National Aeronautics and
Space Administration

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

November 7, 2013

Reply to Attn of: RE-13-124

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

Subject: NASA WSTF Investigation Work Plan for Evaluating Anomalous Detections of NDMA in Monitoring Wells JER-1 and JER-2

NASA proposes to perform an investigation to determine the source of anomalous detections of N-Nitrosodimethylamine (NDMA) in groundwater monitoring wells JER-1 and JER-2. Since the installation of these wells in early 2004, NDMA has been detected in all monitoring zones. However, these detections are not consistent with the typical behavior of the WSTF groundwater contaminant plume. Furthermore, detections of NDMA have been inconsistent and unrepeatable, with frequent data quality exceptions associated with most NDMA sampling events. In conjunction with NMED, NASA has determined that these anomalous detections of NDMA require further investigation. Enclosed is an Investigation Work Plan for Evaluating Anomalous Detections of NDMA in Monitoring Wells JER-1 and JER-2. Enclosure 1 provides a paper copy of the work plan without the appendix. Enclosure 2 provides a CD-ROM with the work plan as a PDF file.

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 of my staff at 575–524–5484.

Michael Zigmond

for Radel Bunker-Farrah
Chief, Environmental Office

2 Enclosures

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National Aeronautics and
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Investigation Work Plan for Evaluating Anomalous Detections of NDMA in Monitoring Wells JER-1 and JER-2

November 2013

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

Investigation Work Plan for Evaluating Anomalous Detections of NDMA in Monitoring Wells JER-1 and JER-2

November 2013

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 knowing violations.

Michael Zigmond

Radel Bunker-Farrah
for Chief, NASA Environmental Office

7 Nov 2013
Date

Executive Summary

The National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF) has provided a variety of test services and support to NASA for the United States space program, Department of Defense, Department of Energy, private industry, and foreign government agencies. Historical testing operations resulted in the creation of a groundwater contaminant plume, a portion of which extends beyond the WSTF industrial boundary towards the United States Department of Agriculture (USDA) Agricultural Research Service's Jornada Experimental Range (JER). In an effort to determine the full nature and extent of the groundwater contaminant plume near the JER, NASA installed two groundwater monitoring wells on JER property. JER-1 and JER-2 are Westbay multi-port wells with three monitoring zones each.

Installation of JER-1 and JER-2 was completed in early 2004, after which groundwater monitoring was initiated. The monitoring zones of these wells have been sampled approximately quarterly since installation. During this time, N-nitrosodimethylamine (NDMA), a carcinogenic chemical associated with the utilization of rocket fuel at WSTF, has been detected in all monitoring zones of both wells. However, the detection of NDMA is not consistent with typical WSTF groundwater plume behavior. In conjunction with the New Mexico Environment Department (NMED), NASA has determined that these anomalous detections of NDMA require further investigation.

In 2011, NASA performed an evaluation of Westbay monitoring wells at WSTF to determine if the lack of pre-sample purging in Westbay wells resulted in the collection of unrepresentative groundwater samples. One zone each within wells JER-1 and JER-2 were utilized for this test. The selected sampling zones in the wells were purged and sampled in an attempt to characterize the potential zone of stagnation surrounding the boreholes. During this evaluation, concentrations of NMDA declined significantly in JER-1-568 and JER-2-508. NASA believes that this indicates that current anomalous NDMA detections in the JER wells are not fully representative of groundwater conditions in the area.

In order to better characterize NDMA concentrations in groundwater at the JER wells, NASA proposes to perform an investigation that includes purging sufficient groundwater from each sampling zone within JER-1 and JER-2 to ensure the collection of representative groundwater. Groundwater samples will be collected throughout the purging exercise to monitor the concentrations of NDMA and other constituents of interest. Analytical data from these samples will be evaluated to determine whether the current JER well configurations provide adequate samples or if modifications or additional monitoring is required. This investigation work plan provides specific information related to the evaluation of NDMA concentrations in the JER area. It describes the planned field work, chemical analyses, data evaluation, reporting requirements, and potential additional work based on the outcome of the investigation.

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List of Acronyms

µg/L	micrograms per liter
bgs	below ground surface
EPA	Environmental Protection Agency
FSA	Fuel Storage Area
ft	foot/feet
GMP	Groundwater Monitoring Plan
ID	Inside diameter
IDW	Investigation-derived waste
in	inch
JDMB	Jornada del Muerto Basin
JER	Jornada Experimental Range
JSC	Johnson Space Center
kg	kilogram
MP	Multi-Port
MPCA	Mid-plume Constriction Area
NASA	National Aeronautics and Space Administration
ND	Not Detected
NDMA	N-nitrosodimethylamine
ng/L	nanograms per liter
NMED	New Mexico Environment Department
PCC	Post-Closure Care
PCE	Tetrachloroethene
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SDR	Sstandard dimension ratio
TCE	Trichloroethene
USDA	United States Department of Agriculture
VOC	Volatile organic compounds
WSTF	White Sands Test Facility

1.0 Introduction

The National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF) currently operates as a field test installation under the NASA Lyndon B. Johnson Space Center (JSC) in Houston, Texas. 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 compatibility testing and simulated use tests for space-bound materials. The WSTF U.S. Environmental Protection Agency (EPA) Facility Identification Number is NM8800019434.

WSTF is located approximately 18 miles northeast of Las Cruces, New Mexico and 65 miles north of El Paso, Texas. 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. Historical operations at WSTF have resulted in a groundwater plume requiring extensive investigation activities and associated corrective actions. Groundwater contaminants migrated from the WSTF source areas into the aquifer of the Jornada del Muerto Basin (JDMB), creating a complex comingled contaminant plume of volatile organic compounds (VOCs) and N-nitrosodimethylamine (NDMA). Conceptualized plume boundaries are shown in Figure 1.2. The nature and extent of groundwater contamination at WSTF is discussed in further detail in Section 2. The majority of the groundwater plume extends from the WSTF industrial areas west towards the JDMB; however, there is a smaller northwest-trending portion of the groundwater contaminant plume that extends from the WSTF Mid-plume Constriction Area (MPCA) towards the United States Department of Agriculture (USDA) Agricultural Research Service's Jornada Experimental Range (JER) (Figure 1.2).

The primary objective of this investigation is to evaluate anomalous detections of NDMA in multi-port groundwater monitoring wells JER-1 and JER-2. To accomplish this objective, NASA has performed an evaluation of historical JER-1 and JER-2 groundwater monitoring well analytical data and developed a plan for the collection and comparison of additional analytical data to better characterize low-level NDMA detections within the JER groundwater monitoring wells. If this additional sampling indicates NDMA is present in the groundwater at this location, more comprehensive investigation work may be required. Additional work may include monitoring well modifications, geophysical evaluations, or exploratory drilling.

2.0 Background

WSTF was established in the early 1960s to support the NASA Apollo Space Program. Primary site activities served to: develop, qualify, refurbish, and test spacecraft propulsion systems, subsystems, and ground support equipment; investigate flight hardware anomalies; test materials and components; and perform hazard and failure analyses.

Hazardous wastes generated at WSTF during testing and evaluation procedures were historically managed in surface impoundments and underground storage tanks that leaked, subsequently contaminating groundwater. From the early 1960s through the mid-1980s, waste impoundments in the 200, 300, 400, and 600 industrial areas contributed to groundwater contamination. To minimize further releases of contaminants, these historical waste impoundments were capped and closed under the Resource Conservation and Recovery Act (RCRA), and approved by the New Mexico Environment Department (NMED) in 1989. The closures were permitted under a Post-Closure Care (PCC) Permit in the early 1990s and continue to be monitored in accordance with the Permit and related plans. The locations of these closures, as well as other pertinent WSTF features, are provided in Figure 1.2.

2.1 Wastes Managed and Released

Contaminants in groundwater originated from historical waste management operations in the WSTF industrial areas (Figure 1.2). NDMA contamination primarily originated from operations in the 300 and 400 Areas. Most of the VOC contamination [trichloroethene (TCE), tetrachloroethene (PCE), trichlorofluoromethane (Freon®[1] 11), dichlorofluoromethane (Freon 21), 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113), and chloroform] originated from the 200 Area with lesser contributions from the 100, 300, 400, and 600 Areas. The draft *WSTF RCRA Facility Investigation* (RFI; NASA, 1996) and the *WSTF Groundwater Monitoring Plan* (GMP; NASA, 2013[a]), approved June 6, 2013 (NMED, 2013[b]), provide additional specific information related to the management and release of chemical wastes that constitute the groundwater contaminant plume.

2.2 Extent of Contamination

The GMP also provides a detailed discussion of the spatial distribution of the seven primary contaminants of concern in groundwater at WSTF. This section briefly describes the extent of the two most widespread groundwater contaminants: NDMA and TCE. The approximate extent and thickness of NDMA and TCE plumes are derived from maps constructed using 2013 concentration data, from cross sections constructed in the draft RFI (NASA, 1996), and from concentration data from wells with multiple completion depths.

2.2.1 N-Nitrosodimethylamine

NDMA is believed to have been released to the environment due to its creation during chemical oxidation of 1,1-dimethylhydrazine (UDMH) by calcium hypochlorite and its likely presence as an impurity in the UDMH. An estimated 34 kilograms (kg) of contaminant mass was released to the environment (NASA, 1996). Figure 2.1 shows a manual interpretation of the NDMA conceptualized groundwater plume at WSTF utilizing analytical data obtained from groundwater sampling in 2013. The NDMA plume extends westward approximately 20,500 feet (ft) (6,300 m) from sources at the 300 and 400 Areas and is as much as 6,500 ft (2,000 m) wide in the area upgradient from the MPCA. Highest concentrations in these areas occur downgradient from the 400 Area and exceed 25,000 ng/L, with the main mass of NDMA along the plume axis. The width of the NDMA plume narrows to less than 3,300 ft (1,000 m) within the MPCA where concentrations are as high as 6,500 ng/L. An additional narrow arm of NDMA contamination is shown extending northwestward from the MPCA. Within the Plume Front area downgradient from the MPCA, the plume widens to approximately 9,850 ft (3,000 m) with concentrations between 1,000 and 5,000 ng/L. The NDMA plume is estimated to range in thickness from approximately 325 to 495 ft (100 to 150 m) within the main body of the contaminant plume near its leading edge.

2.2.2 Trichloroethene

An estimated 4,663 kg of TCE contaminant mass was released to the environment (NASA, 1996). Figure 2.2 shows a manual interpretation of the TCE conceptualized groundwater plume at WSTF utilizing analytical data obtained from groundwater sampling in 2013. The TCE plume extends westward approximately 19,700 ft (6,000 m) from primary sources at the 200 Area and is located within WSTF boundaries with the possible exception of a small privately owned tract in the Plume Front area. The width of the TCE plume is approximately 5,600 ft (1,700 m) in the area upgradient from the MPCA. Downgradient, the width of the TCE plume decreases to less

[1] Freon® is a registered trademark of E.I. du Pont de Nemours & Company Corporation (DuPont).

than 2,000 ft (600 m) in the vicinity of the MPCA. Observed TCE concentrations in MPCA groundwater are between 75 and 200 µg/L. Within the Plume Front west of the MPCA, the TCE plume is approximately 6,600 ft (2,000 m) wide. Concentrations in the Plume Front range from the detection limit to more than 340 µg/L. Based on multiple-depth sampling data, the inferred thickness of the TCE plume at WSTF likely ranges from approximately 325 ft (100 m) to 495 ft (150 m) within the main body of the contaminant plume near its leading edge.

2.3 Potential Receptors

Under current and future conditions, NASA maintains administrative control of the land below which groundwater has been contaminated by historical activities at WSTF. No expansion of water use will occur on lands within NASA's administrative control. Thus, conservatively, the nearest location where a water use well may be installed by an outside entity is at the property boundary downgradient of the plume.

Currently, there are no complete exposure pathways or human or ecological receptors of contaminated groundwater. Downgradient public and WSTF water supply wells comprise potential future pathways for exposure to groundwater contamination. Under current conditions, the nearest downgradient water wells are NASA WSTF water supply wells (Well J and Well K). The distance between the edge of the conceptualized groundwater contaminant plume and the downgradient property boundary is approximately 5,085 ft (1,550 m). The locations of the WSTF water supply wells relative to other pertinent site features are shown in Figure 1.2. Routine sampling of drinking water from the NASA supply wells indicates that the WSTF water supply has not been impacted by WSTF groundwater contaminants. NASA also performed groundwater sampling at six off-site water supply wells in 2010. There was no evidence that these wells had been impacted by the groundwater contaminant plume (NASA, 2010[b]).

2.4 Previous Investigations

NASA has performed numerous environmental investigations at WSTF, including soil sampling, soil gas sampling, air monitoring, and groundwater monitoring that began with monitoring well drilling and installation. The activities associated with historical and ongoing groundwater monitoring, particularly in the JER area, are most applicable to this Plan.

2.4.1 WSTF Groundwater Monitoring Network

The WSTF groundwater monitoring network includes monitoring wells of varying designs for groundwater sampling. The design of groundwater monitoring wells is classified as either conventional or Westbay®[2].

Conventional monitoring wells are designed to monitor a single, discrete location within the water-bearing zone. Conventional monitoring wells consist of a single borehole in which the well casing is installed. The targeted zone is monitored using a segment of slotted, or screened, casing which accesses the formation surrounding this screened interval. The screened interval is isolated from the remainder of the borehole during installation of the casing to ensure only the targeted zone is sampled. Conventional wells are used to measure groundwater elevations and to collect groundwater samples that are representative of the groundwater in the vicinity of the screened interval.

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

Westbay Multi-Port (MP) systems are designed to monitor multiple water-bearing zones within a single borehole. In 1990, NASA began installing and using Westbay multi-port groundwater monitoring systems at WSTF in order to provide vertical delineation of the groundwater contaminant plume. The Westbay MP system is a multiple-level groundwater monitoring system which employs a single, closed access, polyvinyl chloride (PVC) casing with valved ports to perform well monitoring activities. The valved ports are used to provide controlled access to a multiple number of monitoring zones within a single borehole. The Westbay system was selected after an evaluation of several potential groundwater sampling systems because it allows multiple monitoring zones to be installed in a single borehole, significantly reducing the impact and cost of drilling. Groundwater samples are collected directly from the formation, minimizing the production of potentially hazardous purge water. Two diameters of Westbay well casing have been used at WSTF: 1.5-inch (in) inside diameter (ID) casing, designated as MP38 casing; and 2.25-in ID casing, designated as MP55 casing. Since 1990, NASA has installed 44 Westbay monitoring wells at WSTF. Of these, 32 wells are still actively used for facility groundwater monitoring, including JER-1 and JER-2, which are the most recently installed Westbay wells.

2.4.2 Routine Groundwater Monitoring

A detailed discussion of the results of routine groundwater monitoring at WSTF was provided in the *Periodic Monitoring Report for the Second Quarter of 2013* (NASA, 2013[c]). That report included a comprehensive database of historical chemical analytical data from groundwater monitoring.

2.4.3 Groundwater Monitoring in the JER Area

NASA has installed and routinely samples two Westbay monitoring wells on the USDA JER: JER-1 and JER-2. These wells were drilled and installed between October 2003 and January 2004 in order to support horizontal and vertical delineation of the northwest-trending arm of the groundwater contaminant plume. Due to the potential instability of alluvium and bedrock in the area, these wells were designed as Westbay MP55 multi-port wells retrofit within 5.73-in ID multi-screened outer casing to protect the Westbay casing from borehole sloughing or collapse. The outer casing is composed of CertainTeed™[3] standard dimension ratio (SDR) 17 PVC with bell-coupled joints locked with splines for increased tensile strength. Appendix A provides detailed well completion diagrams and lithologic logs for monitoring wells JER-1 and JER-2. These diagrams show specific well construction information for each well, including the location of pumping and sampling ports in the Westbay casing, as well as specific geological information, such as descriptions of rock formations. Figure 2.3 provides a generalized depiction of a sampling zone for the JER monitoring wells.

The JER wells have been sampled approximately quarterly since installation. Analytical data from the initial sampling events at these wells indicated the potential presence of very low levels of two WSTF contaminants of concern: Freon 113 and NDMA. Freon 113 was detected at very low levels in three samples collected at JER-1-688 and JER-2-587 in late April and early May 2004. There was one subsequent detection of this contaminant in JER-1-688 below the practical quantitation limit. These sporadic and unsubstantiated detections led NASA to conclude that Freon 113 is not present in the groundwater at the JER well locations. Table 2.1 summarizes these Freon 113 detections. TCE, one of the typical leading contaminants in WSTF groundwater plume migration, has not been detected in the JER wells.

