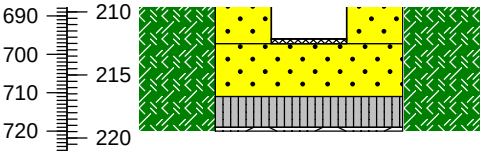
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Sump consists of 20' blank riser and end cap; end cap attached with spline

9.31" minimum ID; 10.75" OD CertainTeed SDR 17 PVC Casing TD = 697.3' (212.5 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Lower Bentonite Seal = 711' (216.7 m)

Top of Slough = 719' (219.2 m; from Geophysical Logs)

17 1/2" Borehole TD = 720' (219.5 m)

WELL COMPLETION DIAGRAM

EXTRACTION

Location ID: **PFE-7** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4, SW 1/4, SW 1/4, Sec 32, T20S, R3E**
Site Coordinates: **168738.66 N/461492.98 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1365.37 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **Davis Gaddy**
Total Depth of Borehole (bgs): **720' (219.5 m)**
Borehole Diameter: **17 1/2" 0-117'; reamed 26"; 17 1/2" 117-720'**
Depth to Bedrock (bgs): **Not Reached**
Depth to Groundwater: **412.11' (125.61 m; measured 8/27/01)**
Total Depth Surface Casing (bgs): **117' (35.7 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **7/25/01-7/29/01**
Date(s) Well Developed: **7/29/01 jetted; 8/27/01 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **697.6' (212.6 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **9.31" min. ID; 10.75" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **398.0-677.6' (121.3-206.5 m)**
Comments: **Well completed as an extraction well below grade in a cement vault**

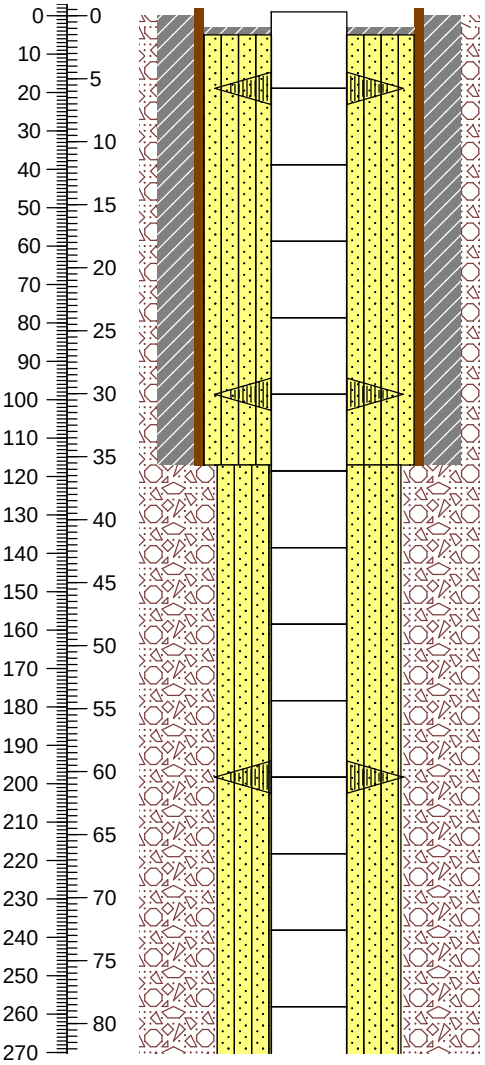
Casing Explanation:

- Surface Casing: **20" Carbon Steel**
- Conventional Casing: **10.75" OD CertainTeed PVC**
- Conventional Screen: **10.75" OD CertainTeed PVC 0.085"-Slot**
- Conventional End Cap: **10.75" OD CertainTeed PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 4/8 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.6 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

Steel cage centralizer bolted together around casing coupling at 18.9' (5.8 m)

NOTE: Number and locations of centralizers were not recorded at installation. Centralizers assumed to have been installed per the well design.

Steel cage centralizer bolted together around casing coupling at 98.6' (30.1 m)

20" OD Carbon Steel Surface Casing Depth = 117' (35.7 m)

Steel cage centralizer bolted together around casing coupling at 198.3' (60.4 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~3' (0.9 m)

Top of 4/8 Sand/Bentonite Mix = 5' (1.5 m)

Field Representatives: Mary Canavan; Geoff Giles; Lela Hunnicutt-Mack; John Pearson; Murray Stepro; and Ron Weaver

The formation is Santa Fe Group Alluvium from surface to 480' (146.3 m)

17 1/2" Borehole cemented to 117' (35.7 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

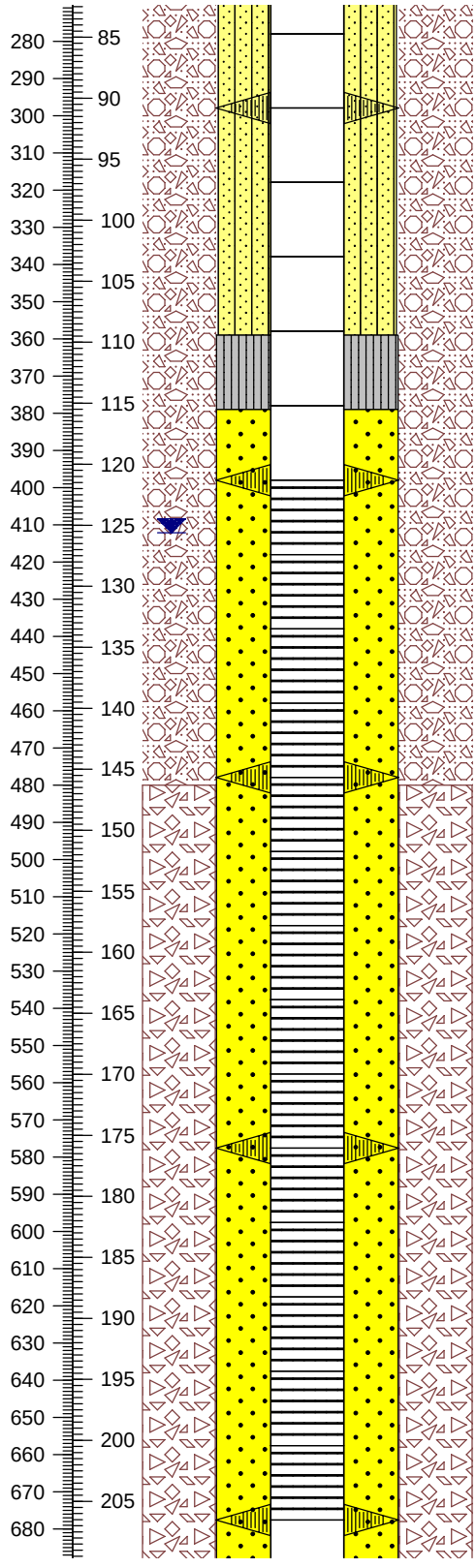
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Steel cage centralizer bolted together around casing coupling at 297.9' (90.8 m)

Steel cage centralizer bolted together around casing coupling at 398.0' (121.3 m)

Top of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 398.0' (121.3 m)

Water Table Depth = 412.11' (125.61 m; measured during development 8/27/01)

Steel cage centralizer bolted together around casing coupling 477.9' (145.7 m)

Steel cage centralizer bolted together around casing coupling 577.6' (176.1 m)

Steel cage centralizer bolted together around casing coupling 677.6' (206.5 m)

Bottom of 9.31" minimum ID; 10.75" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 677.6' (206.5 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Upper Bentonite Seal = 359' (109.4 m)

Top of 4/8 Sand = 379' (115.5 m)

Volcanic-Rich Alluvium Depth = 480' (146.3 m)

Surface Casing
20" Carbon Steel

Conventional Casing
10.75" OD CertainTeed PVC

Conventional Screen
10.75" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
10.75" OD CertainTeed PVC

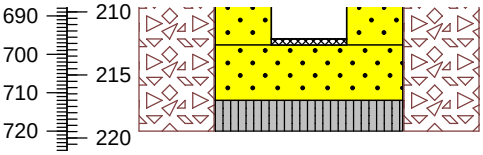
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
4/8 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Sump consists of 20' blank riser and end cap; end cap attached with spline

9.31" minimum ID; 10.75" OD CertainTeed SDR 17 PVC Casing TD = 697.6' (212.6 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Lower Bentonite Seal = 712' (217.0 m)

No Slough

17 1/2" Borehole TD = 720' (219.5 m)

WELL COMPLETION DIAGRAM

INJECTION

Location ID: **PFI-1** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4 NE 1/4 SW 1/4 Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83):**167420.13 N 461686.60 E**
Elevation (Ground Surface): **Below Grade Vault (modification pending)**
Elevation (Top of Casing): **1367.79 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **J. Aguilar**
Total Depth of Borehole (bgs): **1,020' (310.90 m)**
Borehole Diameter: **17 1/2" 0-100'; reamed 26" to 115'; 17 1/2" 115-1,020'**
Depth to Bedrock (bgs): **Not Reached**
Depth to Groundwater: **427.72' (130.37 m)**
Total Depth Surface Casing (bgs): **111' (33.83 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **4/26/00-4/29/00**
Date(s) Well Developed: **8/31/00-9/1/00 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **996.58' (303.76 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **7.85" min. ID; 9.05" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **418.15-976.57' (127.45-297.66 m)**
Comments: **Well completed as an injection well below grade in a cement vault**
8/18/00 took preliminary samples to verify well is contaminant-free

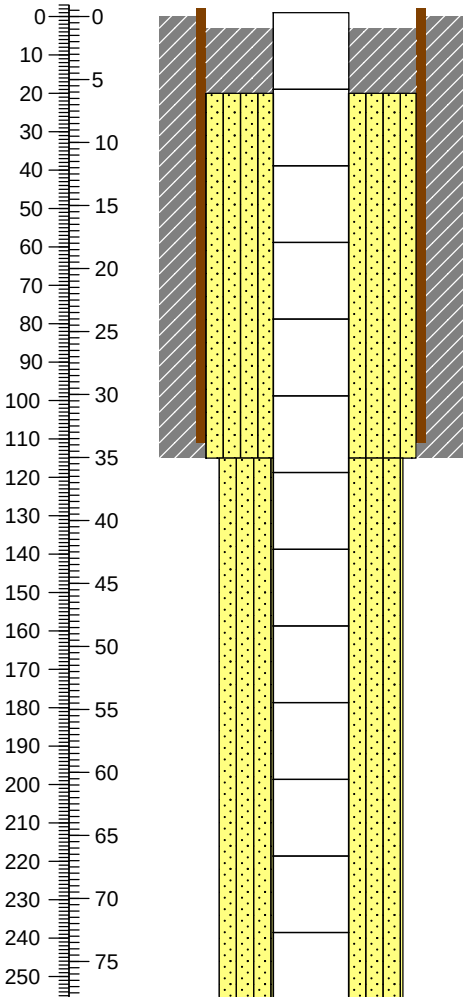
Casing Explanation:

- Surface Casing **20" Carbon Steel**
- Conventional Casing **9.05" OD CertainTeed PVC**
- Conventional Screen **9.05" OD CertainTeed PVC 0.085"-Slot**
- Conventional End Cap **9.05" OD CertainTeed PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 8/12 Sand Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.61 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

20" OD Carbon Steel Surface Casing Depth = 111' (33.83 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~3' (0.9 m)

Top of 8/12 Sand/Bentonite Mix = 20' (6.10 m)

Field Representatives: M. Canavan; G. Giles; L. Hunnicutt-Mack; J.Pearson; M. Stepro; and R. Weaver

The formation is Santa Fe Group Alluvium from surface to 590' (179.83 m)

17 1/2" Borehole cemented to 115' (35.05 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

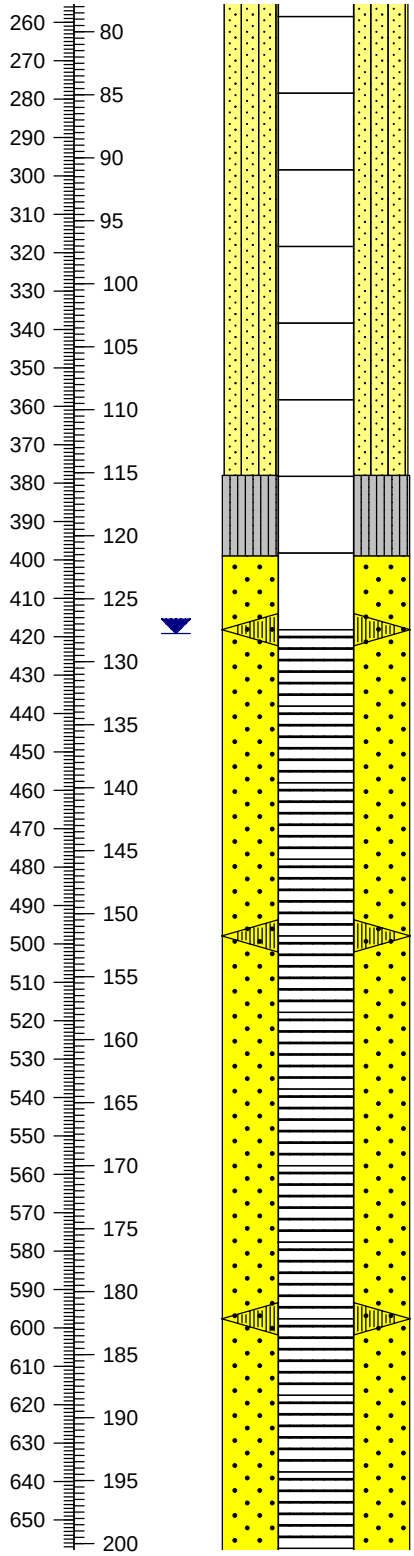
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Steel cage centralizer bolted together around casing coupling at 418.2' (127.47 m)

Top of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 418.2' (127.47 m)

Water Table Depth = 419.18' (127.77 m; measured post-development date unknown)

Steel cage centralizer bolted together around casing coupling 497.9' (151.76 m)

Steel cage centralizer bolted together around casing coupling 597.6' (182.15 m)

Top of Upper Bentonite Seal = 378' (115.21 m)

Top of 4/8 Sand = 399' (121.62 m)

Volcanic-Rich Alluvium Depth = 590' (179.83 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
Steel cage centralizer bolted together around casing coupling 697.3' (212.60 m)	
Steel cage centralizer bolted together around casing coupling 797.0' (242.93 m)	
Steel cage centralizer bolted together around casing coupling 896.7' (273.31 m)	
Steel cage centralizer bolted together around casing coupling 976.6' (297.67 m) Bottom of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 976.6' (297.67 m) Sump consists of 20' blank riser and end cap; end cap attached with spline 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 PVC Casing TD = 996.58' (303.76 m)	Top of Lower Bentonite Seal = 1,005' (306.32 m) Top of Slough = 1,010' (307.85 m; from Geophysical Logs) 17 1/2" Borehole TD = 1,020' (310.90 m)

WELL COMPLETION DIAGRAM

INJECTION

Location ID: **PFI-2** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4 NW 1/4 SE 1/4 Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83):**167269.44 N 462020.54 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1373.21 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **J. Aguilar**
Total Depth of Borehole (bgs): **1,020' (310.90 m)**
Borehole Diameter: **17 1/2" 0-115'; reamed 26"; 17 1/2" 115-1,020'**
Depth to Bedrock (bgs): **Not Reached**
Depth to Groundwater: **436.64' (133.09 m)[date not recorded]**
Total Depth Surface Casing (bgs): **115' (35.05 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **6/20/00-6/24/00**
Date(s) Well Developed: **9/5/00-9/6/00 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **996.62' (303.62 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **7.85" min. ID; 9.05" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **418.13-976.67' (127.45-297.69 m)**
Comments: **Well completed as an injection well below grade in a cement vault**
8/19/00 took preliminary samples to verify well is contaminant-free

Casing Explanation:

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough

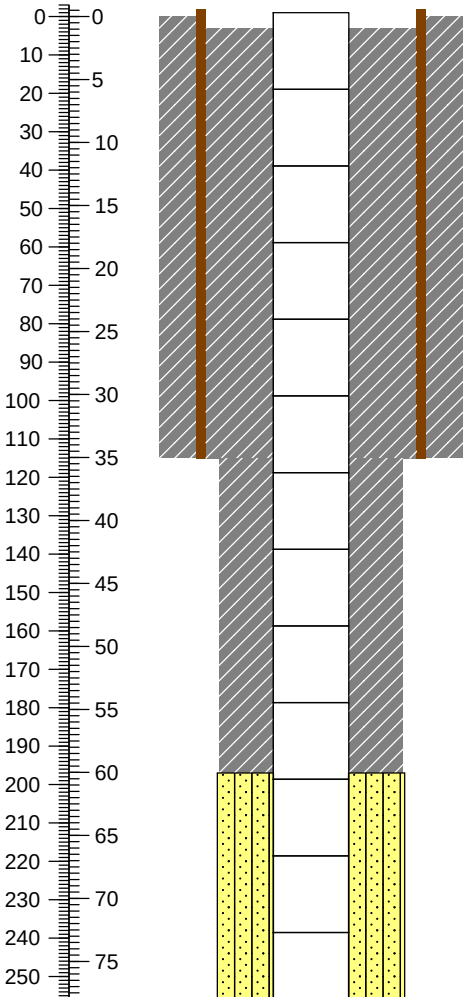
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand

10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.61 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

20" OD Carbon Steel Surface Casing Depth = 115' (35.05 m)

Top of Cement Grout (Portland II) = ~3' (0.9 m)

Field Representatives: M. Canavan; G. Giles; L. Hunnicutt-Mack; J. Kirby; J. Pearson; M. Stepro; and R. Weaver

The formation is Santa Fe Group Alluvium from surface to 570' (173.74 m)

17 1/2" Borehole cemented to 115' (35.05 m)

Top of 8/12 Sand/Bentonite Mix = 197' (60.05 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

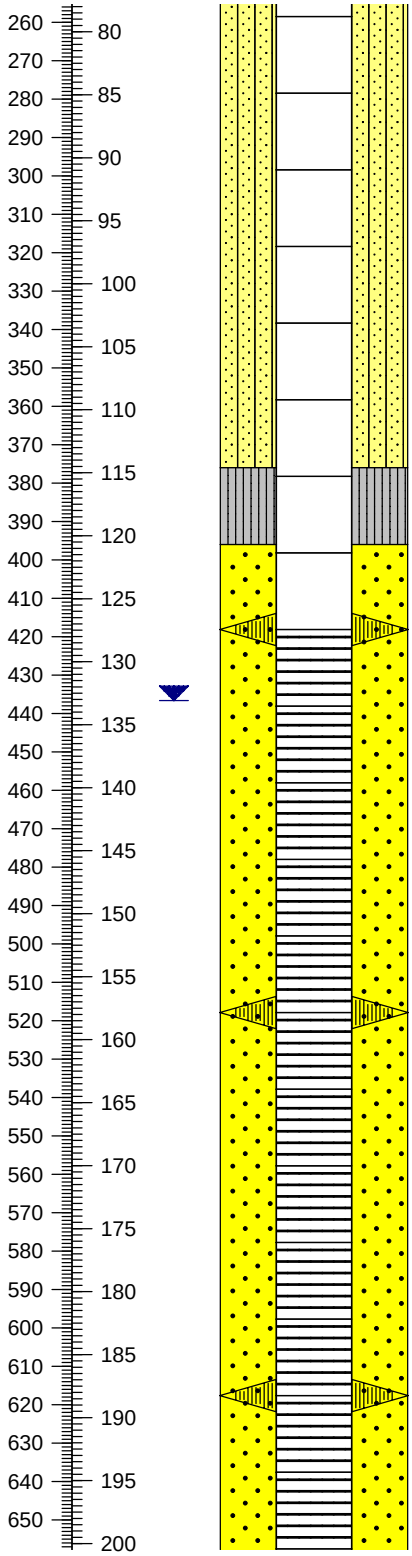
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Steel cage centralizer bolted together around casing coupling at 418.13' (127.45 m)

Top of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 418.13' (127.45 m)

Water Table Depth = 436.64' (133.09 m; measured post-development date unknown)

Steel cage centralizer bolted together around casing coupling 517.9' (157.86 m)

Steel cage centralizer bolted together around casing coupling 617.6' (188.24 m)

Top of Upper Bentonite Seal = 376' (114.60 m)

Top of 4/8 Sand = 396' (120.70 m)

Volcanic-Rich Alluvium Depth = 570' (173.74 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

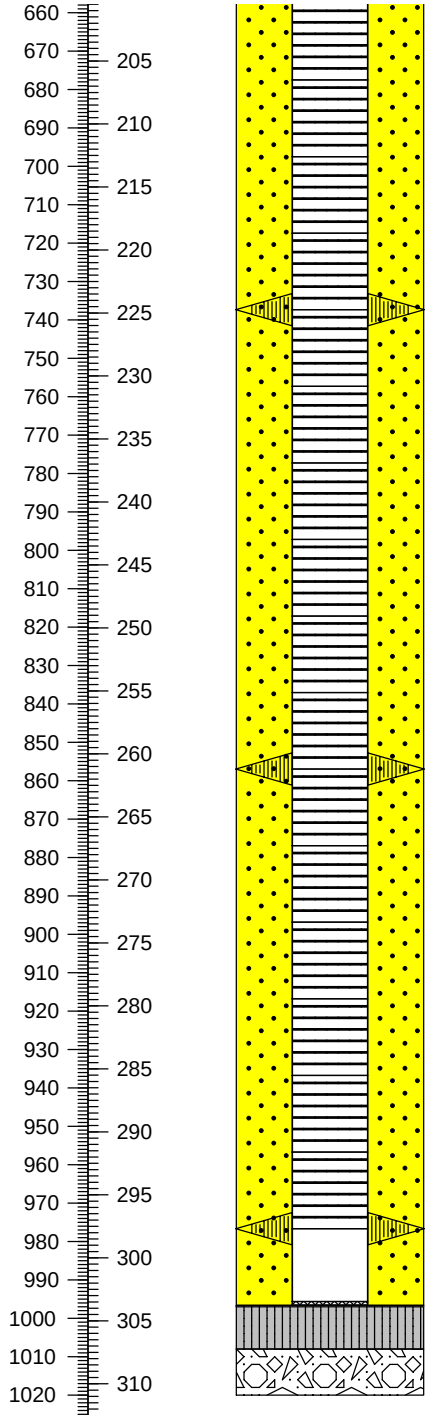
Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Steel cage centralizer bolted together around casing coupling 737.4' (224.76 m)