[3] CertainTeed is a registered trademark of CertainTeed Corporation.

NDMA has been detected on a relatively consistent basis in all six zones of the two JER wells by low-level analyses performed by two separate laboratories. However, analytical results for NDMA in these wells are not consistent. Unlike typical NDMA detections in WSTF groundwater monitoring wells, low-level NDMA results are frequently not repeatable at zones in monitoring wells JER-1 and JER-2, making it difficult to fully characterize the nature of NDMA contamination in these wells. Of 46 field duplicate samples historically collected at the JER wells, 25 of the duplicate samples contained results with relative percent differences outside the 25 percent standard limits set for WSTF, indicating a significant difference in the quality of groundwater between duplicate samples. Detections are also commonly associated with numerous data quality flags, casting doubt on the overall integrity of the sampling process and analytical results at these wells. Of the 164 sampling events where NDMA was detected using the low-level method within the JER wells, 93 sampling events also contained data quality flags indicating matrix interference, blind and laboratory control samples outside standard limits, and method, equipment, and field blank detections. Additionally, only two of the 164 low-level NDMA detections were accompanied by detections in samples analyzed using Modified EPA Method 607. Table 2.2 presents analytical data from NDMA sampling performed at the JER wells. The anomalous nature of NDMA detections in these wells led NASA to question the representativeness of the analytical data. As a result of these anomalous detections, a monitoring zone of each JER well was evaluated during NASA's Westbay well evaluation in 2011 as described in the subsequent section.

2.4.4 Westbay Well Evaluation

On June 25, 2010, NMED responded to a NASA Periodic Monitoring Report with a letter questioning the representativeness of samples collected from NASA's Westbay monitoring wells at WSTF. In that letter, NMED directed NASA to perform an evaluation of the representativeness of groundwater samples collected from Westbay monitoring wells. NASA developed and submitted the *Investigation Work Plan for Evaluating the Representativeness of Groundwater Samples Collected from Westbay® Wells* on November 19, 2010 (NASA, 2010[a]), which was approved by NMED on January 14, 2011 (NMED, 2011[a]). This evaluation consisted of purging the pumping ports associated with specific monitoring zones in several Westbay wells while monitoring a variety of parameters and collecting groundwater samples for various analyses. NASA performed the required investigation in 2011 and submitted to NMED the *Investigation Report for Evaluating the Representativeness of Groundwater Samples Collected from Westbay Wells* on October 20, 2011 (NASA, 2011). In the report, NASA concluded that Westbay monitoring wells may not be appropriate for all locations, but that data generated from them is typically adequate for the decision-making needs of the WSTF groundwater monitoring and restoration programs. NMED approved the report on December 16, 2011 with modifications that directed NASA to replace eight Westbay groundwater monitoring wells with purgeable sampling systems within four years. NMED concluded that in some locations, Westbay wells do not provide representative groundwater samples (NMED, 2011[c]). In response, NASA developed and submitted the *Westbay Well Conversion Work Plan* on November 1, 2012 (NASA, 2012[b]). Following NMED approval on January 16, 2013 (NMED, 2013[a]), and several time extensions for cause, NASA initiated conversion of two Westbay monitoring wells (JP-3 and WW-2) in August 2013. Dedicated low-flow sampling systems were received in late September 2013 but were not installed before the government shutdown in October 2013. They are scheduled for installation in November 2013.

Monitoring zones JER-1-568 and JER-2-508 were tested during the Westbay evaluation in 2011. During the evaluation, groundwater was purged from the pumping ports located approximately five feet below the sampling ports for these monitoring zones. Over the course of purging,

NDMA concentrations in JER-1-568 ranged from 4 ng/L at the onset of the test, to a high of 9.1 ng/L after the removal of just five gallons of groundwater, to a final concentration of 2.6 ng/L after 87 gallons had been purged (Figure 2.4). NDMA concentrations in JER-2-508 decreased from 9.1 ng/L at the onset of the test to non-detect after 110 gallons had been purged (Figure 2.5). As with past sampling at these wells, analytical data were associated with several quality flags. It is noteworthy that the concentration of vinyl chloride in JER-1-568 behaved similarly during the evaluation (Figure 2.6). Vinyl chloride was not detected in JER-2-508 during the evaluation. Comprehensive data collected during the evaluation are provided in the *Investigation Report for Evaluating the Representativeness of Groundwater Samples Collected from Westbay Wells* (NASA, 2011). These variable, but generally decreasing, concentrations indicate that detections of some constituents in the JER wells may not fully represent the groundwater at those locations.

2.5 JER Location

JER-1 and JER-2 are located outside the WSTF boundary on property owned and controlled by the USDA JER in Section 29, T20S, R3E (Figure 2.7). In order to install the two groundwater wells on JER land, NASA entered into an easement agreement with the JER, which was finalized on August 6, 2003 (USDA, 2003).

3.0 Site Conditions

General site conditions at WSTF were described in the RFI (NASA, 1996) and the GMP (NASA, 2013[a]). This section provides a brief discussion of surface and subsurface conditions in the area of the JER wells.

3.1 Surface Conditions

There are no natural surface water bodies in the vicinity of the JER wells. The closest, Isaack Lake, is a playa lake located approximately eight miles (13 km) southwest of the site at the lowest elevation in the JDMB. Topographic maps indicate that numerous well-developed arroyos originate in the eastern areas of WSTF and extend westward before terminating northeast of Isaack Lake. Sheet flow drainage patterns characterize the western half of WSTF, where the JER wells are located.

3.2 Subsurface Conditions

The JER area is characterized by a 410-ft (125 m) to 560-ft (170.7 m) thick sequence of coalescent alluvial fan deposits of the Late Tertiary Santa Fe Group underlain by rhyolitic volcanic bedrock (Appendix A). The alluvium is typically an unconsolidated, poorly sorted, pebble to boulder, polygenetic conglomerate. The variable thickness of alluvium between the two JER groundwater well locations is the result of a series of normal step faults in the bedrock. As a result, bedrock is dropped down toward the west, increasing the thickness of the saturated alluvium within the aquifer.

Groundwater occurs at a depth of approximately 429 to 477 ft (130.8 to 145.4 m) below ground surface (bgs) and is hosted within an unconfined alluvial aquifer. The alluvium and rhyolite bedrock had poor to moderate formation stability to the total depth of drilling.

3.3 Well Conditions Affecting this Investigation

It is well known that PVC casing has the potential to leach constituents into water that contacts the PVC. During routine groundwater monitoring, NASA has observed notable concentrations of several constituents that are believed to be associated with the use of PVC casing in groundwater monitoring

wells. Table 3.1 presents the results of a comprehensive review of analytical data from groundwater sampling at WSTF. This information is presented primarily to demonstrate that constituent leaching from casing components is documented and observed in WSTF groundwater monitoring wells. Later sections of this plan provide more information related to the presence of NDMA as a result of monitoring well components.

4.0 Interpretations of NDMA within JER Wells

Utilizing existing analytical data and available literature, NASA has considered several potential sources for the NDMA detections in the JER wells. This section provides a brief discussion of the recognized potential sources of those NDMA detections.

4.1 Northwest-trending Plume

For several years, NASA believed NDMA detected in the JER wells was the result of natural groundwater and contaminant migration northwestward from the MPCA. In 2007, NASA illustrated the presence of NDMA in the JER area using plume maps included in the quarterly groundwater monitoring report provided to NMED. However, by late 2010, declining NDMA concentrations and the uncertainty associated with those concentrations caused NASA to reconsider the extent of the NDMA plume in the JER area. A close examination of contaminant behavior in other areas of the plume clearly shows that the appearance of the WSTF groundwater plume is first indicated by the detection of several VOCs, primarily Freon 113 and TCE. As previously discussed, VOCs are not present in the JER wells. However, VOCs have been detected in other groundwater monitoring wells located along the conceptualized axis of the northwest-trending arm of the plume. In monitoring wells BLM-18-430 and BLM-5-527, VOCs were detected approximately 10 years before the subsequent detection of NDMA. This is typical of the WSTF groundwater plume, and when considered in conjunction with the anomalous behavior of NDMA detections in the JER wells, led NASA to conclude that NDMA in the JER area was not the result of northwestward plume migration.

4.2 Secondary NDMA Plume

In late 2009, while still evaluating NDMA concentrations in the northwest-trending arm of the contaminant plume, NASA began to explore other potential sources of NDMA in the JER wells. Historical activity in the 500 Fuel Storage Area (FSA) likely resulted in the discharge of NDMA-containing or NDMA-creating waste to the ground. To evaluate the potential impact of these operations on groundwater along the northern boundary of WSTF, NDMA concentrations were evaluated in groundwater between the 500 Area FSA and the JER wells. Utilizing Modified EPA Method 607, NDMA is regularly detected immediately west of the 500 Area FSA in groundwater monitoring wells BW-5-295 and BW-7-211, but was not historically detected further west in monitoring wells BLM-24-565 and 700-E-458 (Figure 1.2). NASA initiated the collection of groundwater samples for the analysis of NDMA by the low-level method from other northern boundary monitoring wells in mid-2007. The very low concentrations of NDMA at these wells (less than 2 ng/L) are consistent with concentrations routinely observed in equipment, field, and trip blanks and are not consistent with the frequently much higher, but somewhat sporadic, concentrations of NMDA in the JER area. They are significantly lower than concentrations observed in JER-1 and JER-2, and thus do not support the existence of a secondary plume along the northern boundary. NASA recently drilled and installed two additional monitoring wells, BLM-41-420 and BLM-41-670, to the west of BLM-24-565. NDMA was detected in BLM-41-420 at 1.3 ng/L in September 2013. This concentration is consistent with the far northern boundary of the current conceptualized groundwater plume rather than with a secondary NDMA plume along the northern boundary.

4.3 NDMA Resulting from Borehole/Well Installation

As described in Section 3.3, the presence of several constituents in groundwater samples is strongly correlated to the use of PVC well materials. Styrene and vinyl chloride have only been detected in PVC wells, and tetrahydrofuran, a common chemical used in the manufacture of PVC, has been detected primarily in PVC wells. Of the 209 detections of tetrahydrofuran in stainless steel wells, 157 were associated with blank flags (Table 3.1). Due to its ubiquitous nature in the manufacture of rubber components, the potential exists for NDMA to be present at very low levels in some well materials, such as the rubber O-rings used in the assembly of Certa-Lok™[4] PVC casing. Monitoring wells JER-1 and JER-2 are the only Westbay wells at WSTF installed within PVC outer casing, which increases the likelihood that materials related to PVC or the rubber O-rings will be present in the groundwater as a result of the increased presence of these constituents at the monitoring location.

The JER wells are installed in or near fractured bedrock, which typically exhibits low hydraulic conductivity and slow natural groundwater movement, contributing to the potential stagnation of groundwater near the Westbay sampling ports. Over time, concentrations of chemicals used in the manufacture of PVC well components could be expected to increase in this stagnant zone of groundwater. Because Westbay wells are not purged prior to sampling, it is possible that groundwater samples may contain relatively high concentrations of constituents associated with the PVC casing used in both the Westbay casing string and the outer casing of the JER wells. Groundwater samples collected from monitoring zones with slow natural groundwater movement without purging are also more likely to contain constituents associated with the stagnant, potentially anoxic conditions within and immediately adjacent to the outer conventional casing and the borehole. During the Westbay well evaluation, concentrations of constituents linked to well materials, and potential groundwater stagnation, decreased significantly as the pumping ports were purged (NASA, 2011). As shown in Figures 2.4 and 2.5, NDMA concentrations also decreased in samples collected from the JER wells during the Westbay well evaluation, providing some evidence that NDMA may be present in JER well samples as a result of well materials rather than groundwater contamination. Additional work is required to determine the merit of this case.

5.0 Scope of Activities

The major objective of this investigation is to evaluate anomalous detections of NMDA in two groundwater monitoring wells installed on the JER. Past detections of NDMA in these wells have been inconsistent and unrepeatable, leading NASA to believe they are not representative of the groundwater at those monitoring locations. A leading factor in the potential unrepresentativeness of the samples is the current use of Westbay monitoring wells, which are not purged prior to sample collection. Given the complex geology of these sampling locations, and the potential for limited natural groundwater movement, no-purge samples may represent relatively stagnant water in the vicinity of the well casing rather than groundwater from the formation.

During the Westbay well evaluation, concentrations of NDMA declined significantly over the course of extended purging (NASA, 2011). NASA proposes to perform additional extended purging at all three zones of both JER wells. While purging, groundwater samples will be collected for the analysis of NDMA and other constituents whose concentrations provide information about the representativeness of groundwater samples collected. Based on the results of the groundwater sampling, NASA will implement additional measures to ensure the collection of representative groundwater samples in the future. Additional investigative work may also be considered.

[4] CertaLok™ is a trademark of CertainTeed Corporation.

6.0 Investigation Methods

This proposed investigation consists primarily of purging groundwater from the JER wells monitoring zones and collecting samples to characterize groundwater within, in the vicinity of, and beyond the Westbay and conventional casing and the borehole. The following sections provide specific information related to project health and safety requirements, groundwater purging and sampling operations, field data collection, chemical analytical testing, management of investigation derived waste (IDW), data evaluation, and a brief discussion of potential follow-on work.

6.1 Safety and Health Requirements

WSTF environmental personnel are familiar with the health and safety requirements associated with sampling groundwater wells. The Environmental Compliance and Operations Contract Safety and Health Plan for Environmental Activities (NASA, 2013[b]) and any appropriate Job Hazard Analyses will be utilized by personnel involved in this project to ensure all requirements are met.

6.2 Well Purging and Sampling

Using current procedural guidance and accepted sampling practices, Westbay multi-port monitoring wells are not purged prior to the collection of groundwater samples. Instead, samples are collected directly from the formation utilizing specialized tools that access one-way valves in the Westbay casing. Groundwater is drawn directly from outside the Westbay casing into clean stainless steel sample collection tubes and dispensed into sample containers. This practice may result in the collection of stagnant groundwater that is not representative of actual groundwater conditions beyond the influence of the monitoring well or borehole.

In order to collect more representative groundwater samples, NASA proposes to purge the pumping port associated with each sampling port in monitoring wells JER-1 and JER-2. Pumping and sampling ports are identified in Table 6.1. First, field crews will confirm that each pumping port is closed using NASA-owned Westbay equipment. A set of groundwater samples will then be collected from the Westbay sampling port using existing equipment and established Westbay sampling procedures. Prior to purging, each pumping port must be opened so a non-dedicated purge pump can be inserted into the well. The purge pump will be activated and allowed to purge a volume of water equal to the volume of the Westbay casing between the pumping port and the top of water in the casing. When the Westbay casing has been evacuated, a set of groundwater samples will be collected. These initial samples are expected to be consistent with historical samples collected from the Westbay wells when purging is not performed. An additional volume of water equal to the volume of the screened interval of the outer conventional casing (18 gallons) will then be purged, after which another set of samples will be collected. These samples are expected to represent groundwater conditions within the borehole, but outside of the outer conventional casing. Next, a volume of groundwater equal to the volume of the borehole surrounding the screened interval (44 gallons) will be purged. Samples that are expected to represent the groundwater immediately outside of the borehole will then be collected. A volume of groundwater equal to two additional borehole volumes (124 gallons) will be then purged. Samples collected after this purge step are expected to represent groundwater conditions within the aquifer beyond the immediate influence of the monitoring well and borehole. In order to ensure that fully representative groundwater is collected, a final set of samples will be collected after an additional two borehole volumes (124 gallons) is purged. Purge and sample information is summarized in Table 6.2.

Purge volumes are based on 10-ft lengths of the 5.72-in ID outer casing and nominal 12.25-in diameter boreholes. Because all monitoring zones in JER-1 and JER-2 are configured the same, purge volumes for each zone are the same. Purge rates and volumes (for each step and cumulative) will be recorded in the

field logbook as required to describe the sampling event. Groundwater indicator parameters will be measured prior to the collection of each set of samples and at other times during purging as personnel are available. Stable groundwater parameter measurements (±10% variation over several consecutive measurements) typically indicate that representative groundwater is being collected. These parameters will be recorded in the field logbook.

6.3 Field Data Collection

Field data collection will consist of information gathered during purging and sampling operations at the JER wells. Prior to initiation of the purging operations described in Section 6.2, WSTF personnel will record pertinent field data such as date, time, weather conditions, personnel present, pumping and sampling equipment in use, sample collection location, conditions that could negatively impact sample quality, and other relevant information in accordance with standard practices and WSTF sampling procedures. Throughout the purging and sampling of individual zones in the JER wells, WSTF sampling personnel will measure field indicator parameters, including pH, temperature, conductivity, oxidation reduction potential, dissolved oxygen, and turbidity. Field indicator parameters will be collected using calibrated flow-through cells in accordance with WSTF's established groundwater sampling procedures. This information, including instrument calibration/verification information, will be recorded in the field logbook for the sampling event.

6.4 Chemical Analytical Testing

Groundwater samples will be collected at the intervals specified in Section 6.2 for analysis of typical WSTF groundwater contaminants (NDMA and VOCs) in addition to several inorganic constituents that proved useful in the evaluation of groundwater quality during the Westbay well evaluation. Groundwater samples will be collected and managed in accordance with well-established site-specific procedural documentation and shipped to contracted off-site analytical laboratories for analysis. Table 6.2 provides a complete list of the analytical requirements associated with this investigation.

6.4.1 Chemical Analytical Methods

For many analytes required in this investigation, NASA requests a chemical analytical method best suited for quantitation of that analyte based on past experience with WSTF groundwater. In other cases, NASA expects the analytical laboratory to propose an analytical method for the most effective and efficient analysis of the compound. In all cases, the analytical laboratory will utilize the most recent EPA and/or industry-accepted chemical analytical methods available for the hazardous constituent specified. The laboratory will be required to achieve the method detection limits, whenever practicable, as indicated in Permit Attachment 17, Section 17.3.3.c of the WSTF Hazardous Waste Permit.

The concentrations of VOCs are best quantitated using the most current version of SW-846 Method 8260. To most effectively quantitate NDMA in the JER wells, NASA recommends the use of the current approved low-level analytical method. Several different methods are used to analyze for metals in groundwater samples. The contracted analytical laboratory specifies the most appropriate analytical method to best achieve the preferred analytical and reporting criteria. Inorganic compounds are analyzed in groundwater samples using several different methods. The recommended methods are provided in Table 6.3. The contracted analytical laboratory may recommend analytical methods other than those requested by NASA to more effectively and efficiently achieve Permit-required analytical criteria. NASA expects to accept these laboratory recommendations if the proposed alternate analytical methods meet or exceed the analytical criteria in the Permit.

6.4.2 Chemical Analytical Data and Laboratories

All data generating steps, including sample collection, shipment, analysis, custody control, document control, data review, and data storage are performed using established procedures to ensure data quality. This plan, coupled with adherence to procedures outlined in site-specific procedural documents, equipment operation and maintenance manuals, analytical statements of work, National Environmental Laboratory Accreditation Conference accreditation standards, laboratory standard operating procedures (SOPs), and laboratory quality manuals ensures data meet the objectives of the WSTF groundwater monitoring program.

WSTF contracts accredited analytical laboratories to analyze groundwater samples in support of the WSTF groundwater monitoring program. Prior to awarding any analytical support contracts, each analytical laboratory must respond to all requirements in the Statement of Work prepared by qualified WSTF contractor environmental organization personnel, submit proof of accreditation by an industry recognized accreditation body and submit the laboratory quality manual and applicable SOP to the contractor environmental organization for review and approval. These documents ensure laboratories meet the performance criteria for WSTF groundwater monitoring activities.

Contracted analytical laboratories will perform all analyses using procedures detailed in the submitted laboratory SOPs and are based on the most recent EPA and industry-accepted preparation and analytical methods for an aqueous matrix (groundwater) as discussed in the previous section.

6.5 Investigation Derived Waste

NASA expects to generate up to 2,000 gallons of IDW in the form of purged groundwater during the implementation of this work plan. Within the permissible accumulation time limits, IDW water will be transferred to and managed at the MPITS in accordance with the GMP (NASA, 2013[a]).

6.6 Evaluation of Results

Groundwater indicator parameters will be collected throughout the purging and sampling operations planned at the JER wells. These field data will be utilized to help determine if, and when, groundwater representative of the formation beyond the borehole is collected. At other WSTF groundwater monitoring locations, the stabilization of indicator parameters within ±10% over several consecutive measurements indicates that representative groundwater has been collected. These data will be used to help confirm that the purging of the Westbay pumping ports in the JER wells resulted in the collection of samples of adequate quality to meet the objective of this investigation.

Upon receipt from the contracted analytical laboratory, chemical analytical data will be verified and validated in accordance with the site-specific procedures summarized in the GMP (NASA, 2013[a]). Following verification and validation, chemical analytical data will be evaluated for obvious trends. Relatively stable concentrations of the constituents selected for this investigation (Table 6.2) will allow NASA to conclude that representative groundwater samples were collected and that concentrations in those samples adequately characterize the groundwater beyond the influence of the well and the borehole.

NASA will utilize the results of the investigation to coordinate any additional follow-on work discussed in the subsequent section of this work plan.

6.7 Follow-on Investigations

Following an evaluation of results obtained during the investigation, NASA may choose to implement follow-on investigations or projects. This section discusses some potential options for additional work and provides the rationale for executing that work.

6.7.1 JER Monitoring Well Modifications

Based on monitoring results from the Westbay well evaluation, it is likely that NDMA concentrations will decline and stabilize at or near non-detect during this investigation. If NDMA concentrations in the JER wells behave in this manner, and past results for NDMA at these locations are deemed unrepresentative, NASA anticipates the need to modify the current groundwater sampling system in these wells. Should this need arise, NASA will likely include the JER wells in the ongoing project to convert existing Westbay wells to sampling systems that can be purged prior to sampling. NASA will evaluate the importance of the JER wells in the overall groundwater monitoring program and determine a schedule for their conversion. NASA will then revise the conversion schedule originally submitted to NMED on November 1, 2012 in the *Westbay Well Conversion Work Plan* (NASA, 2012[b]) and submit the revised schedule to NMED in the investigation report.

If representative groundwater samples yield NMDA concentrations that are inconsistent and unrepeatable like past analytical results, significant purging may not be required. In this instance, NASA will evaluate all of the data collected during the investigation and determine whether modifications to the JER well sampling systems are required. Recommendations will be provided in the evaluation report.

6.7.2 Additional Groundwater Monitoring Wells

If anomalous NDMA detections persist in representative groundwater samples collected during this investigation, NASA will reconsider the need for additional groundwater monitoring wells on the JER. NASA will reevaluate the need to drill and install one or both of the data gap monitoring wells proposed in the *NASA WSTF Drilling Work Plan for Two Groundwater Monitoring Wells on the Jornada Experimental Range* (NASA, 2012[a]). Recommendations for additional groundwater monitoring would be provided in the investigation report, and NASA would revise or execute the drilling work plan after consultation with NMED. Representative samples with no or very low concentrations of NDMA would indicate that NDMA is not present in the groundwater at these locations, or that the existing wells adequately bound the northern extent of the NDMA plume, respectively. Additional monitoring wells would not be required to further characterize the nature and extent of groundwater contamination in the JER area.

6.7.3 Mid-plume Exploration

If representative groundwater samples from the JER wells indicate the presence of NDMA in the groundwater at those locations, it may be concluded that the northwest trending arm of the conceptualized NDMA plume extends beneath the JER. This conclusion would lead to the need to further evaluate the MPCA in order to more adequately address northwestward contaminant migration from the MPCA. Options for additional work in the MPCA include geophysical surveys and exploratory drilling. NASA will identify the need for this work in the investigation report and, if required, develop and submit to NMED the appropriate work plan(s). NASA also plans to use the results from the groundwater dye tracer test currently scheduled for late 2013 to contribute to the development of additional investigation activities in the MPCA.

7.0 Schedule

This investigation consists of three primary phases: 1) pre-investigation planning and preparation; 2) execution of the field investigation activities; and 3) data assessment and preparation of the investigation report detailing the findings of the investigation. The schedule for these activities is presented below. In addition, the follow-on work discussed in Section 6.7 may be required. Schedules for these activities will be presented in the investigation report or additional work plans, as required.

7.1 Planning and Preparation

In addition to NMED review of this work plan, NASA must complete several important activities prior to the initiation of field activities. Resource requirements must be clearly identified and scheduled using the established NASA process for planning, funding, and executing work at WSTF. In addition, off-site resources must be coordinated. NASA expects these activities to require several months after NMED approval of this plan, which is anticipated in January 2014.

7.2 Field Investigation

NASA expects to begin the groundwater purging and sampling described in this work plan April 2014. It is expected that approximately two weeks will be required to purge and sample each JER well. Unforeseen field conditions, off-site resource availability, delays in approval of this work plan, or other complications possibly impacting this schedule will be discussed with NMED as they arise to determine the best resolution.

7.3 Data Assessment and Reporting

NASA expects to complete field activities associated with this investigation in late April or early May 2014. The chemical analytical results from groundwater samples collected are expected to be delivered to WSTF within 30 days of completion of field activities. Chemical analytical data will be evaluated as previously described, a process that typically requires up to two months. Additional resources, guidance, or supporting data will also be assessed and utilized to support the investigation. The results of these evaluations will be incorporated into a final report for submittal to NMED by August 29, 2014. Unforeseen delays in the completion of field investigation activities or data evaluation may adversely impact the completion of the report on this schedule and will be discussed with NMED as soon as possible upon NASA becoming aware of a problem.

8.0 References

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NMED. Approval with Modifications Investigation Report for Evaluating the Representativeness of Groundwater Samples Collected From Westbay Wells National Aeronautics Space Administration (NASA) Johnson Space Center (JSC) White Sands Test Facility (WSTF) Doña Ana County, New Mexico EPA ID #NM08800019434 HWB-NASA-11-012. New Mexico Environment Department Hazardous Waste Bureau, Santa Fe, NM. December 16, 2011(c).

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NMED. Approval Westbay Well Conversion Work Plan National Aeronautics Space Administration (NASA) Johnson Space Center (JSC) White Sands Test Facility (WSTF) Doña Ana County, New Mexico EPA ID #NM08800019434 HWB-NASA-12-021. New Mexico Environment Department Hazardous Waste Bureau, Santa Fe, NM. January 16, 2013(a).

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Figures

Figure 1.1 **WSTF Location Map**

(SEE NEXT PAGE)

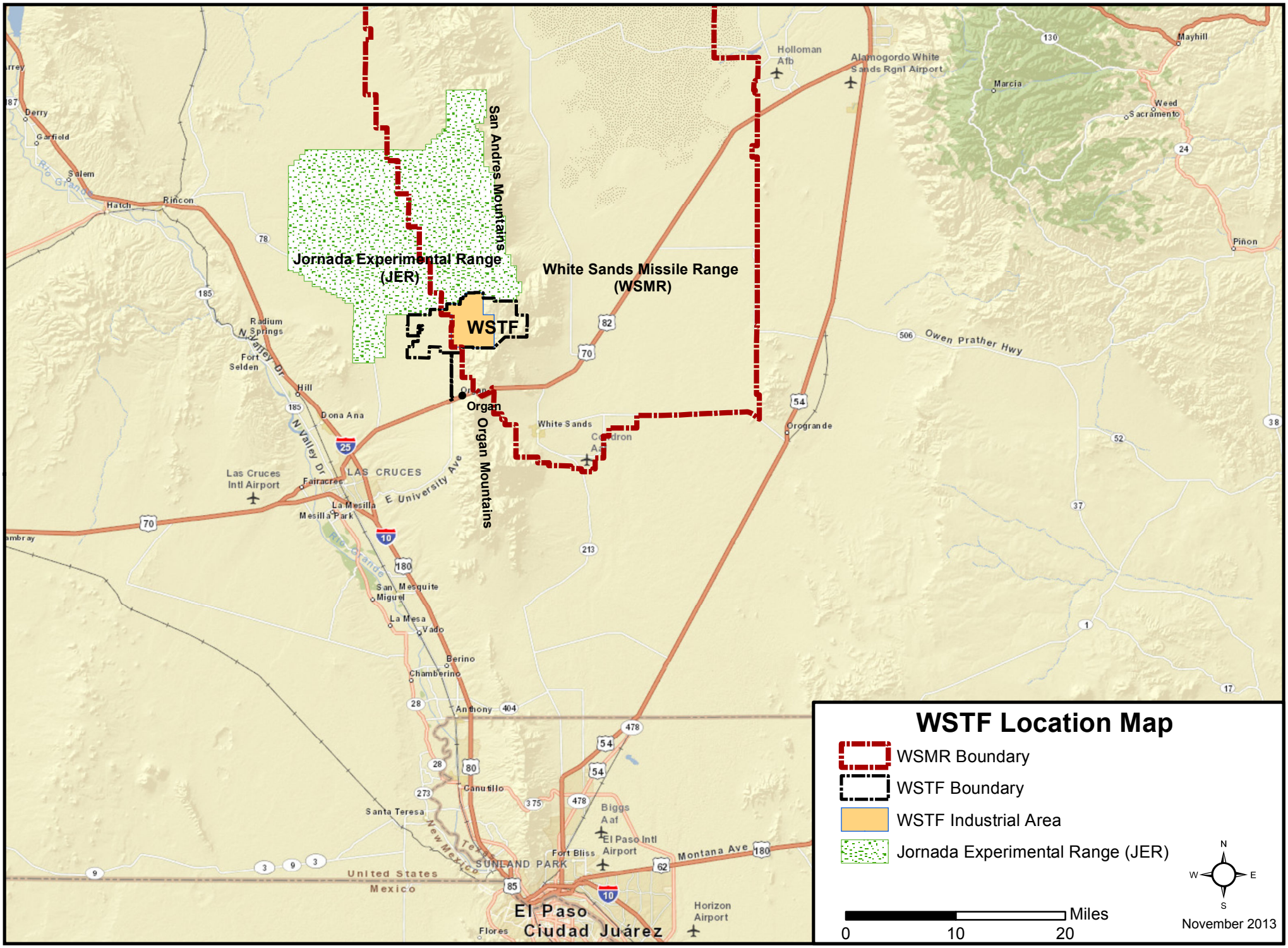
WSTF Location Map
WSMR Boundary
WSTF Boundary
WSTF Industrial Area
Jornada Experimental Range (JER)
Miles
0
10
20
N
S
E
W
November 2013
Jornada Experimental Range (JER)
San Andres Mountains
White Sands Missile Range (WSMR)
WSTF
Organ
Organ Mountains
Holloman Afb
Alamogordo White Sands Rgnl Airport
Mayhill
Marcia
Weed
Sacramento
Piñon
Owen Prather Hwy
Orogrande
White Sands
Cloudcroft
Derry
Garfield
Salem
Hatch
Rincon
Radium Springs
Fort Selden
N Valley Dr
Hill
Dona Ana
LAS CRUCES
Las Cruces Intl Airport
Fairacres
La Mesilla
Mesilla Park
E University Ave
Rio Grande
San Miguel
Mesquite
La Mesa
Vado
Berino
Chamberino
Anthony
Canutillo
Santa Teresa
New Mexico
Texas
SUNLAND PARK
Fort Bliss
Biggs Aaf
El Paso Intl Airport
Montana Ave
United States
Mexico
El Paso
Ciudad Juárez
Flores
Horizon Airport