Steel cage centralizer bolted together around casing coupling 857.0' (261.21 m)

Steel cage centralizer bolted together around casing coupling 976.67' (297.69 m)

Bottom of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 976.67' (297.69 m)

Sump consists of 20' blank riser and end cap; end cap attached with spline

7.85" minimum ID; 9.05" OD CertainTeed SDR 17 PVC Casing TD = 996.62' (303.77 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Lower Bentonite Seal = 997' (303.89 m)

Top of Slough = 1,008' (307.24 m; measured 6/21/00; 1,016' (309.68 m) from Geophysical Logs)

17 1/2" Borehole TD = 1,020' (310.90 m)

WELL COMPLETION DIAGRAM

INJECTION

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **PFI-3**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NW 1/4 SE 1/4 SE 1/4 Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83):**167095.20 N** **462179.48 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1376.17 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **J. Aguilar**
Total Depth of Borehole (bgs): **1,020' (310.90 m)**
Borehole Diameter: **17.5" 0-115' (35.05 m)--reamed 26"; 17.5" 115-1,020'**
Depth to Bedrock (bgs): **Not Reached**
Depth to Groundwater: **446.74' (136.17 m)[date not recorded]**
Total Depth Surface Casing (bgs): **111.5' (33.99 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **5/24/00-5/27/00**
Date(s) Well Developed: **9/8/00-9/9/00 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **996.89' (303.85 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **7.85" min. ID; 9.05" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **417.95 - 976.89' (127.39 - 297.76 m)**
Comments: **Well completed as an extraction well below grade in a cement vault**
8/23-24/00 took preliminary samples to verify well is contaminant-free

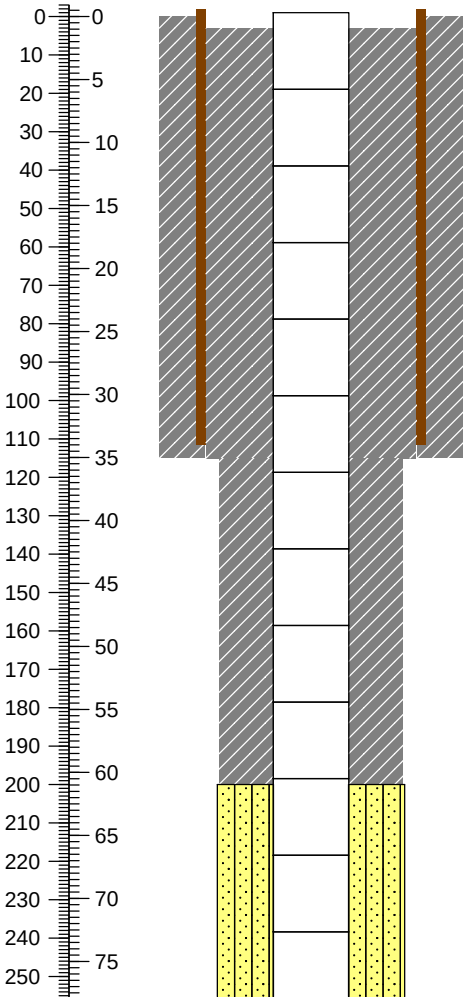
Casing Explanation:

- Surface Casing **20" Carbon Steel**
- Conventional Casing **9.05" OD CertainTeed PVC**
- Conventional Screen **9.05" OD CertainTeed PVC 0.085"-Slot**
- Conventional End Cap **9.05" OD CertainTeed PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 8/12 Sand Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.6 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

20" OD Carbon Steel Surface Casing Depth = 111.5' (33.99 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~3' (0.9 m)

Field Representatives: M. Canavan; G. Giles; L. Hunnicutt-Mack; J. Pearson; and M. Stepro

The formation is Santa Fe Group Alluvium from surface to 560' (170.69 m)

17 1/2" Borehole cemented to 115' (35.05 m)

Top of 8/12 Sand/Bentonite Mix = 200' (60.96 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

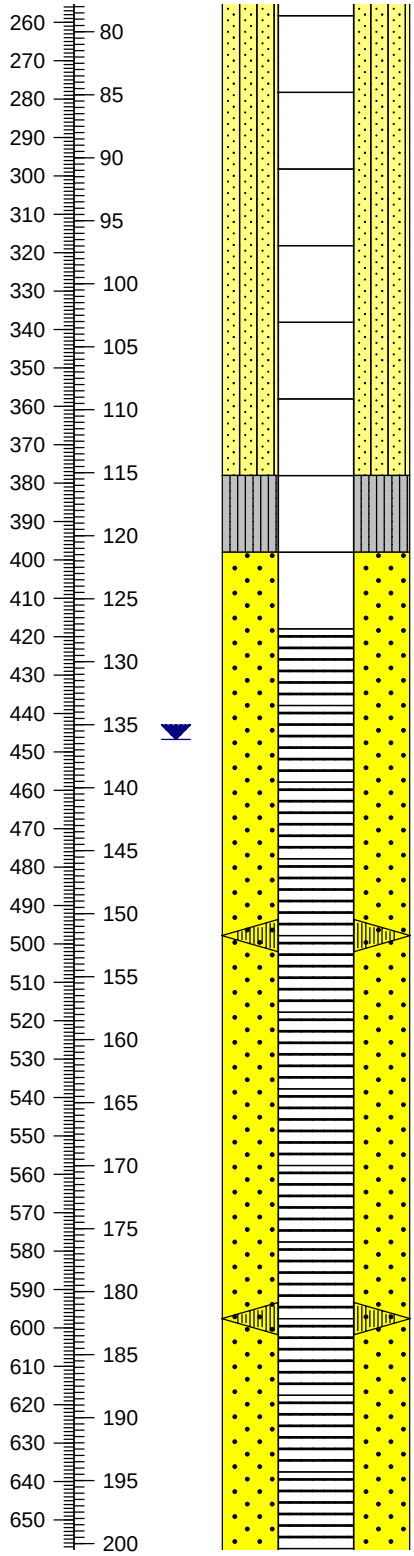
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



NOTE: Number and locations of centralizers were not recorded at installation. Centralizers assumed to have been installed per the well design.

Top of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 417.95' (127.39 m)

Water Table Depth = 446.74' (136.17 m; measured post-development date unknown)

Steel cage centralizer bolted together around casing coupling at 497.8' (151.73 m)

Steel cage centralizer bolted together around casing coupling 597.6' (182.15 m)

Top of Upper Bentonite Seal = 378' (115.21 m)

Top of 4/8 Sand = 398' (121.31 m)

Volcanic-Rich Alluvium Depth = 560' (170.69 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

	Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
660 / 205		
670 / 205		
680 / 210		
690 / 210		
700 / 215	Steel cage centralizer bolted together around casing coupling 697.4' (212.57 m)	
710 / 215		
720 / 220		
730 / 225		
740 / 225		
750 / 230		
760 / 230		
770 / 235		
780 / 240		
790 / 240		
800 / 245	Steel cage centralizer bolted together around casing coupling 797.2' (242.99 m)	
810 / 245		
820 / 250		
830 / 255		
840 / 255		
850 / 260		
860 / 260		
870 / 265		
880 / 270		
890 / 270		
900 / 275	Steel cage centralizer bolted together around casing coupling 897.0' (273.41 m)	
910 / 275		
920 / 280		
930 / 285		
940 / 285		
950 / 290		
960 / 290	Steel cage centralizer bolted together around casing coupling 976.9' (297.76 m)	
970 / 295		
980 / 300	Bottom of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 976.89' (297.76 m)	Top of Lower Bentonite Seal = 1,009' (307.54 m)
990 / 300	Sump consists of 20' blank riser and end cap; end cap attached with spline	Top of Slough = 1,016' (309.68 m; from Geophysical Logs)
1000 / 305	7.85" minimum ID; 9.05" OD CertainTeed SDR 17 PVC Casing TD = 996.89' (303.85 m)	17 1/2" Borehole TD = 1,020' (310.90 m)
1010 / 305		
1020 / 310		

WELL COMPLETION DIAGRAM

INJECTION

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **PFI-4**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4, SE 1/4, SE 1/4, Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83):**166966.72 N/462362.43 E**
Elevation (Ground Surface): **Below Grade Vault**
Elevation (Top of Casing): **1379.44 m**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **Juan Aguilar**
Total Depth of Borehole (bgs): **911' (277.7 m)**
Borehole Diameter: **17 1/2" 0-115'; reamed 26"; 17 1/2" 115-911'**
Depth to Bedrock (bgs): **Not Reached**
Depth to Groundwater: **457.86' (139.56 m)**
Total Depth Surface Casing (bgs): **115' (35.1 m)**
Diameter and Type Surface Casing: **19.5" ID; 20" OD Carbon Steel**

Date(s) Well Installed: **7/19/00-7/21/00**
Date(s) Well Developed: **9/9/00-9/10/00 pumping**
Field Representative(s): **See Annular Descriptions**
Total Depth Well Casing (bgs): **897.7' (273.6 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **7.85" min. ID; 9.05" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **397.9-877.8' (121.3-267.6 m)**
Comments: **Well completed as an injection well below grade in a cement vault**
8/20/00 took preliminary samples to verify well is contaminant-free

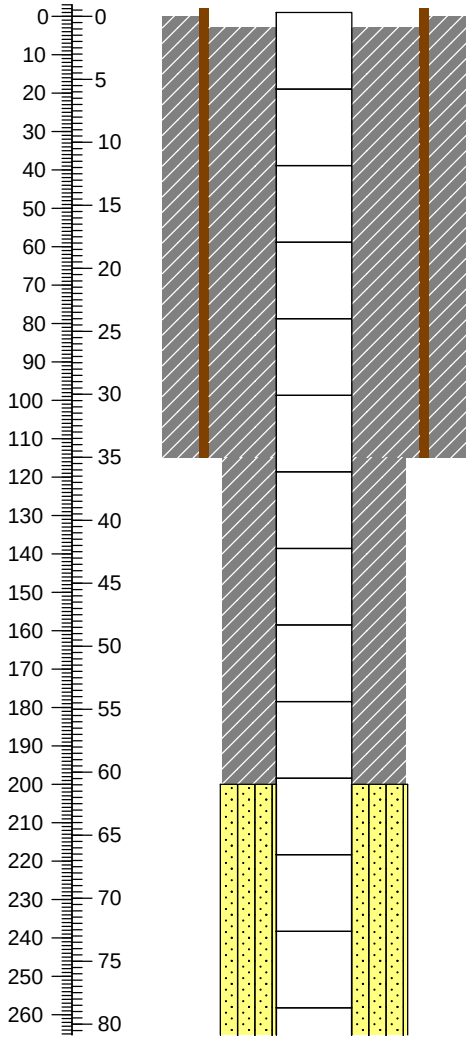
Casing Explanation:

- Surface Casing — **20" Carbon Steel**
- Conventional Casing — **9.05" OD CertainTeed PVC**
- Conventional Screen — **9.05" OD CertainTeed PVC 0.085"-Slot**
- Conventional End Cap — **9.05" OD CertainTeed PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 8/12 Sand Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1' (0.3 m) ags installed at installation. Casing was later cut below ground surface as well was completed within a cement well vault.