Figure 1.2 WSTF Features and NDMA/TCE Plumes

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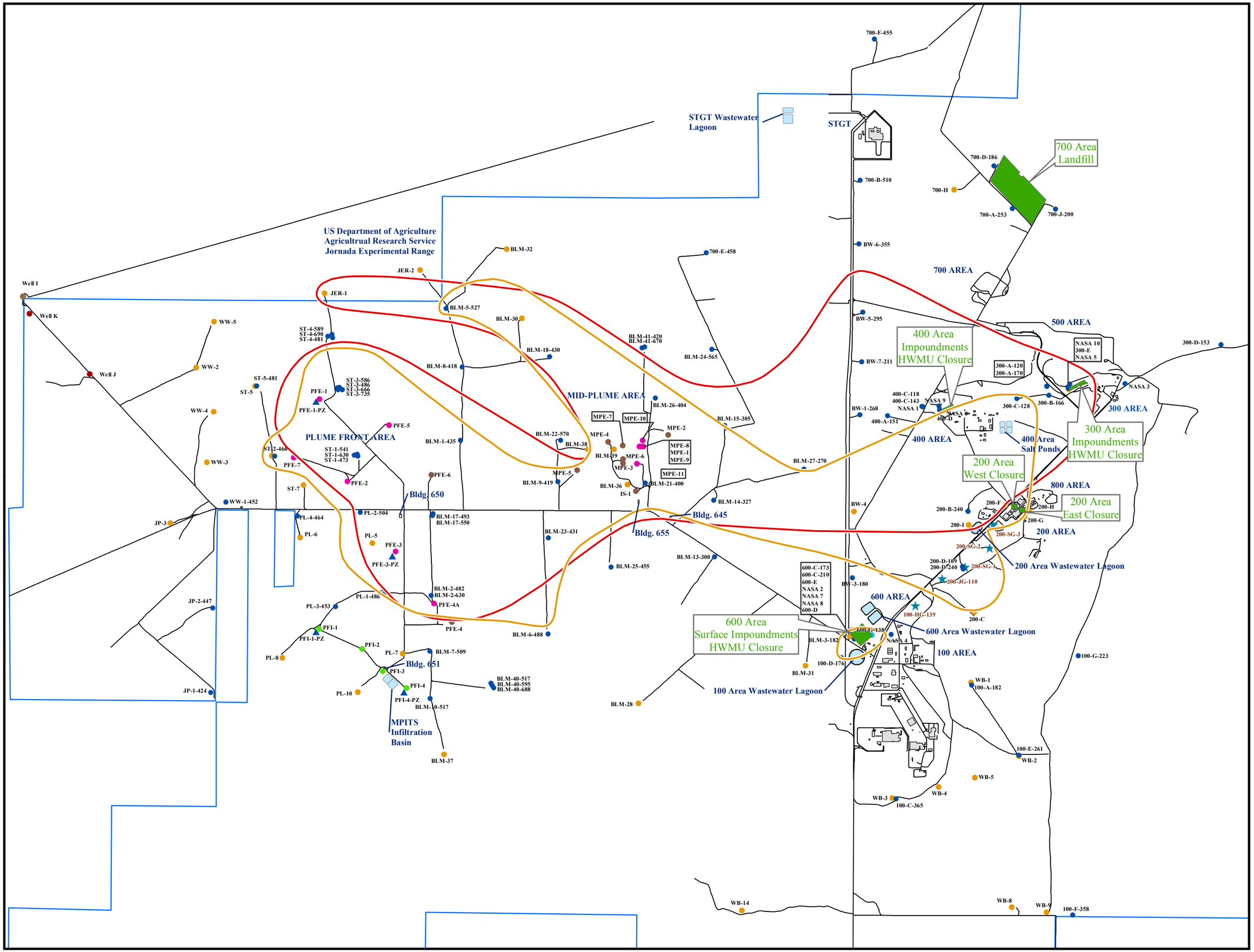


NASA-WSTF Site Features and NDMA and TCE Concentrations in Groundwater

- NDMA Equiconcentration Line (4.2 ppt)
- TCE Equiconcentration Line (2.6 ppb)
- Road
- WSTF Boundary
- Building (Bldg)
- Impoundment
- RCRA Post Closure Care

Wells

- Conventional Well
- Perched Well
- Multiport Well
- MSVGM Well
- Extraction Well
- Injection Well
- Piezometer
- Exploration Well
- Production Well

Note:
Method 607 NDMA results corrected for extraction efficiency.
NDMA ND - Non-detect values <0.21 ppt (NDMA-LL) or <4.4 ppt (607)
Analytical data for perched groundwater well 600-G-138 was included in contouring groundwater concentrations for TCE.
TCE ND - Non-detect values <0.2 ppb

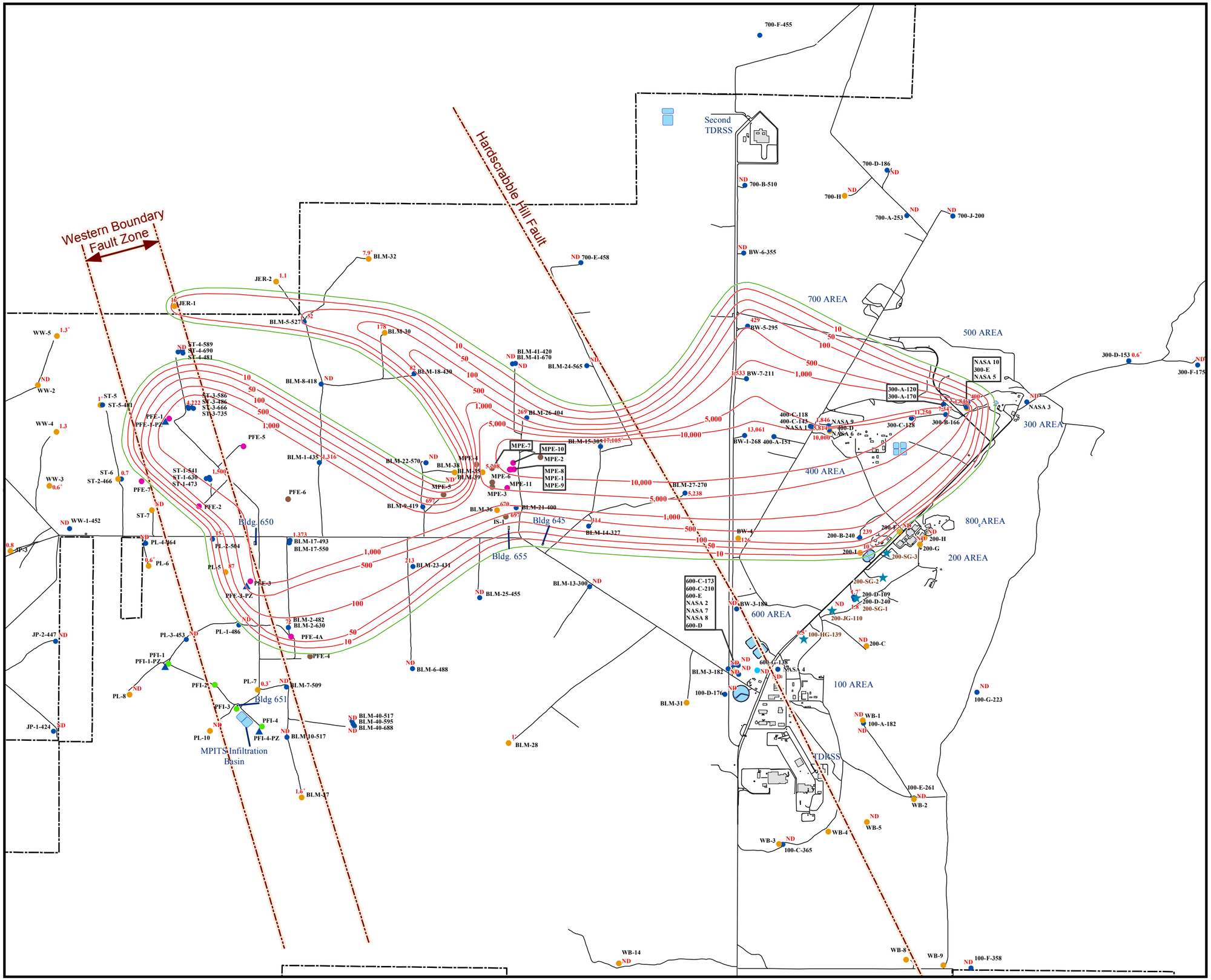
Feet
0 2,000 4,000

N

November 2013

Figure 2.1 **Hand-contoured NDMA Plume**

(SEE NEXT PAGE)



NDMA Maximum Concentrations in Groundwater for Second Quarter 2013

- Equiconcentration Line (ppt)
- NDMA Cleanup Level (4.2 ppt)
- Roads
- Faults
- Building (Bldg)
- WSTF Boundary
- Impoundment
- Conventional Well
- Perched Well
- Multiport Well
- MSVGM Well
- Extraction Well
- Injection Well
- Piezometer
- Exploration Well
- Production Well

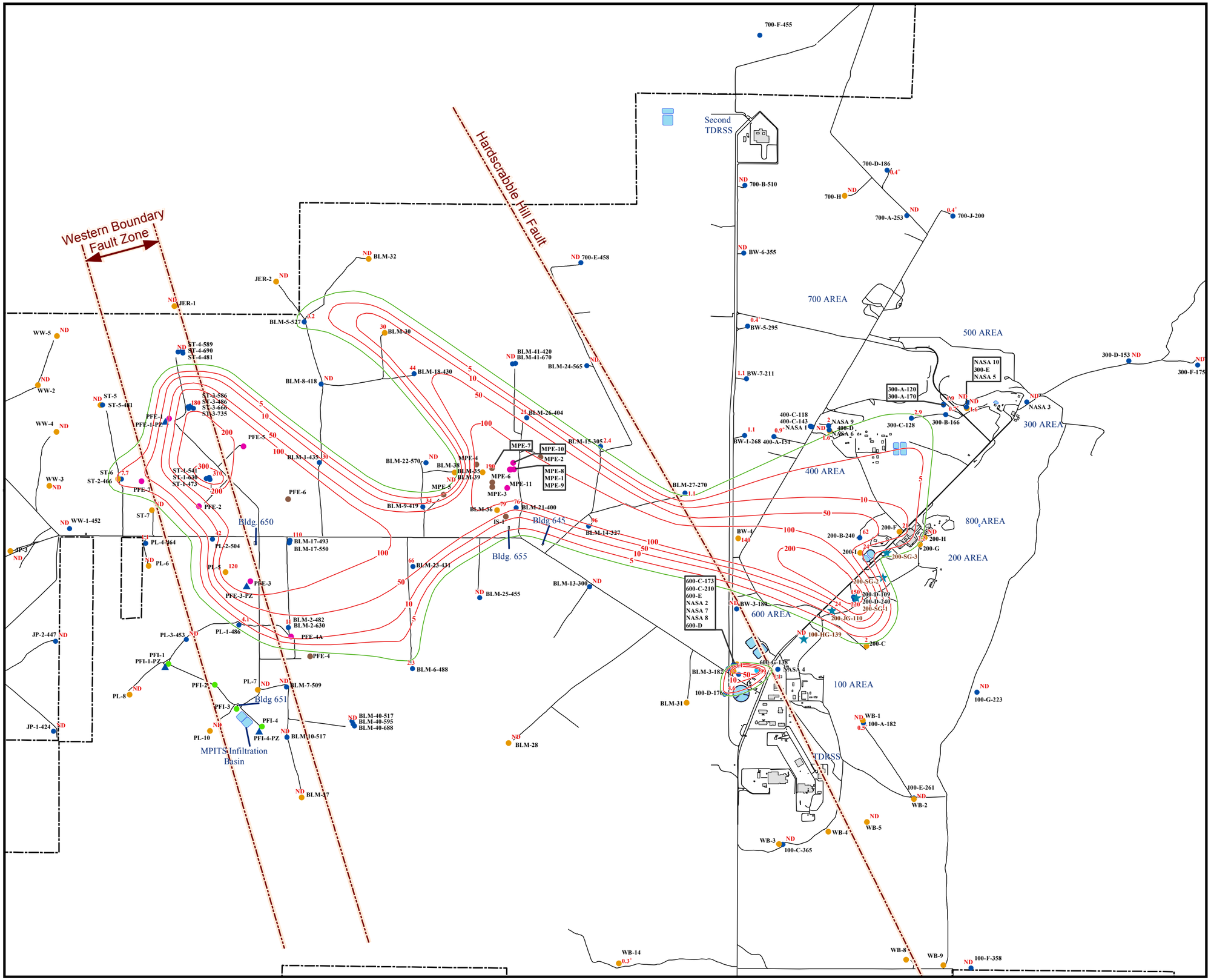
Note:
Method 607 NDMA results corrected for extraction efficiency.
+ - Data value has a QA flag. See Appendix A.2 for specific flags.
ND - Non-detect values <0.21 ppt (NDMA-LL) or <4.4 ppt (607)

Feet
0 2,500 5,000

N

Figure 2.2 **Hand-contoured TCE Plume**

(SEE NEXT PAGE)



TCE Maximum Concentrations in Groundwater for Second Quarter 2013

- Equiconcentration Line (ppb)
- TCE Cleanup Level (2.6 ppb)
- Roads
- Faults
- Building (Bldg)
- WSTF Boundary
- Impoundment
- Conventional Well
- Perched Well
- Multiport Well
- MSVGM Well
- Extraction Well
- Injection Well
- Piezometer
- Exploration Well
- Production Well

Note:
Analytical data for perched groundwater well 600-G-138 was included in contouring groundwater concentrations for TCE.
+ - Data value has a QA flag.
See Appendix A.2 for specific flags.
ND - Non-detect values <0.2 ppb

Feet
0 2,500 5,000

N

Figure 2.3 **JER Well Configuration**

(SEE NEXT PAGE)

JER Well Configuration

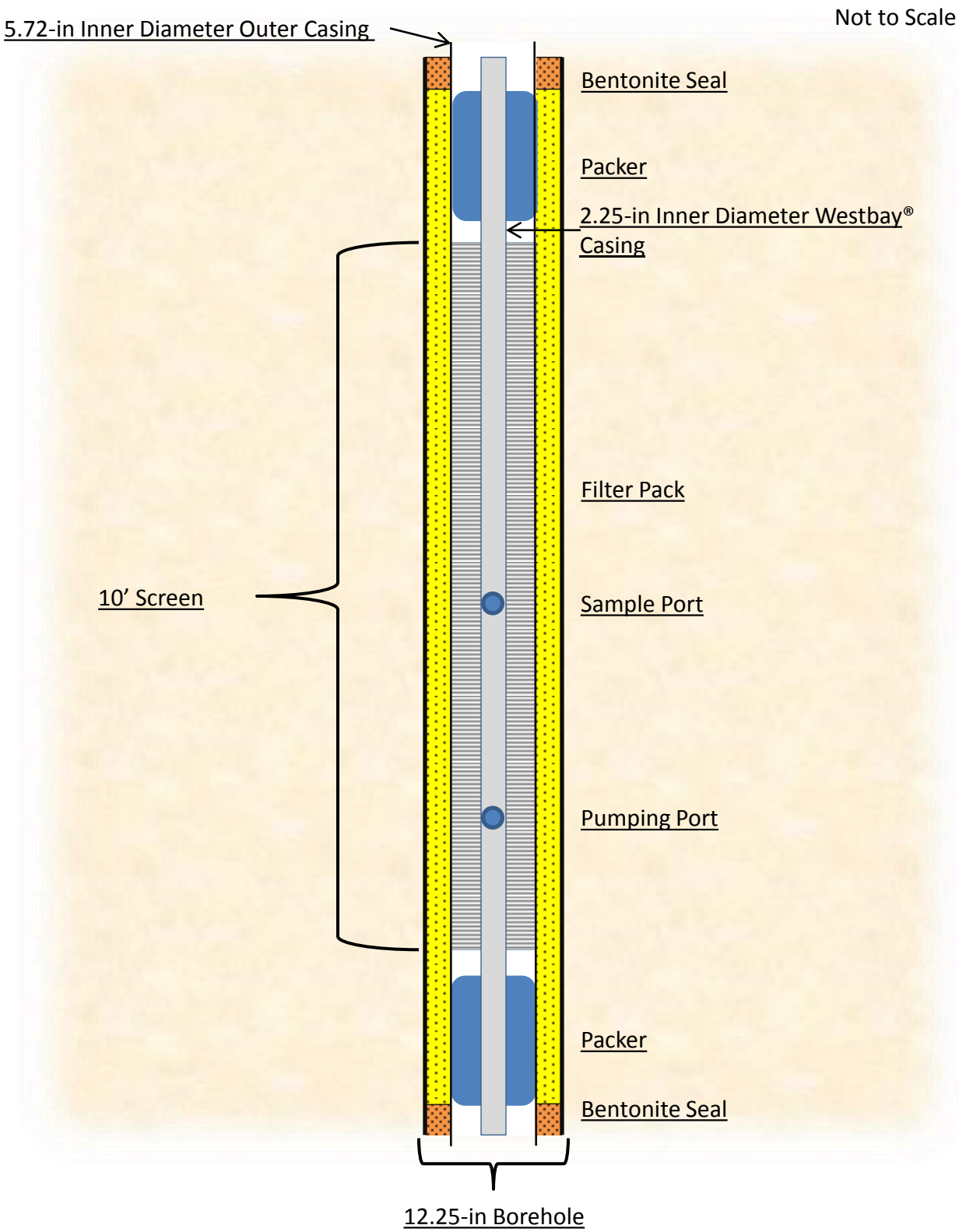


Figure 2.4 NDMA Concentrations in JER-1-568 During Westbay Well Evaluation

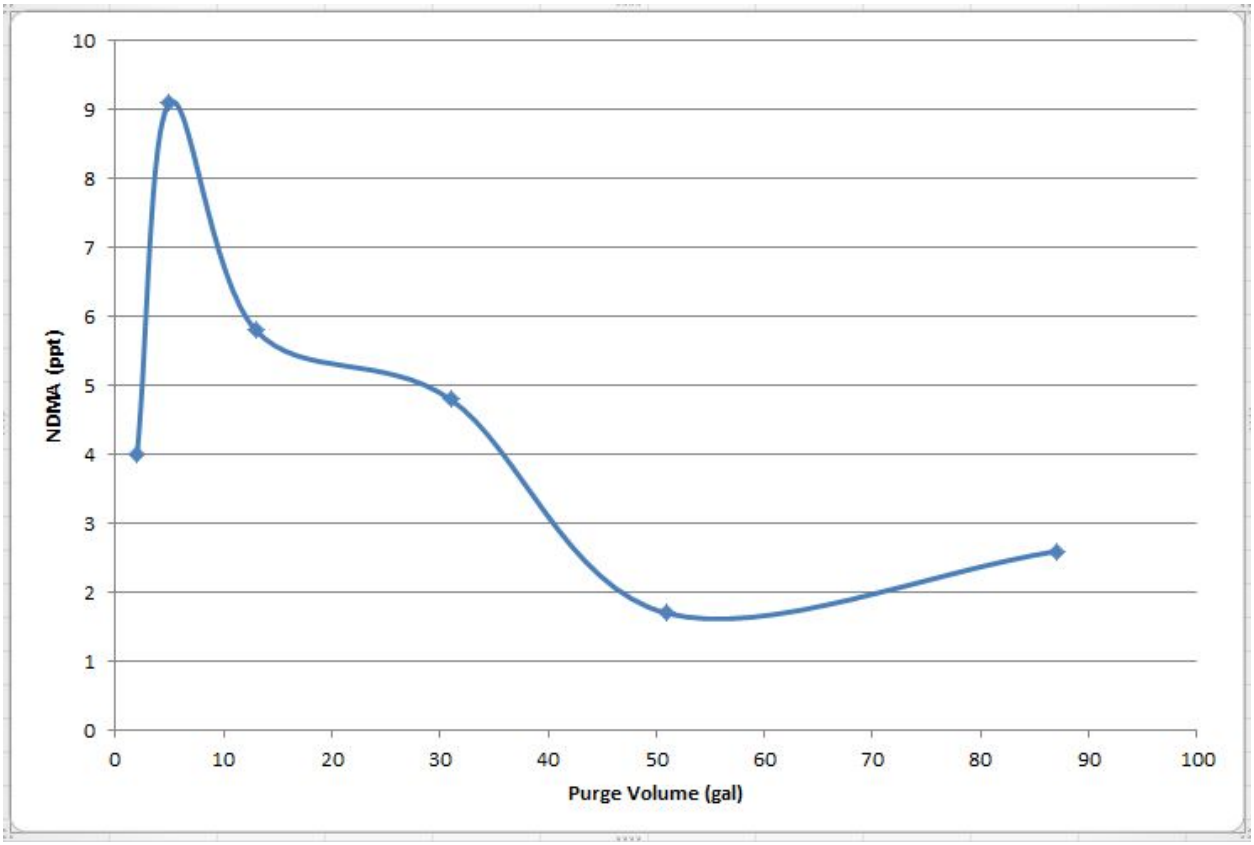


Figure 2.5 NDMA Concentrations in JER-2-508 During Westbay Well Evaluation

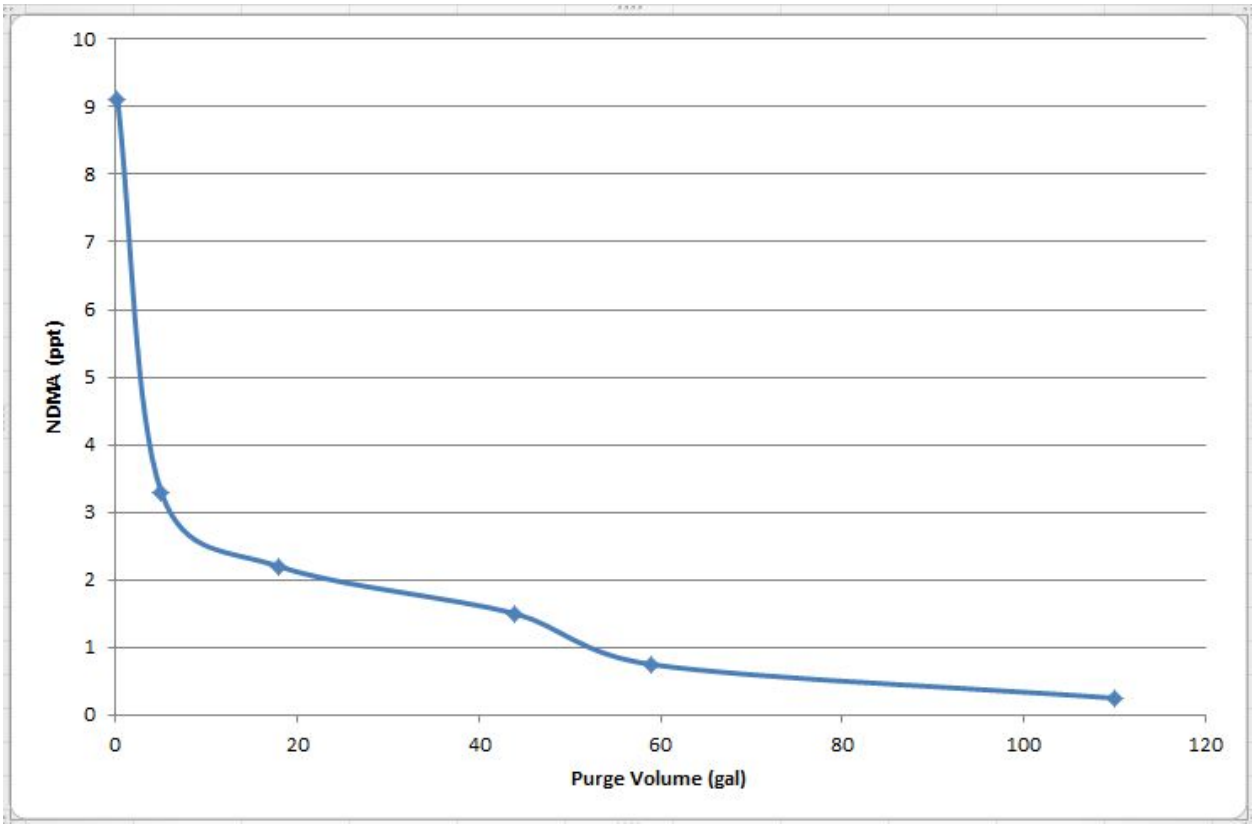


Figure 2.6 Vinyl Chloride Concentrations in JER-1-568 During Westbay Well Evaluation

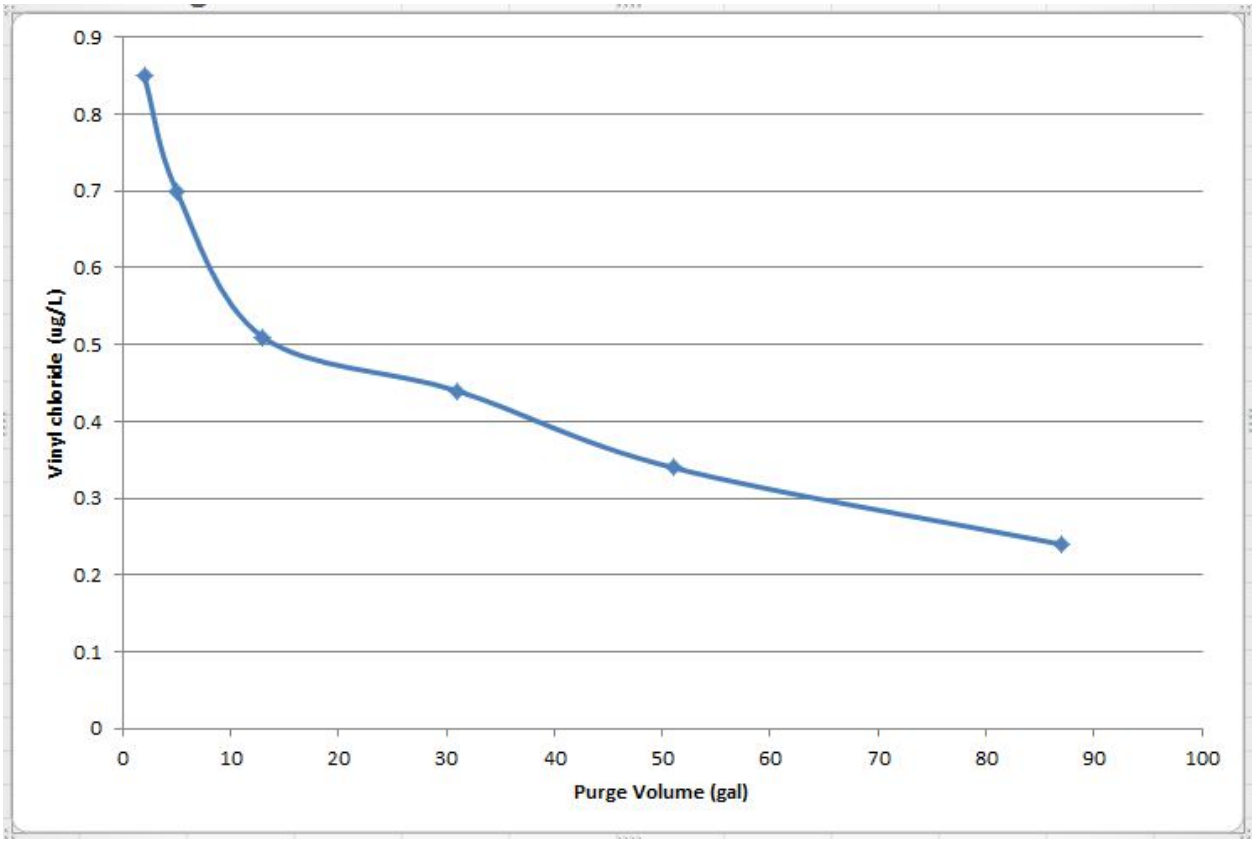


Figure 2.7 **JER Location**

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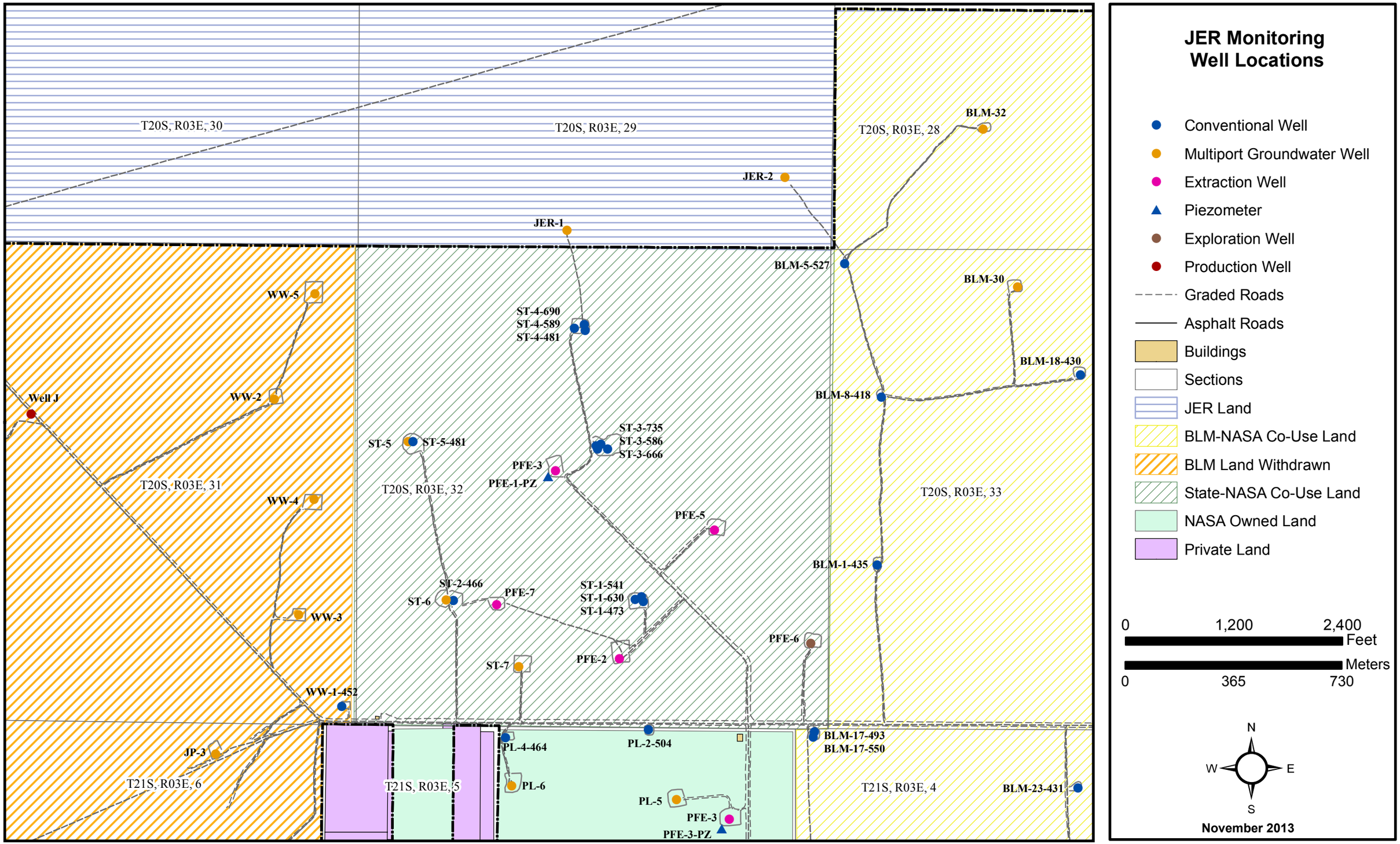

JER Monitoring Well Locations
Conventional Well
Multiport Groundwater Well
Extraction Well
Piezometer
Exploration Well
Production Well
Graded Roads
Asphalt Roads
Buildings
Sections
JER Land
BLM-NASA Co-Use Land
BLM Land Withdrawn
State-NASA Co-Use Land
NASA Owned Land
Private Land
0
1,200
2,400
Feet
Meters
0
365
730
N
W
E
S
November 2013
T20S, R03E, 30
T20S, R03E, 29
T20S, R03E, 28
T20S, R03E, 31
T20S, R03E, 32
T20S, R03E, 33
T21S, R03E, 6
T21S, R03E, 5
T21S, R03E, 4
BLM-32
JER-2
JER-1
BLM-5-527
BLM-30
BLM-18-430
BLM-8-418
BLM-1-435
BLM-17-493
BLM-17-550
BLM-23-431
WW-5
WW-2
Well J
WW-4
WW-3
WW-1-452
JP-3
ST-4-690
ST-4-589
ST-4-481
ST-5
ST-5-481
ST-3-735
ST-3-586
ST-3-666
PFE-3
PFE-1-PZ
PFE-5
ST-2-466
ST-6
PFE-7
ST-1-541
ST-1-630
ST-1-473
PFE-2
ST-7
PFE-6
PL-4-464
PL-2-504
PL-6
PL-5
PFE-3
PFE-3-PZ

Tables

Table 2.1 1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113) Detections in JER-1 and JER-2

Well ID	Event Date	Result	Units	PQL	MDL	QA Flag
JER-2-587	20-Apr-04	1.4	µg/L	0.5	0.083	
JER-2-587	20-Apr-04	0.53	µg/L	0.5	0.083	
JER-1-688	5-May-04	2.0	µg/L	0.5	0.083	
JER-1-688	23-Sep-08	0.23	µg/L	1.0	0.29	J

J – The result is an estimate value less than the quantitation limit, but greater than or equal to the detection limit.

MDL – Method detection limit.

PQL – Practical quantitation limit.