Surface Casing Stick-Up = 2' (0.6 m) ags at installation. Later cut below ground surface as well was completed within a cement well vault.

20" OD Carbon Steel Surface Casing Depth = 115' (35.1 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II) = ~3' (0.9 m)

Field Representatives: Lela Hunnicutt-Mack; John Pearson; Murray Stepro; and Ron Weaver

The formation is Santa Fe Group Alluvium from surface to 566' (172.5 m)

17 1/2" Borehole cemented to 115' (35.1 m)

Top of 8/12 Sand/Bentonite Mix = 200' (61.0 m)

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

	Well Descriptions All depths listed are bgs (unless noted)	Annular/Borehole Descriptions All depths listed are bgs
270 / 85		
280 / 90		
290 / 95		
300 / 100		
310 / 105		
320 / 110		Top of Upper Bentonite Seal = 354' (107.9 m)
330 / 115		Top of 4/8 Sand = 378' (115.2 m)
340 / 120	Steel cage centralizer bolted together around casing coupling at 397.9' (121.3 m)	
350 / 125	Top of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 397.9' (121.3 m)	
360 / 130		
370 / 135		
380 / 140	Water Table Depth = 457.86' (139.56 m; measured post-development date unknown)	
390 / 145		
400 / 150	Steel cage centralizer bolted together around casing coupling 497.7' (151.7 m)	
410 / 155		
420 / 160		
430 / 165		
440 / 170		
450 / 175		Volcanic-Rich Alluvium Depth = 566' (172.5 m)
460 / 180		
470 / 185	Steel cage centralizer bolted together around casing coupling 597.6' (182.1 m)	
480 / 190		
490 / 195		
500 / 200		
510 / 205		

Surface Casing
20" Carbon Steel

Conventional Casing
9.05" OD CertainTeed PVC

Conventional Screen
9.05" OD CertainTeed PVC
0.085"-Slot

Casing Explanation:

Conventional End Cap
9.05" OD CertainTeed PVC

Bolted Steel Cage Centralizers

Water Table

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
8/12 Sand Bentonite Mix
Slough

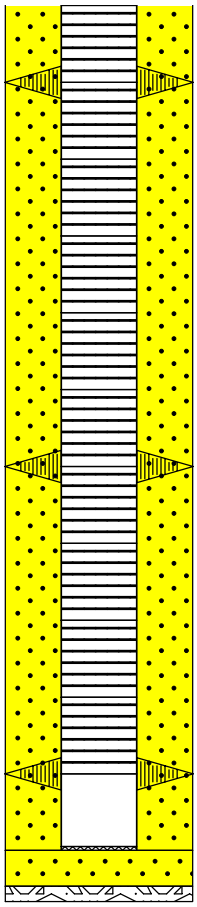
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand

10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910

210 215 220 225 230 235 240 245 250 255 260 265 270 275



Well Descriptions
All depths listed are bgs (unless noted)

Steel cage centralizer bolted together around casing coupling 697.7' (212.6 m)

Steel cage centralizer bolted together around casing coupling 797.7' (243.1 m)

Steel cage centralizer bolted together around casing coupling 877.8' (267.6 m)

Bottom of 7.85" minimum ID; 9.05" OD CertainTeed SDR 17 0.085"-Slot PVC Screen = 877.8' (267.6 m)

Sump consists of 20' blank riser and end cap; end cap attached with spline

7.85" minimum ID; 9.05" OD CertainTeed SDR 17 PVC Casing TD = 897.7' (273.6 m)

Annular/Borehole Descriptions
All depths listed are bgs

Volcanic Rhyolite Bedrock Depth = 890' (271.3 m)

No Lower Bentonite Seal

Top of Slough = 907' (276.5 m; from Geophysical Logs)

17 1/2" Borehole TD = 911' (277.7 m)

WELL COMPLETION DIAGRAM

Exploration Well

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **MPE-1**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4 NE 1/4 SE 1/4, Sec 33, T20S, R3E**
Site Coordinates: **168825.02N 464184.53E**
Elevation (Brass Cap): **1418.09 m AMSL**
Elevation (Top of Casing): **1418.56 m AMSL**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **J. Aguilar**
Total Depth of Borehole (bgs): **~560' (170.69 m)**
Borehole Diameter: **Reamed 17 1/2" to 120'; 12 1/4" to 560'**
Depth to Bedrock (bgs): **~250' (76.20 m)**
Depth to Groundwater: **327.59' (99.85 m) TOC (~12/2006)**
Total Depth Surface Casing (bgs): **120.00' (36.57 m)**
Diameter and Type Surface Casing: **13 1/2" ID, 14" OD Steel**

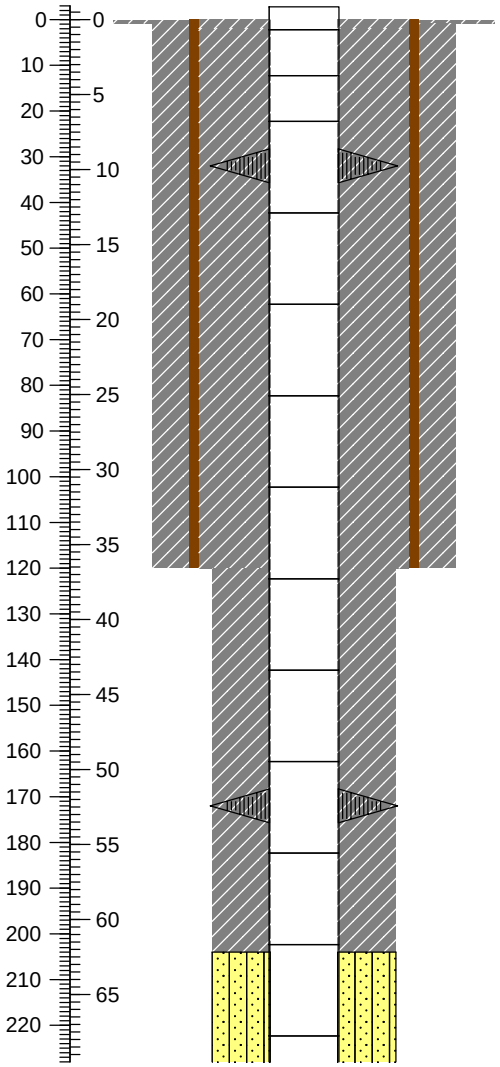
Date(s) Well Installed: **7/9/99 - 7/10/99**
Date(s) Well Developed: **7/14/99 - 8/6/99 (Initial)**
Field Representative(s): **J. Pearson**
Total Depth Well Casing (bgs): **522.72' (159.33 m)**
Type of Casing: **316L Stainless Steel**
Diameter Well Casing: **Nominal 6"**
Casing Schedule: **5**
Screened Zone (bgs): **362.46 - 512.70' (110.48 - 156.27 m)**
Comments: **This well is located on a MPCA structure identified from shallow seismic data.**
bgs = below ground surface TOC = Top of Casing
AMSL = Above Mean Sea Level

Casing Explanation:

- Surface Casing — **Steel Surface Casing**
- Conventional Casing — **Nominal 6" 316L Stainless Steel**
- Conventional Screen — **Nominal 6" 316L Stainless Steel 0.020"-Slot Wire-Wrapped**
- Conventional End Cap — **Nominal 6" 316L Stainless Steel**
- **Welded Steel Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 10/20 Sand Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand



Well Descriptions
All depths listed are bgs (unless noted)

Conventional Well Stick-Up = ~2.8' (0.85 m)

The well was completed with a ~3' x ~3' cement pad, barrier posts, and a locking steel well cap surrounding the casing at ground surface.

Three steel centralizers welded to casing at ~32' (9.75 m)

14" OD Steel Surface Casing Depth = 120.00' (36.58 m)

Three steel centralizers welded to casing at ~172' (52.43 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Cement Grout (Portland II Cement with 5% Bentonite) ~ 2' (0.61 m)

17 1/2" Borehole cemented to 120.00' (36.58 m)

Top of 10/20 Sand/Bentonite Mix = ~204' (62.18 m)

Surface Casing
Steel Surface Casing

Conventional Casing
Nominal 6" 316L Stainless Steel

Conventional Screen
Nominal 6" 316L Stainless Steel
0.020"-Slot Wire-Wrapped

Casing Explanation:

Conventional End Cap
Nominal 6" 316L Stainless Steel

Welded Steel Centralizers

Water Table

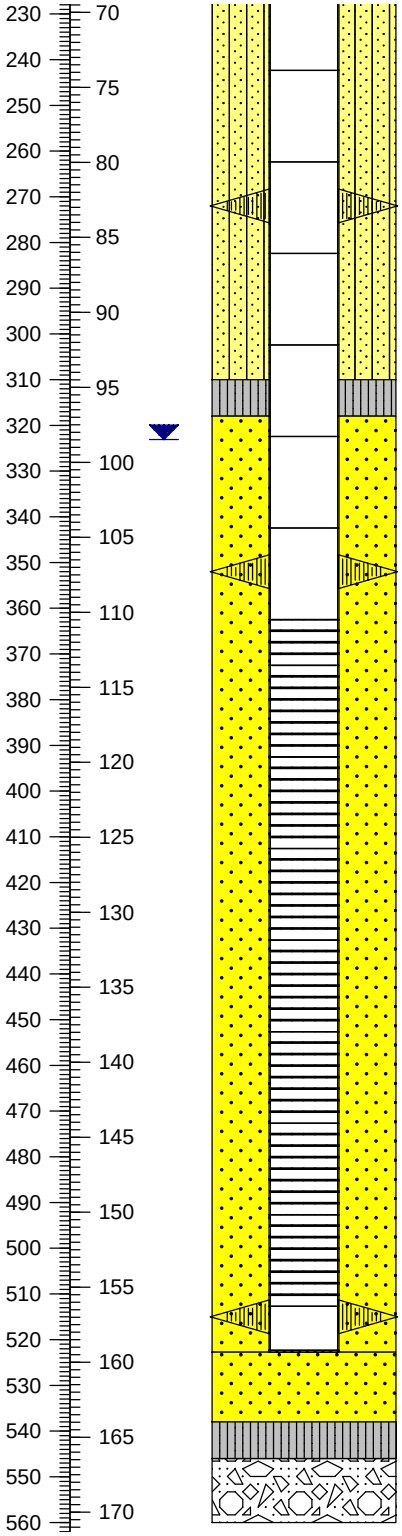
Cement
Bentonite (Grout Well DF)
Bentonite Seal
10/20 Sand Bentonite Mix
Slough