Table 2.2 Comparison of Historical JER-1 and JER-2 NDMA Results

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-1-488	5/10/2004	ND	ppb	0.005		6.6	ng/L	0.4	
JER-1-488	7/14/2004	ND	ppb	0.005		12	ng/L	0.4	
JER-1-488	10/28/2004	ND	ppb	0.005		2	ng/L	0.4	QD
						1.5	ng/L	0.4	QD A RB
JER-1-488	1/20/2005	ND	ppb	0.005		11	ng/L	0.4	RB FB
JER-1-488	5/3/2005	0.006	ppb	0.005	J	4.7	ng/L	0.4	RB
JER-1-488	8/4/2005	ND	ppb	0.005		12	ng/L	0.4	RB
JER-1-488	11/8/2005	ND	ppb	0.005		2.2	ng/L	0.4	FB
JER-1-488	2/2/2006	ND	ppb	0.005		5	ng/L	0.23	
JER-1-488	5/8/2006	ND	ppb	0.005		4.2	ng/L	0.23	RB
JER-1-488	8/23/2006	ND	ppb	0.005		ND	ng/L	0.23	
						0.3	ng/L	0.23	J RB
JER-1-488	12/14/2006	ND	ppb	0.005		130	ng/L	0.23	
JER-1-488	3/8/2007	ND	ppb	0.005		37	ng/L	0.23	RB
JER-1-488	6/11/2007	ND	ppb	0.005		2.8	ng/L	0.23	
JER-1-488	9/12/2007	ND	ppb	0.005		ND	ng/L	0.23	
JER-1-488	12/7/2007	ND	ug/l	0.005		0.6	ng/L	0.1	J RB FB
JER-1-488	3/13/2008	ND	ug/L	0.005		ND	ng/L	0.1	J RB
JER-1-488	6/5/2008	ND	ug/L	0.005		0.6	ng/L	0.1	J RB
						0.7	ng/L	0.1	J RB
JER-1-488	9/24/2008	ND	ug/L	0.005		0.9	ng/L	0.1	J EB
JER-1-488	12/5/2008	ND	ug/L	0.005		1.9	ng/L	0.23	J
JER-1-488	3/13/2009	ND	ug/L	0.005		0.6	ng/L	0.5	FB
JER-1-488	6/17/2009	ND	ug/L	0.005		5.1	ng/L	0.5	J

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-1-488	9/28/2009	ND	ug/L	0.005		0.6	ng/L	0.5	
JER-1-488	1/8/2010	ND	ug/L	0.005		5.7	ng/L	0.5	
JER-1-488	4/13/2010	ND	ug/L	0.005		ND	ng/L	0.5	RB i A
JER-1-488	7/13/2010	ND	ug/L	0.005		3.2	ng/L	0.5	J
JER-1-488	10/5/2010	ND	ug/L	0.005		0.8	ng/L	0.5	
JER-1-488	3/1/2011	ND	ug/L	0.005		ND	ng/L	0.5	J EB
JER-1-488	9/7/2011	ND	ug/L	0.005		0.5	ng/L	0.5	
JER-1-488	3/9/2012	ND	ug/L	0.005		1.1	ng/L	0.5	EB
JER-1-488	11/8/2012	ND	ug/L	0.005		0.9	ng/L	0.5	
JER-1-488	3/2/2013	ND	ug/L	0.005		ND	ng/L	0.24	
JER-1-568	10/26/2004	ND	ppb	0.005		7.2	ng/L	0.4	A SP RB
JER-1-568	1/19/2005	ND	ppb	0.005		28	ng/L	0.4	RB
						23	ng/L	0.4	RB
JER-1-568	5/2/2005	ND	ppb	0.005		6.5	ng/L	0.4	RB
						6.9	ng/L	0.4	RB
JER-1-568	8/4/2005	ND	ppb	0.005		24	ng/L	0.4	RB
						23	ng/L	0.4	RB
JER-1-568	11/8/2005	ND	ppb	0.005		20	ng/L	0.4	QD
						11	ng/L	0.4	QD
JER-1-568	2/1/2006	ND	ppb	0.005		25	ng/L	0.23	
JER-1-568	5/8/2006	ND	ppb	0.005		360	ng/L	0.23	RB
JER-1-568	8/24/2006	ND	ppb	0.005		31	ng/L	0.23	RB
JER-1-568	12/14/2006	ND	ppb	0.005		6.7	ng/L	0.23	QD
						38	ng/L	0.23	QD

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-1-568	3/7/2007	ND	ppb	0.005		7.2	ng/L	0.23	RB QD
						28	ng/L	0.23	RB QD
JER-1-568	6/8/2007	ND	ppb	0.005		17	ng/L	0.23	
JER-1-568	9/7/2007	ND	ppb	0.005		22	ng/L	0.23	
						23	ng/L	0.23	
JER-1-568	12/6/2007	ND	ug/l	0.005		16	ng/L	0.1	RB
JER-1-568	3/12/2008	ND	ug/L	0.005		4.3	ng/L	0.1	Q
						5.3	ng/L	0.1	Q
JER-1-568	6/5/2008	ND	ug/L	0.005		2.6	ng/L	0.1	RB
JER-1-568	9/23/2008	ND	ug/L	0.005		13	ng/L	0.1	RB FB
JER-1-568	12/4/2008	ND	ug/L	0.005		30	ng/L	0.23	
JER-1-568	3/12/2009	ND	ug/L	0.005		5.8	ng/L	0.5	
						6.1	ng/L	0.5	
JER-1-568	6/16/2009	ND	ug/L	0.005		360	ng/L	0.5	
JER-1-568	9/28/2009	ND	ug/L	0.005		12	ng/L	0.5	
JER-1-568	1/8/2010	ND	ug/L	0.005		170	ng/L	0.5	Q
JER-1-568	4/12/2010	ND	ug/L	0.005		31	ng/L	0.5	Q
JER-1-568	7/13/2010	ND	ug/L	0.005		9.2	ng/L	0.5	QD RB A
						5.9	ng/L	0.5	QD RB i A
JER-1-568	10/5/2010	ND	ug/L	0.005		2.1	ng/L	0.5	
						2.6	ng/L	0.5	
JER-1-568	3/2/2011	ND	ug/L	0.005		4.4	ng/L	0.5	EB i
						3.7	ng/L	0.5	EB
JER-1-568	3/7/2012	ND	ug/L	0.005		1.1	ng/L	0.5	EB
JER-1-568	11/7/2012	ND	ug/L	0.005		ND	ng/L	0.5	

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-1-568	3/2/2013	ND	ug/L	0.005		4.3	ng/L	0.22	
JER-1-688	5/5/2004	ND	ppb	0.005		2.6	ng/L	0.4	
JER-1-688	7/9/2004	ND	ppb	0.005		8.2	ng/L	0.4	
JER-1-688	10/25/2004	ND	ppb	0.005		6.4	ng/L	0.4	
JER-1-688	1/18/2005	ND	ppb	0.005		2.8	ng/L	0.4	RB
JER-1-688	5/2/2005	ND	ppb	0.005		0.5	ng/L	0.4	
JER-1-688	8/3/2005	ND	ppb	0.005		18	ng/L	0.4	RB FB
JER-1-688	11/8/2005	ND	ppb	0.005		8.4	ng/L	0.4	
JER-1-688	2/1/2006	ND	ppb	0.005		12	ng/L	0.23	
JER-1-688	5/5/2006	ND	ppb	0.005		12	ng/L	0.23	RB QD
						17	ng/L	0.23	RB QD
JER-1-688	8/24/2006	ND	ppb	0.005		7	ng/L	0.23	RB
JER-1-688	12/13/2006	ND	ppb	0.005		5.2	ng/L	0.23	
JER-1-688	3/7/2007	ND	ppb	0.005		6.5	ng/L	0.23	RB
JER-1-688	6/8/2007	ND	ppb	0.005		28	ng/L	0.23	
JER-1-688	9/6/2007	ND	ppb	0.005		25	ng/L	0.23	SP
JER-1-688	12/6/2007	ND	ug/l	0.005		5.3	ng/L	0.1	RB
JER-1-688	3/11/2008	ND	ug/L	0.005		3.6	ng/L	0.1	
JER-1-688	6/4/2008	ND	ug/L	0.005		4.3	ng/L	0.1	RB
JER-1-688	9/23/2008	ND	ug/L	0.005		11	ng/L	0.1	RB
JER-1-688	12/4/2008	ND	ug/L	0.005		34	ng/L	0.23	
JER-1-688	3/12/2009	ND	ug/L	0.005		1	ng/L	0.5	J
JER-1-688	6/16/2009	ND	ug/L	0.005		7	ng/L	0.5	
JER-1-688	9/26/2009	ND	ug/L	0.005		7.4	ng/L	0.5	
JER-1-688	1/7/2010	ND	ug/L	0.005		32	ng/L	0.5	

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-1-688	4/12/2010	ND	ug/L	0.005		0.6	ng/L	0.5	J
JER-1-688	7/7/2010	ND	ug/L	0.005		110	ng/L	0.5	A
JER-1-688	10/4/2010	ND	ug/L	0.005		6.7	ng/L	0.5	
JER-1-688	3/2/2011	ND	ug/L	0.005		26	ng/L	0.5	
JER-1-688	9/6/2011	ND	ug/L	0.005		4.1	ng/L	0.5	EB
JER-1-688	3/8/2012	ND	ug/L	0.005		1	ng/L	0.5	J EB
JER-1-688	11/7/2012	ND	ug/L	0.005		ND	ng/L	0.5	
JER-1-688	3/1/2013	ND	ug/L	0.005		16	ng/L	0.22	
JER-2-508	4/20/2004	ND	ppb	0.005		5.9	ng/L	0.2	
JER-2-508	7/19/2004	ND	ppb	0.005		12.2	ng/L	0.4	
JER-2-508	10/13/2004	ND	ppb	0.005		123	ng/L	0.4	QD
						41.4	ng/L	0.4	QD
JER-2-508	1/24/2005	ND	ppb	0.005		10	ng/L	0.4	RB QD
						6.5	ng/L	0.4	RB QD
						37	ng/L	0.4	RB QD
						57.8	ng/L	0.4	RB QD
JER-2-508	5/5/2005	ND	ppb	0.005		37.5	ng/L	0.4	RB QD A
						8.8	ng/L	0.4	RB QD FB
JER-2-508	8/8/2005	0.007	ppb	0.005	J	25	ng/L	0.4	RB QD
						191.4	ng/L	0.4	RB QD
JER-2-508	11/10/2005	ND	ppb	0.005		20.5	ppt	0.4	FB
JER-2-508	2/2/2006	ND	ppb	0.005		288	ng/L	0.23	QD
JER-2-508	2/2/2006	ND		0.005		112	ng/L	0.23	QD
JER-2-508	5/4/2006	ND	ppb	0.005		34	ng/L	0.23	RB
JER-2-508	8/22/2006	ND	ppb	0.005		180	ng/L	0.23	RB

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-2-508	12/8/2006	ND	ppb	0.005		92	ng/L	0.23	RB
JER-2-508	3/6/2007	ND	ppb	0.005		190	ng/L	0.23	RB QD
						54	ng/L	0.23	RB QD
JER-2-508	6/5/2007	ND	ppb	0.005		62	ng/L	0.23	RB QD
						29	ng/L	0.23	RB QD
						38	ng/L	0.1	
JER-2-508	12/5/2007	ND	ug/l	0.005		3.6	ng/L	0.1	RB
						4.8	ng/L	0.1	RB
JER-2-508	3/10/2008	ND	ug/L	0.005		4.4	ng/L	0.1	Q
						3.8	ng/L	0.1	Q
JER-2-508	6/3/2008	ND	ug/L	0.005		1.6	ng/L	0.1	RB Q
JER-2-508	9/10/2008	ND	ug/L	0.005		3.2	ng/L	0.1	RB
JER-2-508	12/3/2008	ND	ug/L	0.005		41	ng/L	0.1	TB
JER-2-508	3/10/2009	ND	ug/L	0.005		1	ng/L	0.5	J
JER-2-508	6/15/2009	ND	ug/L	0.005		32	ng/L	0.5	
JER-2-508	10/5/2009	ND	ug/L	0.005		27	ng/L	0.5	
JER-2-508	1/19/2010	ND	ug/L	0.005		85	ng/L	0.5	
JER-2-508	4/15/2010	ND	ug/L	0.005		0.68	ng/L	0.5	J
						0.91	ng/L	0.5	J
JER-2-508	7/16/2010	ND	ug/L	0.005		2.2	ng/L	0.5	RB A
JER-2-508	10/7/2010	ND	ug/L	0.005		1.2	ng/L	0.5	
JER-2-508	3/8/2011	ND	ug/L	0.005		9.1	ng/L	0.5	
JER-2-508	9/12/2011	ND	ug/L	0.005		1.3	ng/L	0.5	EB
JER-2-508	3/8/2012	ND	ug/L	0.005		ND	ng/L	0.5	
						ND	ng/L	0.5	

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-2-508	11/9/2012	ND	ug/L	0.006		1.39	ng/L	0.5	EB
						1.37	ng/L	0.5	EB
JER-2-508	3/6/2013	ND	ug/L	0.006		ND	ng/L	0.47	
JER-2-587	4/20/2004	ND	ppb	0.005		3.8	ng/L	0.2	
JER-2-587	7/15/2004	ND	ppb	0.005		7.4	ng/L	0.4	
JER-2-587	10/12/2004	ND	ppb	0.005		21.6	ng/L	0.4	
JER-2-587	1/24/2005	ND	ppb	0.005		9.2	ng/L	0.4	RB QD
						6.9	ng/L	0.4	RB QD
						21.1	ng/L	0.4	RB QD
						40.7	ng/L	0.4	RB QD
JER-2-587	5/4/2005	ND	ppb	0.005		ND	ng/L	0.4	
JER-2-587	8/9/2005	ND	ppb	0.005		13.5	ng/L	0.4	RB
JER-2-587	11/9/2005	ND	ppb	0.005		18.2	ng/L	0.4	QD
						8.2	ng/L	0.4	QD
JER-2-587	2/2/2006	ND	ppb	0.005		22	ng/L	0.23	
						20	ng/L	0.23	
JER-2-587	5/9/2006	ND	ppb	0.005		13	ng/L	0.23	RB
JER-2-587	8/21/2006	ND	ppb	0.005		190	ng/L	0.23	RB
JER-2-587	12/8/2006	ND	ppb	0.005		200	ng/L	0.23	RB QD
						17	ng/L	0.23	RB QD
JER-2-587	3/6/2007	ND	ppb	0.005		14	ng/L	0.23	RB QD
						3.4	ng/L	0.23	RB QD
JER-2-587	6/5/2007	ND	ppb	0.005		5.9	ng/L	0.23	RB
JER-2-587	9/4/2007	ND	ppb	0.005		35	ng/L	0.23	
						41	ng/L	0.23	

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-2-587	12/4/2007	ND	ug/l	0.005		6.8	ng/L	0.1	RB
JER-2-587	3/10/2008	ND	ug/L	0.005		2.6	ng/L	0.1	QD
						4.3	ng/L	0.1	QD
JER-2-587	6/2/2008	ND	ug/L	0.005		1.8	ng/L	0.1	RB FB
JER-2-587	9/11/2008	ND	ug/L	0.005		7.7	ng/L	0.1	RB
JER-2-587	12/3/2008	ND	ug/L	0.005		38	ng/L	0.23	QD
						8.9	ng/L	0.23	QD
JER-2-587	3/9/2009	ND	ug/L	0.005		0.7	ng/L	0.5	J QD
						5	ng/L	0.5	QD
JER-2-587	6/12/2009	ND	ug/L	0.005		1.9	ng/L	0.5	
						0.6	ng/L	0.5	J
JER-2-587	10/5/2009	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-587	1/15/2010	ND	ug/L	0.005		15	ng/L	0.5	TB QD
						42	ng/L	0.5	TB QD
JER-2-587	4/14/2010	ND	ug/L	0.005		16	ng/L	0.5	EB
JER-2-587	7/16/2010	ND	ug/L	0.005		4.4	ng/L	0.5	TB QD RB A
						2.9	ng/L	0.5	TB QD RB A
JER-2-587	10/6/2010	ND	ug/L	0.005		2	ng/L	0.5	
						1.3	ng/L	0.5	
JER-2-587	3/3/2011	ND	ug/L	0.005		1.8	ng/L	0.5	
JER-2-587	9/9/2011	ND	ug/L	0.005		1.4	ng/L	0.5	
JER-2-587	3/12/2012	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-587	11/9/2012	ND	ug/L	0.004		2.09	ng/L	0.5	EB
JER-2-587	3/5/2013	ND	ug/L	0.005		1.1	ng/L	0.45	
						1	ng/L	0.46	