1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand

Annular Materials Explanation:

10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Three steel centralizers welded to casing at ~ 272' (82.90 m)

Water Table = 327.59' (99.85 m; TOC)

Three steel centralizers welded to casing at ~352' (107.29 m)

Top of (6" ID) 316L Schedule 5 Wire-Wrapped Stainless Steel 0.020"-Slot Screen (Extra Strength) = 362.46' (110.49 m)

Bottom of (6" ID) 316L Schedule 5 Wire-Wrapped Stainless Steel 0.020"-Slot Screen (Extra Strength) = 512.70' (156.27 m)

Three steel centralizers welded to casing at ~ 515' (156.97 m)

(6" ID) 316L Schedule 5 Stainless Steel Casing TD = 522.72' (159.33 m)

Sump consists of 10' blank riser and end cap

Annular/Borehole Descriptions
All depths listed are bgs

Volcanic Bedrock Depth = ~250.0' (76.20 m)

Top of Upper Bentonite Seal = ~310' (94.49 m)

Top of 10/20 Sand = ~318' (96.93 m)

Top of Lower Bentonite Seal = ~538' (163.98 m)

Top of Slough = ~546' (166.42 m)

12 1/4" Borehole TD = ~560' (170.69 m)

WELL COMPLETION DIAGRAM

Exploration Well

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **MPE-8**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4 NE 1/4 SE 1/4 Sec 33, T20S, R3E**
Site Coordinates: **168822.75 N 464152.59 E**
Elevation (Ground Surface): **1417.62 m AMSL**
Elevation (Top of Casing): **1418.54 m AMSL**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **L. Pasquale, L. P. Garcia, and W. Chamberlain**
Total Depth of Borehole (bgs): **620.00' (189.98 m)**
Borehole Diameter: **9 7/8" to 406' (123.75 m); 6 3/4" to 620' (188.98 m)**
Depth to Bedrock (bgs): **~296' (90.22 m)**
Depth to Groundwater: **322.47' (98.29 m) TOC (6/24/05)**
Total Depth Surface Casing (bgs): **403.00' (122.83 m)**
Diameter and Type Surface Casing: **6 7/8" ID, 7 5/8" OD Steel**

Date(s) Well Installed: **3/5/03-3/7/03**
Date(s) Well Developed: **4/8/03 to 4/28/03**
Field Representative(s): **M. Canavan, L. Hunnicutt-Mack, and M. Stepro**
Total Depth Well Casing (bgs): **601.31' (183.28 m)**
Type of Casing: **Flush-Threaded Carbon Steel**
Diameter Well Casing: **5 7/8" ID, 6 5/8" OD**
Casing Schedule: **14#J; 3120# Collapse**
Screened Zone (bgs): **380.02-490.56' (wide); 490.56-600.50' (close)**
Comments: **This well is located on a MPCA structure identified from shallow seismic data. Well produced >30 gpm during preliminary development. AMSL = Above Mean Sea Level bgs = below ground surface. TOC = Top of Casing**

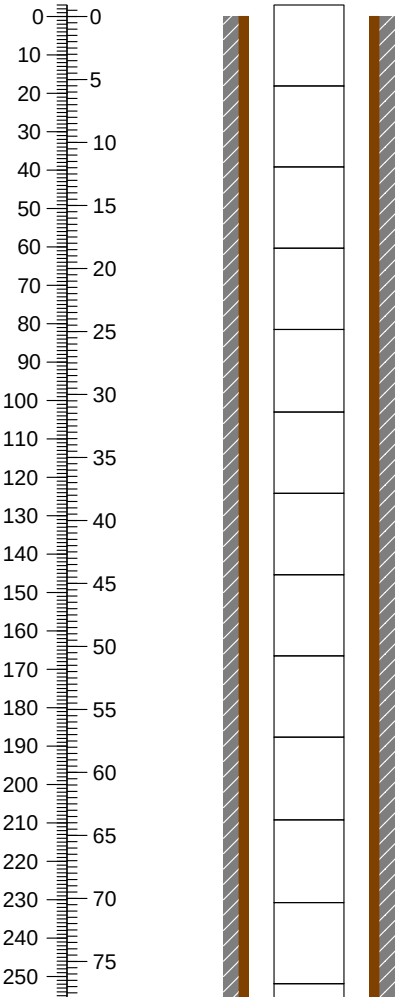
Casing Explanation:

- Surface Casing — **7 5/8" OD Steel**
- Conventional Casing — **5 7/8" ID Steel**
- Conventional Screen — **5 7/8" ID Steel (Wider Spaced-2 Slots/1') 1"-1 1/2"x1/4" Slot Size**
- Conventional Screen — **5 7/8" ID Steel (Closer Spaced-4 Slots/1') 1"-1 1/2"x1/4" Slot Size**
- Conventional End Cap — **5 7/8" ID Steel**
- **Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 10/20 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Conventional Casing Stick-Up = ~3.02' (0.92 m)
Well has not been completed with ~3' x ~3' cement pad, barrier posts, or locking steel well cap surrounding the casing above ground surface to date (7/05)

No Centralizers Used

Annular/Borehole Descriptions
All depths listed are bgs

No Annular Materials Installed

Santa Fe Group Alluvium from surface to ~296' (90.22 m)

During hydrofracturing process, 16/30 sand was injected into formation to prop open any fractures created

Casing Explanation:

Surface Casing
7 5/8" OD Steel

Conventional Casing
5 7/8" ID Steel

Conventional Screen
5 7/8" ID Steel (Wider Spaced-2 Slots/1')
1"-1 1/2"x1/4" Slot Size

Conventional Screen
5 7/8" ID Steel (Closer Spaced-4 Slots/1')
1"-1 1/2"x1/4" Slot Size

Conventional End Cap
5 7/8" ID Steel

Centralizers

Water Table

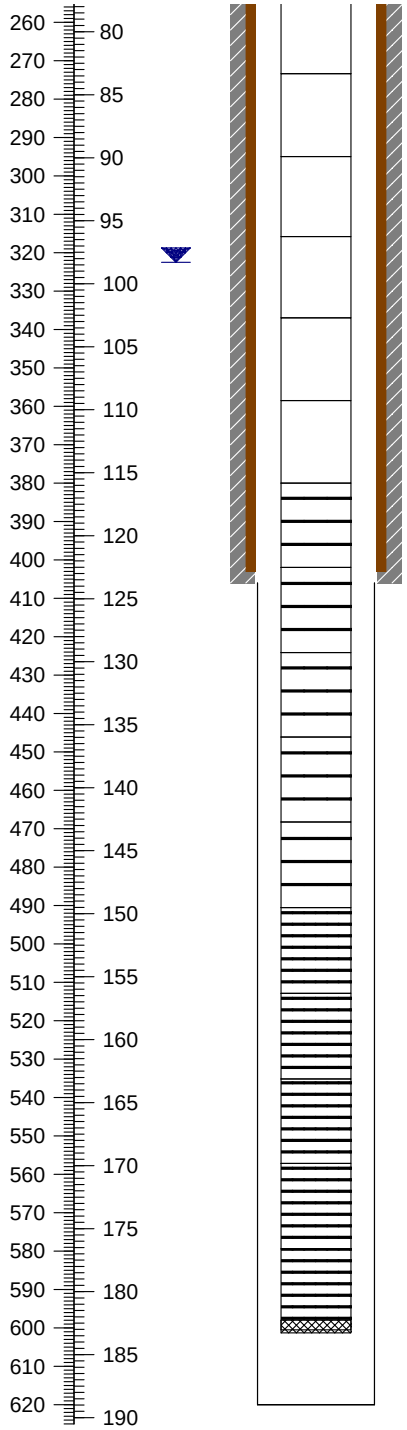
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
10/20 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Water Table = 322.47' (98.29 m) (Measured 6/24/05; post-development)

Top of Widely Spaced Slotted Screen = 380.02' (115.83 m)

Slots = Vertical Machine-Cut 1" to 1 1/2" Long x 1/4" Wide

Widely Spaced Slots = 2 Slots per 1' Length

7 5/8" OD Steel Surface Casing Depth = 403.00' (122.8 m)

Top of Closely Spaced Slotted Screen = 490.56' (149.52 m)

Slots = Vertical Machine-Cut 1" to 1 1/2" Long x 1/4" Wide

Closely Spaced Slots = 4 Slots per 1' Length

Bottom of Closely Spaced Slots = 600.50' (183.03 m)

End cap was tapered and welded to screen

5 7/8" ID Steel Casing TD = 601.31' (183.28 m)

Rhyolite Bedrock Depth = ~296' (90.22 m)

9 7/8" Borehole Cemented to ~406' (123.75 m)

6 3/4" Borehole 406.00 - 620.00' (123.75 - 188.98 m)

Volcanic Rhyolite Tuff Bedrock Depth = ~455' (138.68 m)

Volcanic Flow Banded Rhyolite to Rhyolite Bedrock Depth = ~485' (147.83 m)

No Slough

6 3/4" Borehole TD = 620.00' (188.98 m)

WELL COMPLETION DIAGRAM
EXPLORATION WELL

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **MPE-9** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4 NE 1/4 SE 1/4 Sec 33 T20S R3E**
NM State Plane Coordinates (NAD 83): **168822.88 N 464160.14 E (preliminary)**
Elevation (Ground Surface): **1417.53 m (prelim. ground surface)**
Elevation (Top of Casing): **~1.5' (0.5 m) ags (~1417.07 m)**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **G. Cardenas, D. Ward**
Total Depth of Borehole (bgs): **625' (190.5 m)**
Borehole Diameter: **17 1/2" 0-100'; 12 1/4" 100-625'**
Depth to Bedrock (bgs): **296' (90.2 m); Rhyolite**
Depth to Groundwater: **322.9' (98.43 m) TOC (1/5/05)**
Total Depth Surface Casing (bgs): **100' (30.5 m)**
Diameter and Type Surface Casing: **13 1/2" ID; 14" OD Carbon Steel**

Date(s) Well Installed: **7/28/04 to 8/4/04**
Date(s) Well Developed: **8/4/04 bail; 8/6/04-8/23/04 pump**
Field Representative(s): **G. Giles; L. Hunnicutt-Mack; J. Pearson**
Total Depth Well Casing (bgs): **618.46' (188.51 m)**
Type of Casing: **CertainTeed SDR 17 PVC**
Diameter Well Casing: **6 1/4" ID; 6 9/10" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **398.50 - 598.50' (121.46 - 182.42 m)**
Comments: **This well may be converted to an extraction well.**
bgs = below ground surface
ags = above ground surface TOC = Top of Casing
ID = Inside Diameter OD = Outside Diameter