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-2-689	4/19/2004	ND	ppb	0.005		4	ng/L	0.2	
JER-2-689	7/15/2004	ND	ppb	0.005		2.5	ng/L	0.4	
JER-2-689	10/12/2004	ND	ppb	0.005		12	ng/L	0.4	
JER-2-689	1/21/2005	ND	ppb	0.005		6.9	ng/L	0.4	RB FB QD
						18.1	ng/L	0.4	RB QD
JER-2-689	5/4/2005	ND	ppb	0.005		1.7	ng/L	0.4	RB
JER-2-689	8/5/2005	ND	ppb	0.005		3.6	ng/L	0.4	RB FB
JER-2-689	11/9/2005	ND	ppb	0.005		1.6	ng/L	0.4	
JER-2-689	2/1/2006	ND	ppb	0.005		7	ng/L	0.23	
JER-2-689	5/4/2006	ND	ppb	0.005		7.3	ng/L	0.23	RB FB
JER-2-689	8/11/2006	ND	ppb	0.005		1.8	ng/L	0.23	J RB
JER-2-689	12/6/2006	ND	ppb	0.005		0.8	ng/L	0.23	J RB FB
JER-2-689	3/5/2007	ND	ppb	0.005		0.7	ng/L	0.23	J RB
JER-2-689	6/4/2007	ND	ppb	0.005		1	ng/L	0.23	J RB
JER-2-689	9/4/2007	ND	ppb	0.005		0.8	ng/L	0.23	J EB
JER-2-689	12/4/2007	ND	ug/l	0.005		ND	ng/L	0.1	
JER-2-689	3/6/2008	ND	ug/L	0.005		ND	ng/L	0.1	
JER-2-689	6/2/2008	ND	ug/L	0.005		ND	ng/L	0.1	
JER-2-689	9/10/2008	ND	ug/L	0.005		1.7	ng/L	0.1	RB
						1	ng/L	0.1	RB
JER-2-689	12/2/2008	ND	ug/L	0.005		ND	ng/L	0.23	
JER-2-689	3/9/2009	ND	ug/L	0.005		0.5	ng/L	0.5	J
JER-2-689	6/12/2009	ND	ug/L	0.005		1.8	ng/L	0.5	
JER-2-689	9/29/2009	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-689	1/14/2010	ND	ug/L	0.005	T	1.1	ng/L	0.5	

Well ID	Event Date	Method 607 Analysis				Low-Level NDMA Method			
		Result	Units	Detection Limit	QA Flag	Result	Units	Detection Limit	QA Flag
JER-2-689	4/13/2010	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-689	7/14/2010	ND	ug/L	0.005		1.6	ng/L	0.5	RB A
JER-2-689	10/6/2010	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-689	3/9/2011	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-689	9/8/2011	ND	ug/L	0.005		0.55	ng/L	0.5	J EB
JER-2-689	3/9/2012	ND	ug/L	0.005		ND	ng/L	0.5	
JER-2-689	11/9/2012	ND	ug/L	0.0045		0.62	ng/L	0.5	EB
JER-2-689	3/5/2013	ND	ug/L	0.0044		ND	ng/L	0.45	

A – The result of an analyte for the laboratory control sample, initial calibration verification, or continuing calibration verification was outside standard limits.
EB – The analyte was detected in the equipment blank.
FB – The analyte was detected in the field blank.
i – The result, quantitation limit, and/or detection limit may have been affected by matrix interference.
J – The result is an estimated value less than the quantitiation limit, but greater than or equal to the detection limit.
ND – The analyte was not detected.
Q – The result for the blind control sample was outside standard limits.
QD – The relative percent difference for a field duplicate was outside standard limits.
RB – The analyte was detected in the method blank.
SP – The matrix spike recovery and/or the relative percent difference for matrix spike duplicates was outside standard limits.
TB – The analyte was detected in the trip blank.

Table 3.1 Groundwater Constituents Associated with PVC Monitoring Wells

Analyte	Site-Wide				JER Wells	
	# of Samples	# of Detects in PVC Wells	# of Detects in Stainless Steel (SS) Wells	# SS Detects with Blank Flags	# of Samples	# of Detects
Styrene	13,023	728	0	0	189	0
1,2-Dichloroethane	13,098	59	24	9	189	0
Acrylonitrile	11,158	468	0	0	189	0
Tetrahydrofuran	10,849	1,647	209	157	189	18
Vinyl chloride	13,099	294	0	0	189	97
1,1-Dichloroethane (1,1-DCA)	13,099	44	7	0	189	3
Carbon Disulfide	12,065	229	51	44	189	41

Table 6.1 JER-1 and JER-2 Sampling and Pumping Port Information

Well ID	Westbay Zone	Port Type	Depth of Port
JER-1	JER-1-488	Sample	488
JER-1	JER-1-493	Pumping	492.9
JER-1	JER-1-568	Sample	568.3
JER-1	JER-1-573	Pumping	573.2
JER-1	JER-1-688	Sample	688
JER-1	JER-1-693	Pumping	692.9
JER-2	JER-2-508	Sample	508.2
JER-2	JER-2-513	Pumping	513.2
JER-2	JER-2-587	Sample	586.9
JER-2	JER-2-592	Pumping	591.7
JER-2	JER-2-689	Sample	688.5
JER-2	JER-2-693	Pumping	693.4

Table 6.2 Purge and Sample Requirements for Pumping Ports in JER-1 and JER-2

Sample Set	Purge Requirement	Rationale for Sample Collection	Purge Volume (gallons)	Cumulative Purge Volume (gallons)	Measurement/Analyte
1	None	Sampled collected with Westbay equipment to provide project baseline for comparison	0	0	All in Table 6.3
2	Volume of the Westbay casing between the pumping port and the top of water	Provide "no purge" samples collected with conventional purge/sampling equipment; represent groundwater immediately outside the Westbay casing in the conventional outer casing	TBD[1]	TBD[1]	All in Table 6.3
3	Volume of the screened interval of the outer conventional casing	Represent groundwater outside the conventional outer casing within the borehole	18	TBD + 18	All in Table 6.3
4	Volume of the borehole surrounding the screened interval	Represent groundwater immediately outside the conventional outer casing	44	TBD + 62	All in Table 6.3
5	Two additional borehole volumes	Represent groundwater conditions within the aquifer beyond the immediate influence of the well and borehole	124	TBD + 186	All in Table 6.3
6	Two additional borehole volumes	Represent groundwater conditions well beyond the well and borehole	124	TBD + 310	All in Table 6.3

TBD – Indicates that the volume to be purged will be calculated based on the depth to water in the Westbay casing at the time of sampling.

Table 6.3 Analytical Requirements

Measurement/Analyte	CAS #	Collection or Analytical Method[1]
Indicator Parameters[2]	NA	In-line flow-through cell
Volatile Organic Compounds (VOCs)	Several[4]	SW-846 Method 8260B
N-Nitrosodimethylamine (NDMA)	62-75-9	Low-level NDMA
Total Organic Carbon	7440-44-0	SW-846 Method 9060
Total Dissolved Solids	NA	Standard Method 2540 C
Total Metals[3]	Several[3]	Several[3]
Nitrate/Nitrite as Nitrogen	NA	EPA Method 353.2

[1] – Indicates the expected method for this analysis. The specific method will be determined during the procurement of analytical services based on input from potential contracted analytical laboratories.

[2] – Indicator parameters consist of pH, temperature, conductivity, dissolved oxygen, oxidation reduction potential, and turbidity.

[3] – Total metals samples will be analyzed for aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, tin, vanadium, and zinc by the best available method proposed by the analytical laboratory.

[4] – VOC samples will be analyzed for WSTF's standard suite of volatiles, which includes approximately 37 analytes. For more information, refer to Table 3 of the NASA WSTF Groundwater Monitoring Plan (NASA, 2013[a]).

Appendix A
Completion Diagrams and Lithologic Logs for JER-1 and JER-2

WELL COMPLETION DIAGRAM

RETROFIT WESTBAY® MONITORING WELL

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

Location ID: **JER-1**

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

Township and Range: **SE 1/4 SE 1/4 SW 1/4 Sec. 29, T20S, R3E**
NM State Plane Coordinates (NAD 83-meters): **170003.50N 461730.73E**
Elevation (Brass Cap): **1370.73 m AMSL**
Elevation (Top of Casing): **1371.24 m AMSL**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **C. Brunson; W. Brunson (Supervisor)**
Total Depth of Borehole (bgs): **753' (229.5 m)**
Borehole Diameter: **17.5" (0'-76'); 12.25" (76'-753')**
Depth to Bedrock (bgs): **560' (170.7 m); Rhyolite**
Depth to Groundwater: **429' (130.8 m) TOC (1/8/04)**
Total Depth Surface Casing (bgs): **76' (23.2 m)**
Diameter and Type Surface Casing: **13.5" ID; 14" OD Steel**
Date(s) Well Installed: **10/29/03 - 1/10/04**
Date(s) Well Developed: **CW = 12/1/03 - 12/8/03; WB = 4/5/04 - 4/20/04**

Field Representative(s): **Canavan, Giles, Hunnicutt-Mack, Pearson, Stepro**
Total Depth Well Casing(s) (bgs): **CW = 718.0' (218.8 m); WB = 713.0' (217.3 m)**
Type of Casing(s): **CW = CertainTeed SDR 17 PVC; WB = PVC**
Diameter Well Casing(s): **CW = 5.728" ID; 6.625" OD; WB = 2.25" ID; 2.9" OD**
Casing Schedule: **CW = Standard Dimension Ratio 17**
CW Screened Zone(s)(bgs): **483.1-493.1' (147.2-150.3 m); 563.0-573.0' (171.6-174.7 m); 682.9-692.9' (208.1-211.2 m)**
WB Sampling Zone(s)(bgs): **488' (149.37 m); 568.32' (173.79 m); 688.01' (210.17 m)**
WB Packer Zone(s)(bgs): **477.71-497.79' (146.25-152.34 m); 558.03-578.11' (170.63-176.77 m); 677.72-697.80' (207.07-213.15 m)**
Comments: **CW = Conventional Well WB = Westbay Well**
AMSL = Above Mean Sea Level bgs = below ground surface
TOC = Top of Casing Sampling zone = 209.81 m
CW casing was slotted in middle 10' of 20' blank casing

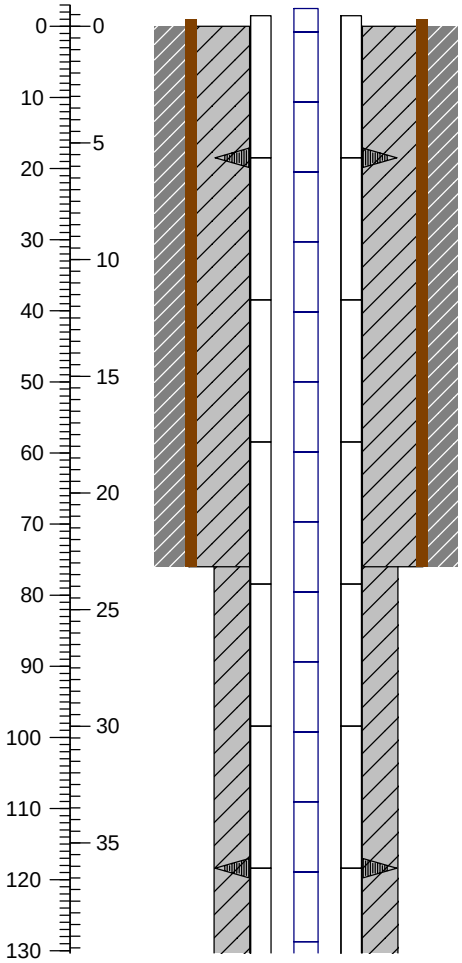
Casing Explanation:

- Surface Casing — **13.5" ID; 14" OD Steel**
- Conventional Casing — **6.625" OD CertainTeed PVC**
- Conventional Screen — **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap — **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Westbay® Well Stick-Up = ~2.5' at installation (0.8 m); 0.52 m surveyed
Conventional Well Stick-Up = ~1.5' at installation (0.5 m)
Well completed with ~3' x ~3' cement pad, barrier posts, and locking steel well cap surrounding the casings above ground surface
Steel Centralizer Bolted on at Joint = 18.5' (5.6 m)

14" OD Steel Surface Casing Depth = 76' (23.2 m)

Steel Centralizer Bolted on at Joint = 118.4' (36.1 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Bentonite Grout (Grout Well DF) = 0'

17 1/2" Diameter Borehole Cemented to 76' (23.2 m)

Casing Explanation:

- Surface Casing — **13.5" ID; 14" OD Steel**
- Conventional Casing — **6.625" OD CertainTeed PVC**
- Conventional Screen — **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap — **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

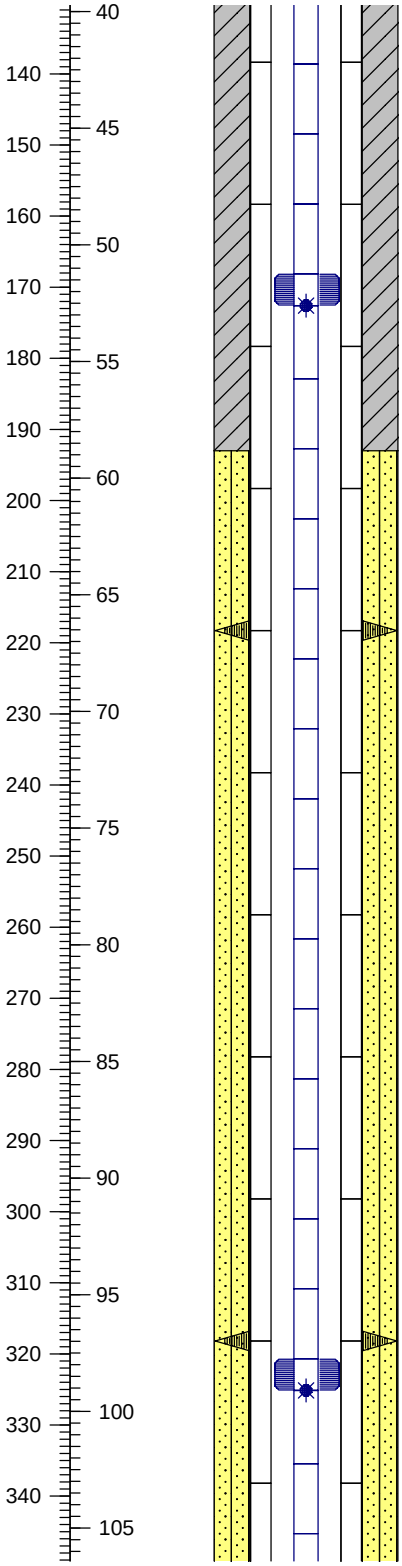
Annular Materials Explanation:

- 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



Stabilizing Packer Depth = 168.11'-172.58' (51.24-52.60 m)
MP Depth (with Filter Sock) = 172.58' (52.60 m)

Steel Centralizer Bolted on at Joint = 218.3' (66.5 m)

Steel Centralizer Bolted on at Joint = 318.2' (97.0 m)

Stabilizing Packer Depth = 320.67'-325.14' (97.74-99.10 m)
MP Depth (with Filter Sock) = 325.14' (99.10 m)

Top of 10/20 Sand/Bentonite Mix = 193' (58.8 m)

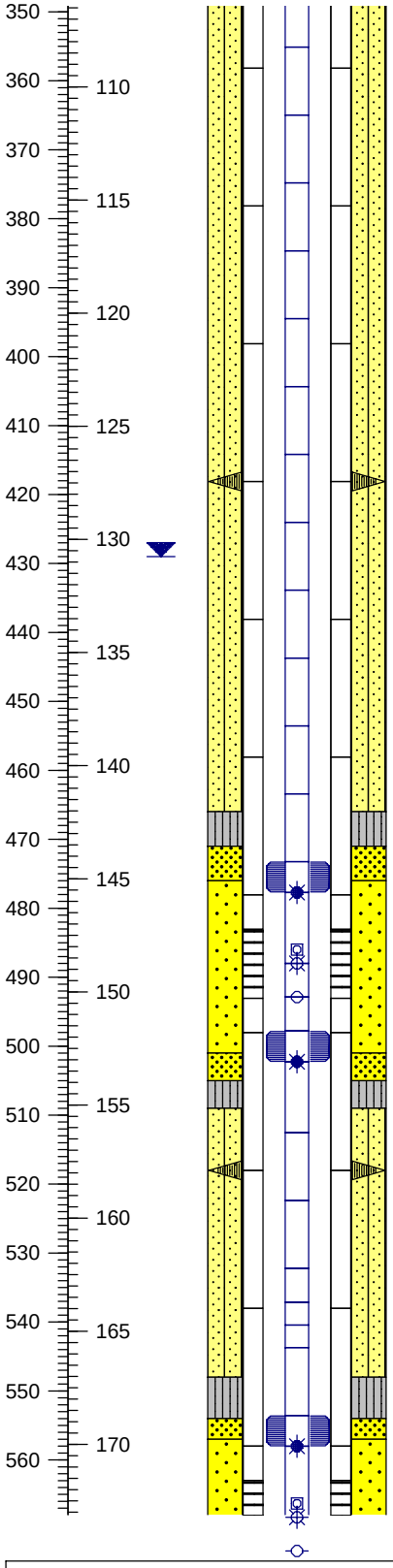
Casing Explanation:

- Surface Casing — **13.5" ID; 14" OD Steel**
- Conventional Casing — **6.625" OD CertainTeed PVC**
- Conventional Screen — **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap — **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Steel Centralizer Bolted on at Joint = 418.1' (127.4 m)

Water Table = 429' (130.8 m)(TOC - Measured 1/8/04 in conventional casing before Westbay® Casing Installation)

NOTE: depth-o-port is the official depth in meters calculated from actual peizometric levels at the port.