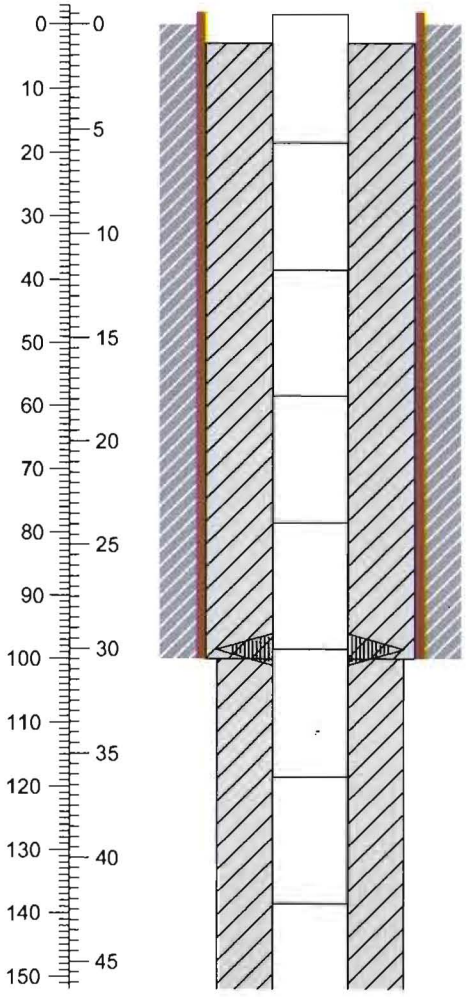
Casing Explanation:

- Surface Casing: **14" OD Carbon Steel**
- Conventional Casing: **6 1/4" ID; 6 9/10" OD PVC**
- Conventional Screen: **6 1/4" ID; 6 9/10" OD PVC SDR 17 CertainTeed 0.025"-slot**
- Conventional End Cap: **6 1/4" ID; 6 9/10" OD PVC**
- **Bolted Stainless Steel**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 12/20 Sand Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stick-Up = ~1.5' (0.46 m) ags

Surface Casing Stick-Up = ~2.0' (~0.61 m) ags

The well may be completed with a ~3' x ~3' cement pad, barrier posts, and a steel flange for hanging a pump, and a containment building or well vault.

Steel centralizer bolted together around casing coupling at 98.5' (30.02 m)

14" OD Carbon Steel Surface Casing Depth = 100' (30.5 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Bentonite Grout (Grout Well DF) = ~3.0' (0.91 m)

The formation is Santa Fe Group Alluvium from surface to 296' (90.2 m)

17 1/2" Borehole cemented to 100' (30.5 m)

Surface Casing
14" OD Carbon Steel

Conventional Casing
6 1/4" ID; 6 9/10" OD PVC

Conventional Screen
6 1/4" ID; 6 9/10" OD PVC
SDR 17 CertainTeed 0.025"-slot

Casing Explanation:

Conventional End Cap
6 1/4" ID; 6 9/10" OD PVC

Bolted Stainless Steel

Water Table

Annular Materials Explanation:

Cement

Bentonite (Grout Well DF)

Bentonite Seal

12/20 Sand Bentonite Mix

Slough

1/8 Gravel

4/8 Sand

6/9 Sand

8/12 Sand

8/20 Sand

10/20 Sand

16/40 Sand

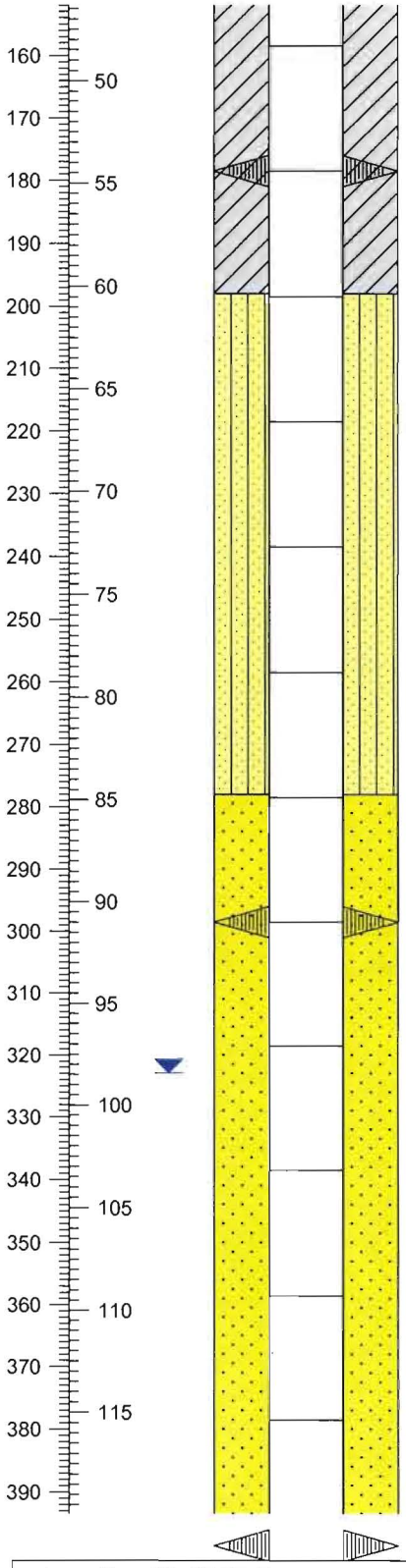
20/40 Sand

30/70 Sand

Feet/Meters

Well Descriptions
All depths listed are bgs (unless noted)

Annular/Borehole Descriptions
All depths listed are bgs



Steel cage centralizer bolted together around casing coupling at 178.5' (54.41 m)

Top of 10/20 Sand/Bentonite Mix = 198' (60.4 m)

Top of 10/20 Sand = ~278' (~84.7 m)(Exact depth not measured)

Volcanic Flow Banded Rhyolite to Rhyolite Bedrock Depth = 296' (90.2 m)

Steel cage centralizer bolted together around casing coupling at 298.5' (90.98 m)

Water Table Depth = 322.9' (98.43 m; measured post-development 1/5/05)

Steel cage centralizer bolted together around casing

Surface Casing
14" OD Carbon Steel

Conventional Casing
6 1/4" ID; 6 9/10" OD PVC

Conventional Screen
6 1/4" ID; 6 9/10" OD PVC
SDR 17 CertainTeed 0.025"-slot

Casing Explanation:

Conventional End Cap
6 1/4" ID; 6 9/10" OD PVC

Bolted Stainless Steel

Water Table

Annular Materials Explanation:

Cement

Bentonite (Grout Well DF)

Bentonite Seal

12/20 Sand Bentonite Mix

Slough

1/8 Gravel

4/8 Sand

6/9 Sand

8/12 Sand

8/20 Sand

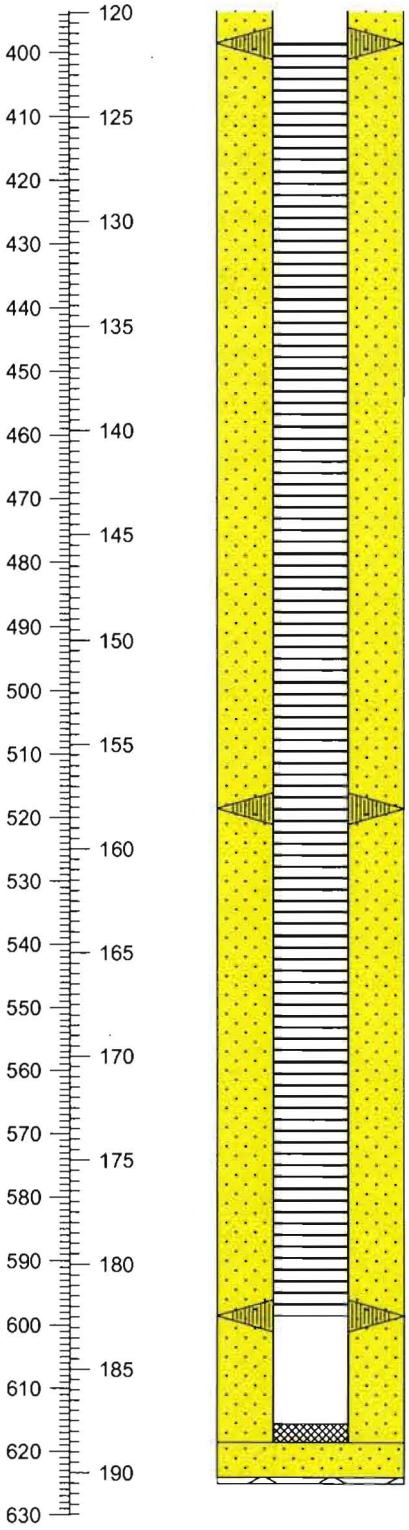
10/20 Sand

16/40 Sand

20/40 Sand

30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

coupling at 398.5' (121.46 m)

Top of 6 1/4" ID CertainTeed SDR 17 0.025"-Slot PVC Screen = 398.50' (121.46 m)

Steel cage centralizer bolted together around casing coupling at 518.5' (158.04 m)

Steel cage centralizer bolted together around casing coupling at 598.5' (182.42 m)

Bottom of 6 1/4" ID CertainTeed SDR 17 0.025"-Slot PVC Screen = 598.50' (182.42 m)

Sump consists of 20' blank riser and end cap; end cap attached with spline and bolted on

6 1/4" ID; 6 9/10" OD CertainTeed SDR 17 PVC Casing TD = 618.46' (188.51 m)

Annular/Borehole Descriptions
All depths listed are bgs

Volcanic Rhyolite Crystal-Lithic Tuff Bedrock Depth = 450' (137.2 m)

Volcanic Altered Ash-Flow Tuff Bedrock Depth = 480' (146.3 m)

Volcanic Rhyolite Bedrock Depth = 510' (155.4 m)

Top of Slough = 624' (190.2 m)(sounded 7/28/04)

12 1/4" Borehole TD = 625' (190.5 m)

WELL COMPLETION DIAGRAM

Exploration Well

Location ID: **MPE-10** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4 NE 1/4 SE 1/4 Sec. 33, T20S, R3E**
NM State Plane Coordinates (NAD 83):**168871.20N 464177.77E (prelim)**
Elevation (Ground Surface): **1417.37 m (preliminary)**
Elevation (Top of Casing): **1.04' (0.32 m) ags (~1417.69 m)**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **G. Cardenas**
Total Depth of Borehole (bgs): **601.41' (183.31 m)**
Borehole Diameter: **24" to 9.0'; 17 1/2" to 355'.0; 12 1/4" to 601.4'**
Depth to Bedrock (bgs): **~235' (71.63 m); Rhyolite**
Depth to Groundwater: **318.48' (97.07 m); TOC - Measured 2/15/2007**
Total Depth Surface Casing (bgs): **355.00' (108.20 m) per geophysics**
Diameter and Type Surface Casing: **13 1/2" ID, 14" OD Carbon Steel**

Date(s) Well Installed: **9/14/04 - 9/15/04 (Initial)**
Date(s) Well Developed: **9/15/04 to 10/06/04 (Initial)**
Field Representative(s): **M. Canavan, G. Giles (Initial)**
Total Depth Well Casing (bgs): **597.40' (182.09 m)**
Type of Casing: **CertainTeed SDR 17 PVC**
Diameter Well Casing: **6" ID, 6 9/10" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **397.20' - 597.30' (121.07 - 182.06 m)**
Comments: **This well is located on a MPCA structure identified from shallow seismic data.**
PVC casing installed on 12/9/2006
bgs = below ground surface. TOC = Top of Casing

Casing Explanation:

- Surface Casing **14" OD Carbon Steel**
- Conventional Casing **6" ID PVC**
- Conventional Screen **6" ID; 6 9/10" OD PVC 0.032"**
- Conventional End Cap **6" ID PVC**
- **Bolted Steel Cage Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- 8/12 Sand

Feet/Meters	**Well Descriptions** All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
0 / 0	Conventional casing stick-up = 1.04' (0.32 m)	
	No surface casing stick-up	24" borehole cemented to 9.00' (2.74 m)
	20" Steel Conductor pipe installed and cemented to 9.00' (2.74 m) bgs	
	Steel cage centralizer bolted together around casing coupling at 17.01' (5.19 m)	
		Top of bentonite grout (Grout Well DF) = 33.45' (10.20 m)
	Steel cage centralizer bolted together around casing coupling at 97.05' (29.58 m)	
	Steel cage centralizer bolted together around casing coupling at 197.10' (60.08 m)	
		Top of 8/12 Sand = ~200' (60.96 m)
		Volcanic bedrock (Rhyolite) depth = ~235' (71.63 m)

Surface Casing
14" OD Carbon Steel

Conventional Casing
6" ID PVC

Conventional Screen
6" ID; 6 9/10" OD PVC
0.032"

Casing Explanation:

Conventional End Cap
6" ID PVC

Bolted Steel Cage Centralizers

Water Table

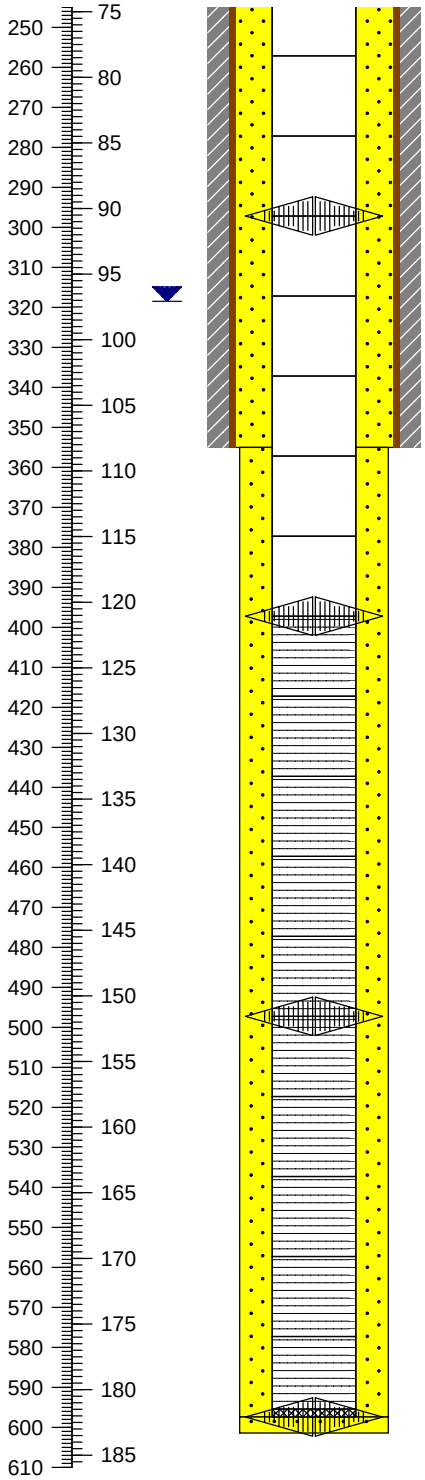
Annular Materials Explanation:

Cement

Bentonite
(Grout Well DF)

8/12 Sand

Feet/Meters



Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
	Volcanic bedrock (Flow-Banded Rhyolite) depth ~ 250' (76.20 m)
Steel cage centralizer bolted together around casing coupling at 297.15' (90.57 m)	
Water Table = 318.48' (97.07 m); TOC - Measured 2/15/2007	
14" OD steel surface casing depth = 355.00' (108.20 m)	17 1/2" borehole cemented to 355.00' (108.20 m)
	12 1/4" borehole 355.00' - 601.41' (TD) (108.20 - 183.31 m)
Steel cage centralizer bolted together around casing coupling at 397.20' (121.07 m)	
Top of 6" ID CertainTeed SDR 17 0.032"-Slot PVC Screen = 397.20' (121.07 m)	Altered volcanic bedrock depth = ~400' (121.92 m)
	Volcanic bedrock (Dacite) depth = ~460' (140.21 m)
Steel cage centralizer bolted together around casing coupling at 497.25' (151.56 m)	
	Volcanic bedrock (Rhyolite) depth = ~515' (156.97 m)
Bottom of 6" ID CertainTeed SDR 17 0.032"-Slot PVC Screen = 597.30' (182.06 m)	
Steel cage centralizer bolted together around casing at 597.40' (182.09 m)	
6" ID; 6 9/10" OD CertainTeed SDR 17 PVC Casing TD = 597.40' (182.09 m)	12 1/4" borehole TD = 601.41' (183.31 m)

WELL COMPLETION DIAGRAM

Potential Extraction Well

Location ID: **MPE-11**

Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4 SE 1/4 SE 1/4 Sec. 33, T20S, R3E**
NM State Plane Coordinates (NAD 83):**168690.40 N 464133.81 E**
Elevation (Ground Surface): **1416.96 m (pending final survey)**
Elevation (Top of Casing): **1.83' (0.56 m) ags (~1417.52 m)**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **G. Cardenas**
Total Depth of Borehole (bgs): **609.00' (185.62 m)**
Borehole Diameter: **24" to 10'; 17 1/2" to 423'; 12 1/4" to 609'**
Depth to Bedrock (bgs): **~310' (94.48 m); Rhyolite**
Depth to Groundwater: **494.80' (150.82 m) TOC (2/15/2007)**
Total Depth Surface Casing (bgs): **420.00' (128.02 m) (Original)**
Diameter and Type Surface Casing: **13.5" ID/14" OD Carbon Steel**

Date(s) Well Installed: **1/05, 1/07/07**
Date(s) Well Developed: **Bail/Swab (1/8 - 6/07); Pump (1/10 - 16/07)**
Field Representative(s): **M. Canavan, J. Pearson**
Total Depth Well Casing (bgs): **600.00' (182.88 m)**
Type of Casing: **CertainTeed PVC**
Diameter Well Casing: **6" ID/ 6.9" OD**
Casing Schedule: **SDR 17**
Screened Zone (bgs): **499.75 - 599.96' (152.32 - 182.87 m)**
Comments: **Original carbon steel well casing installed 10/15/04 was pulled, borehole reamed, and PVC well casing installed for potential use as Mid-Plume extraction well. bgs = below ground surface TOC = Top of Casing**

Surface Casing
Nominal 14" OD Carbon Steel

Conventional Casing
6" ID PVC

Conventional Screen
6" ID; 6.9" OD PVC
0.032"

Casing Explanation:

Conventional End Cap
6" ID PVC

Bolted Steel Cage Centralizers

Water Table

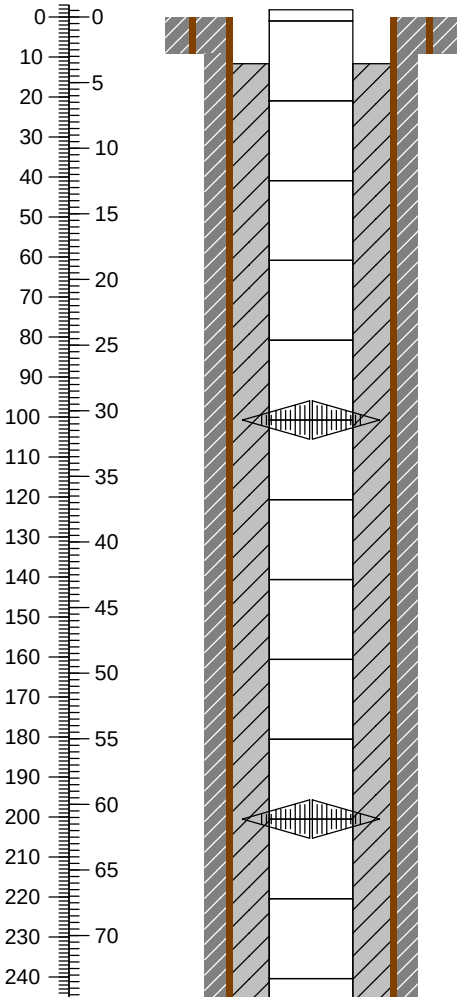
Annular Materials Explanation:

Cement

Bentonite
(Grout Well DF)

8/12 Sand

Feet/Meters



Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
Conventional casing stick-up = 1.83' (0.56 m)	
No surface casing stick-up	24" borehole cemented to 10.00' (3.05 m)
20" steel conductor pipe installed and cemented to 9.00' (2.74 m) bgs.	
	Top of bentonite grout (Grout Well DF) = 11.70' (3.57 m)
Steel cage centralizer bolted together around casing coupling at 100.75' (30.71 m)	
Steel cage centralizer bolted together around casing coupling at 200.50' (61.11 m)	

Surface Casing
Nominal 14" OD Carbon Steel

Conventional Casing
6" ID PVC

Conventional Screen
6" ID; 6.9" OD PVC
0.032"

Casing Explanation:

Conventional End Cap
6" ID PVC

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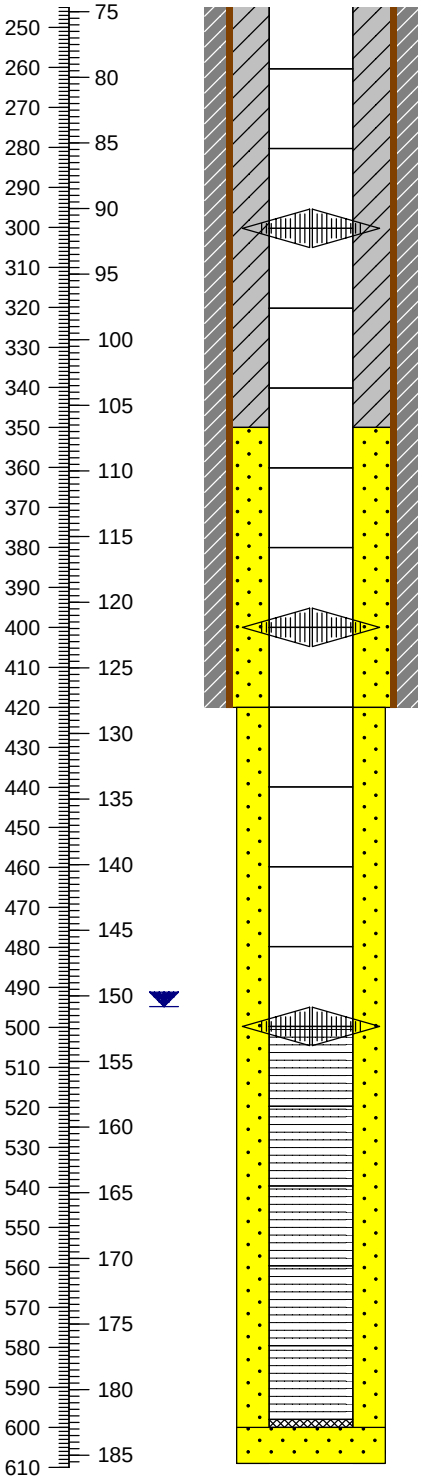
(Grout Well DF)

8/12 Sand

Feet/Meters



Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
Steel cage centralizer bolted together around casing coupling at 300.25' (91.52 m)	Volcanic bedrock (Rhyolite) depth = ~310' (94.49 m)
14" OD steel surface casing depth = 355.00' (108.20 m)	Top of 8/12 Sand = ~350' (106.68 m)
Steel cage centralizer bolted together around casing coupling at 400.00' (121.92 m)	
	17 1/2" borehole Cemented to 423.00' (128.93 m)
Steel cage centralizer bolted together around casing coupling at 499.75' (152.32 m)	
Water table = 494.80' (150.82m) TOC (2/15/2007)	
Top of 6" ID CertainTeed SDR 17 0.032" - Slot PVC Screen = 499.75' (152.32 m)	
Bottom of 6" ID CertainTeed SDR 17 0.032" - Slot PVC Screen = 599.96' (182.87 m)	
6" ID; 6.9" OD CertainTeed SDR 17 PVC Casing TD = 600.00' (182.88 m)	12 1/4" borehole TD = 609.00' (185.62 m)

Appendix B
PFTS Instrumentation and Control System Features

The control system has the ability to:

- Startup the treatment system in either "auto" or "manual" mode;
- Operate the system with any combination of extraction wells online, one or both air strippers in operation, any number of UV lamps operating, and any combination of injection wells online;
- Shut down an injection well if it detects out-of-tolerance conditions;
- Shut down an extraction well if it detects out-of-tolerance conditions;
- Shut down the entire system if it detects of-of-tolerance conditions;
- Sound an audible alarm in the treatment building and initiate an operator notification if a system shutdown has occurred or if an alarm condition could lead to a system shutdown;
- Log system alarms and data to workstation for troubleshooting, historical trending, and preventive maintenance analyses;
- Allow system shutdown by an Emergency Stop button; and
- Allow the operator to initiate a controlled shutdown of the treatment system.

The following components are installed as part of the instrumentation and control (I&C) system:

Extraction Well Vaults

- Flow meters
- Water-level pressure transducers
- Wellhead pressure transducers
- PLCs
- Power monitors
- Fiber optic cable connection to network
- Motor control centers and submonitors
- Well pumps
- Associated control wiring, hand switches, lights, etc.

Building 650- PFTS facility

- Scale cleaning system control panel
- Scale control system control panel
- Building 650 PLC control panel
- Air stripper #1 PLC control panel and motor controls
- Air stripper #2 PLC control panel and motor controls
- UV reactor PLC control panel and power supply cabinet
- Various Building 650 electrical sensors; sump float switches, compressed air pressure switch,
- Cartridge filter pressure switch, and pressure transducers
- Flow meters at air strippers and UV reactor inlets
- Leak detection system control panel
- Automate pressure relief valve
- Alarm autodialer
- Building 650 power monitor
- Control station PC, backup PC, printer, and alarm autodialer
- Wiring and communication links between the control station PC, all PLCs, treatment equipment, leak detection system, and alarm autodialer

- Associated control wiring, hand switches, indicator lights, etc.

Building 651- Injection Manifold Building

- Building 651 PLC control panel
- PFI well flow meters
- PFI well flow control valves
- Fiber optic cable connection to network
- Associated control wiring, hand switches, indicator lights, etc.

Injection Wells

- Flow meters (backwash flow only)
- Injection downhole control valves
- Injection line remote operated valve
- Backwash line remote operated valve
- Water-level transducers
- Well head pressure transducers
- PLCs
- Power monitors
- Fiber optic cable connection to network
- Well pumps and motor controls
- Vault float switch (to shunt trip)
- Associated control wiring, hand switches, lights, etc.

Appendix C
PFTS Alarm Conditions

Amber alarm conditions:

- Effluent block valve fails to open
- Effluent block valve fails to close
- Recycle block valve fails to open
- Recycle block valve fails to close
- Spent cleaning solution tank level HI
- Spent cleaning solution tank level HI-HI
- Air stripper flow fails HI or LO
- Air stripper discharge pressure fails HI
- UV inlet pressure fails HI
- UV air pressure fails LO
- UV wiper fault
- UV lamp contactor fault
- UV lamp GFI fault
- UV lamp HI-temp fault
- UV lamp amps fail HI or LO
- UV lamp volts fail LO

Red alarm conditions:

- PFE-X pump failure (two or more extraction wells inoperable)
- Sump level HI (Building 650)
- Pipeline leak detected
- Filter skid pressure HI-HI
- Air stripper fails (commanded on but not operating)
- Air stripper water flow fails HI-HI or LO-LO
- Air stripper water level fails HI or LO
- Air stripper air pressure fails HI or LO
- Air stripper air filter pressure HI
- UV moisture detected in lamp enclosure
- UV water flow fails LO
- UV water level fails LO
- UV water temp fails HI
- UV not enough lamps on
- UV wiper fault if longer than 24 hr
- UV irradiance LO-LO
- UV inlet pressure HI-HI
- UV lamp enclosure door open
- UV power cabinet temperature fails HI
- UV power cabinet door open
- Building 650 compressed air pressure LO
- PFI flow to grade detected
- PFI backwash flow HI or LO
- PFI backwash valve Fail to Open or Close
- PFI injection valve Fail to Open or Close

- PFI injection valve pressure HI or LO
- PFI GN2 pressure HI or LO
- PFI float switch shunt tripped
- PFI pump Fail to Start or Stop
- PFI well level HI
- PFI well head pressure HI or LO
- PLC communication failure
- HMI emergency stop
- Emergency stop button depressed (outside main entrance to Building 650)
- UV console emergency stop button depressed

Appendix D
MPITS Instrumentation and Control System Features

The MPITS HMI displays information and has the ability to:

- Connects to the network for communication with the PLC
- Start the process input pacing constant for chemical addition
- Place the control of the extraction wells in manual or auto and monitor well level, well head pressure, flow, and status, and alarms
- Monitor surge tank level
- Place air stripper filters in manual or auto mode and monitor inlet and outlet pressures and filter status
- Start the air stripper and monitor air flow, sump level
- Place UV filters in manual or auto mode and monitor inlet and outlet pressures and filter status
- Monitor the UV process variables, system status, critical information, and alarms
- Cycle the discharge and recirculation valves, and monitor status

The MPITS PLC has the ability to:

- Connects to the network for communication with the HMI
- Provide the logic control to start the process within operating parameters, alarm, and output signal to chemical feed pump
- Provide the logic to control the extraction wells and receive information on level, well head pressure, flow, status, and alarm
- Receive information from the surge tank level sensors and alarm and provide information to control the extraction well pumps
- Provide the logic to control the air stripper filter auto change over, receive inlet and outlet pressure information, and alarm
- Provide the logic to start the air stripper, receive information from pressure switches, air flow meters, level transducer and motor status
- Provide the logic to control the UV filter auto change over, receive inlet and outlet pressure information, and alarm
- Provide the logic to shutdown the MPITS process when major and critical alarms have been received and alarm
- Provide the logic to place the effluent valves in either discharge or recirculation position.
- Send signals to the Auto Dialer

The following components are installed as part of the instrumentation and control (I&C) system:

Extraction Well Vaults

- Flow meters
- Well head pressure transducers
- Water level transducers
- Leak detection system
- Power monitoring system
- Shunt trip
- Combination starter with auxiliary contacts.

Building 655- PFTS facility

- Network hub
- Transient voltage surge suppressor
- Shunt trip circuit
- Auto dialer
- Influent flow meter
- Chemical metering pump
- Surge tank level transducer, high level switch, and low level switch
- Air stripper inlet and outlet pressure transducer, inlet valve position indicator, and flow
- Air stripper air inlet flow transducer, air sump high and low pressure switch, sump level transducer
- UV air filter inlet and outlet pressure transducers and inlet valve position indicator
- UV system
  - Flow meter
  - Transmissivity analyzer
  - Reactor water level switch
  - Reactor water temperature switch
  - Reactor irradiance transmitter
  - Power monitor
  - PLC
  - HMI
  - Power distribution center

Appendix E
MPITS Alarm Conditions

The list of treatment alarms that force the UV system to increase UV intensity to 100% are identified as "Major" alarms and provided below.

- UV Transmittance Low
- System UV Transmittance Meter Faulted (Optiview)
- System UV Transmittance Analog Signal Fault
- Water Temperature Low
- Water Temperature High
- System Inlet Water Temperature Analog Signal Fault
- Train UV Dose Low
- Train Power Level Low
- Train UV Log Reduction Low Train UV
- Train Water Flow Low
- Train Water Flow High
- Train Water Flow Meter Analog Signal Fault
- Rector communications control board (CCB) A Communications Lost Fault Present
- Reactor Low UV Intensity
- Reactor Multiple Lamp Failure (NOT Broken Lamp)
- UV Log Reduction Low

The list of "Critical" treatment shutdown alarms (UV and process) includes:

- Air Stripper Air Pressure Low
- UV Pump1 Failed To Stop
- UV Pump2 Failed To Stop
- UV Broken Lamp)
- Train Water Level
- Reactor Multiple Lamp Failure
- Reactor Wiper Fault
- Reactor CCB A Communications Lost Fault Present
- UV Log Reduction Low Critical Alarm
- UV System Critical Alarm
- UV Train Critical Alarm
- System PLC Faulted Major Fault Detected
- System input/output Module Fault Present

The List of critical safety related shutdowns includes:

- B655 Sump High-High Level
- Control Room Emergency Push Button Station
- East Exterior Door Emergency Push Button Station
- B655 Loss of Phase
- Fire Flow Alarm
- B655 Loss/Imbalance/and Loss of phase of Main Power