Packer Depth = 473.24-477.71' (144.89-146.25 m)
MP Depth (with Filter Sock) = 477.71' (146.25 m)
Top of PVC 0.020"-Slot Screen = 483.1' (147.2 m)(Slotted in middle 10' of 20' joint)

Magnetic Collar Depth = 486.00' (148.76 m)
Sampling MP Depth = 488.00' (149.37 m)
PP Depth = 492.87' (150.86 m)
Bottom of PVC 0.020"-Slot Screen = 493.1' (150.3 m)

Packer Depth = 497.79-502.26' (152.34-153.70 m)
MP Depth (with Filter Sock) = 502.44' (153.70 m)

Steel Centralizer Bolted on at Joint = 518.0' (157.9 m)

Packer Depth = 553.56-558.03' (169.27-170.63 m)
MP Depth (with Filter Sock) = 558.03' (170.63 m)
Top of PVC 0.020"-Slot Screen = 563.0' (171.6 m)(Slotted in middle 10' of 20' joint)
Magnetic Collar Depth = 566.32' (173.18 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Upper Bentonite Seal = 466' (142.0 m)
Top of Upper 30/70 Sand = 471' (143.6 m)
Top of 10/20 Sand = 476' (145.1 m)
Top of Lower 30/70 Sand = 501' (152.7 m)
Top of Lower Bentonite Seal = 504' (153.6 m)
Top of 10/20 Sand/Bentonite Mix = 509' (155.1 m)
Top of Upper Bentonite Seal = 548' (167.0 m)
Top of Upper 30/70 Sand = 554' (168.9 m)
Top of 10/20 Sand = 557' (169.8 m)
Volcanic Bedrock Depth = 560' (170.7 m)

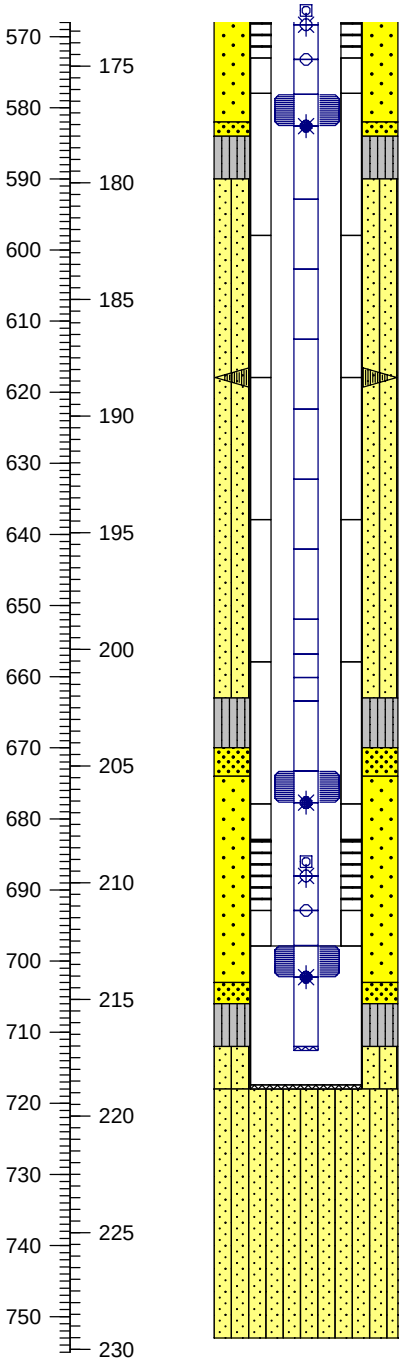
Casing Explanation:

- Surface Casing — **13.5" ID; 14" OD Steel**
- Conventional Casing — **6.625" OD CertainTeed PVC**
- Conventional Screen — **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap — **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Sampling MP Depth = 568.32' (173.79 m)
PP Depth = 573.19' (175.28 m)
Bottom of PVC 0.020"-Slot Screen = 573.0' (174.7 m)

Packer Depth = 578.11-582.58' (176.77-178.14 m)
MP Depth (with Filter Sock) = 582.58' (178.14 m)

Steel Centralizer Bolted on at Joint = 617.9' (188.3 m)

Packer Depth = 673.25-677.72' (205.71-207.07 m)
MP Depth (with Filter Sock) = 677.72' (207.07 m)
Top of PVC 0.020"-Slot Screen = 682.9' (208.1 m)(Slotted in middle 10' of 20' joint)

Magnetic Collar Depth = 686.01' (209.56 m)
Sampling MP Depth = 688.01' (210.17 m)
PP Depth = 692.89' (211.66 m)
Bottom of PVC 0.020"-Slot Screen = 692.9' (211.2 m)

Packer Depth = 697.80-702.27' (213.15-214.51 m)
MP Depth (with Filter Sock) = 702.27' (214.51 m)

Westbay® MP 55 Casing TD = 712.97' (217.5 m)

Conventional 6.625" CertainTeed SDR 17 PVC Well TD = 718.0' (218.8 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Lower 30/70 Sand = 582' (177.4 m)
Top of Lower Bentonite Seal = 584' (178.0 m)
Top of 10/20 Sand/Bentonite Mix = 590' (179.8 m)

Top of Upper Bentonite Seal = 663' (202.1 m)

Top of Upper 30/70 Sand = 670' (204.2 m)
Top of 10/20 Sand = 674' (205.4 m)

Top of Lower 30/70 Sand = 703' (214.3 m)
Top of Lower Bentonite Seal = 706' (215.2 m)
Top of 10/20 Sand/Bentonite Mix = 712' (217.0 m)

Top of Slough = 752' (229.2 m)(from Geophysical Log)
12 1/4" Borehole TD = 753' (229.5 m)

BOREHOLE LITHOLOGIC LOG

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

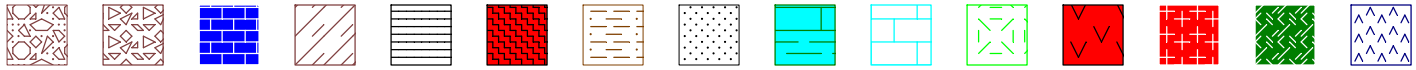
Location ID: **JER-1**

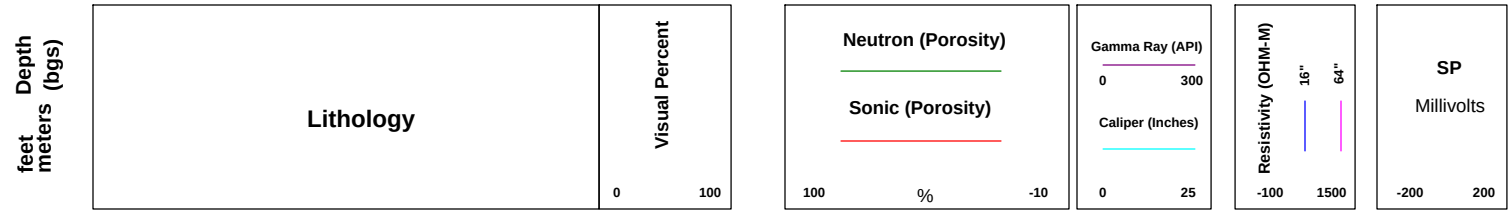
Site ID: **NASA-WSTF, Doña Ana County, NM**

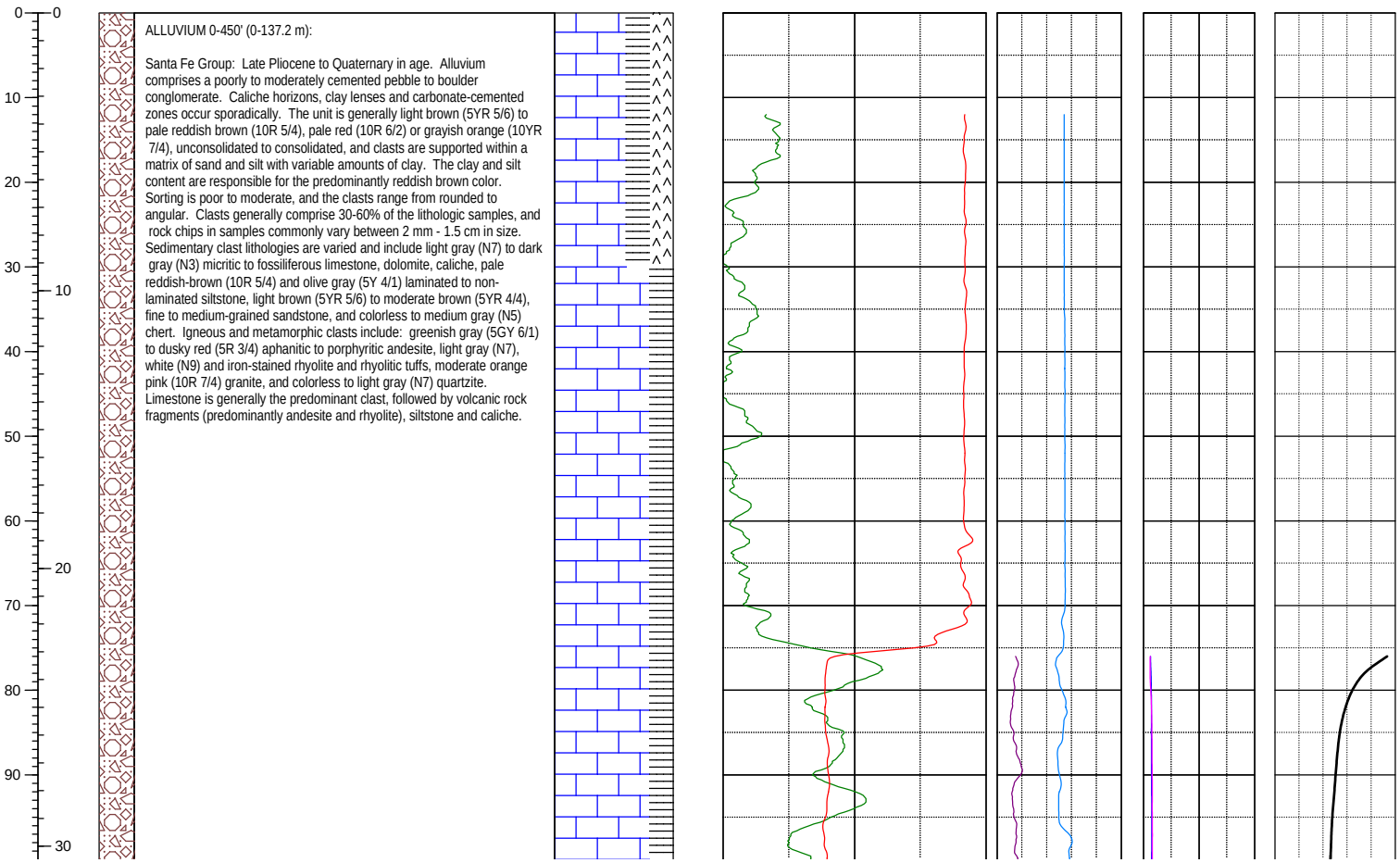
Township and Range: **SE 1/4 SE 1/4 SW 1/4 Section 29, T20S, R3E**
NM State Plane Coordinates (NAD 83): **170003.50 N 461730.73E**
Elevation (Brass Cap): **1370.73 m AMSL**
Total Depth of Borehole (bgs): **753' (229.5 m)**
Depth to Bedrock (bgs): **560' (170.7 m); Rhyolite**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **C. Brunson**

Depth to Groundwater: **429' (130.8 m) TOC (1/8/04)**
Surface Casing Depth and Diameter: **14" OD Steel set to 76' (23.2 m)**
Borehole Diameter: **12 1/4"**
Geologist Field Rep: **M. Canavan, G. Giles, L. Hunnicutt-Mack, J. Pearson,**
Dates Drilling Started and Completed: **10/29/03 to 11/4/03**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **A. Henderson**
Comments: **AMSL = Above Mean Sea Level TOC = Top of Casing**
Field Reps, continued: and M. Stepro

Explanation:

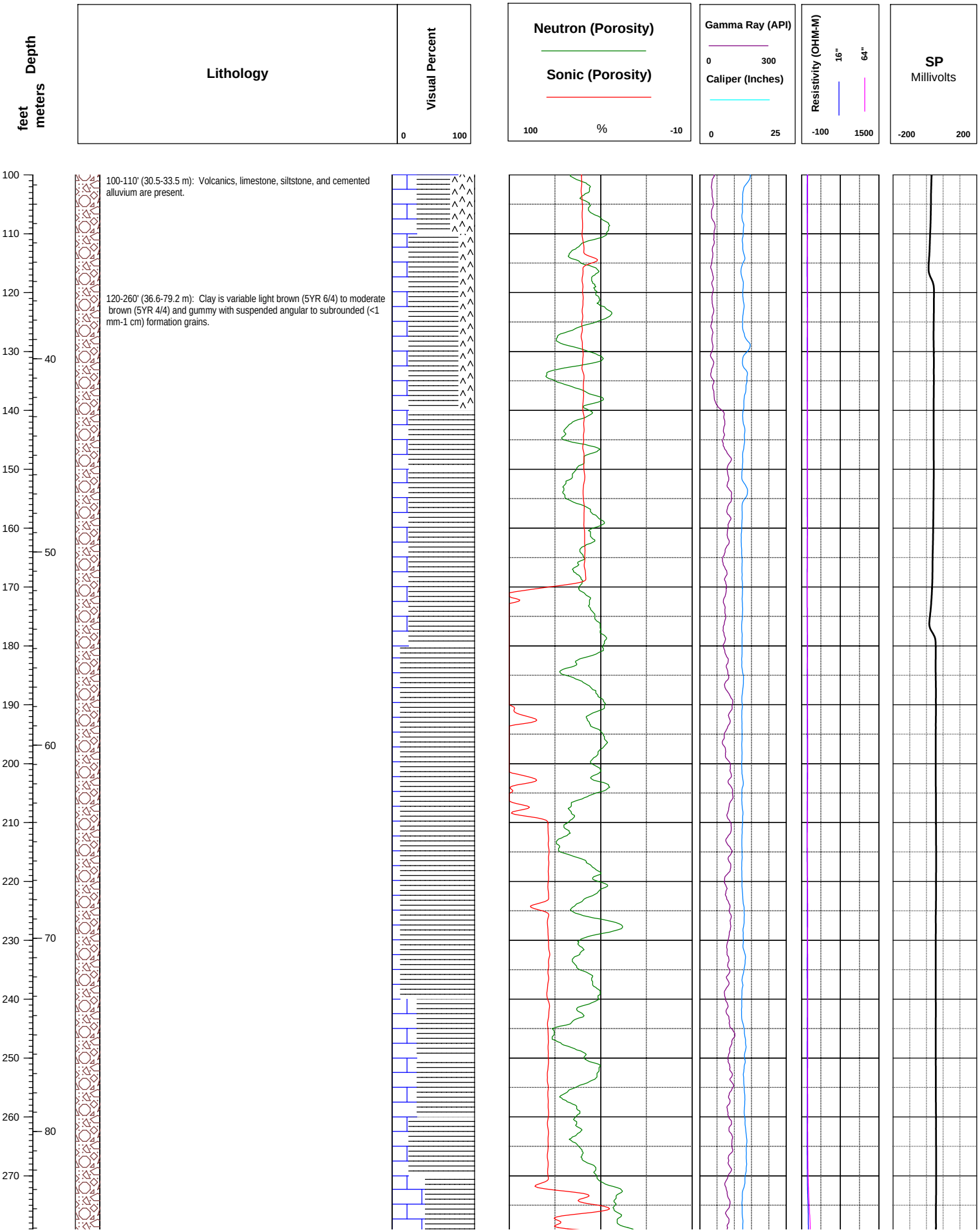


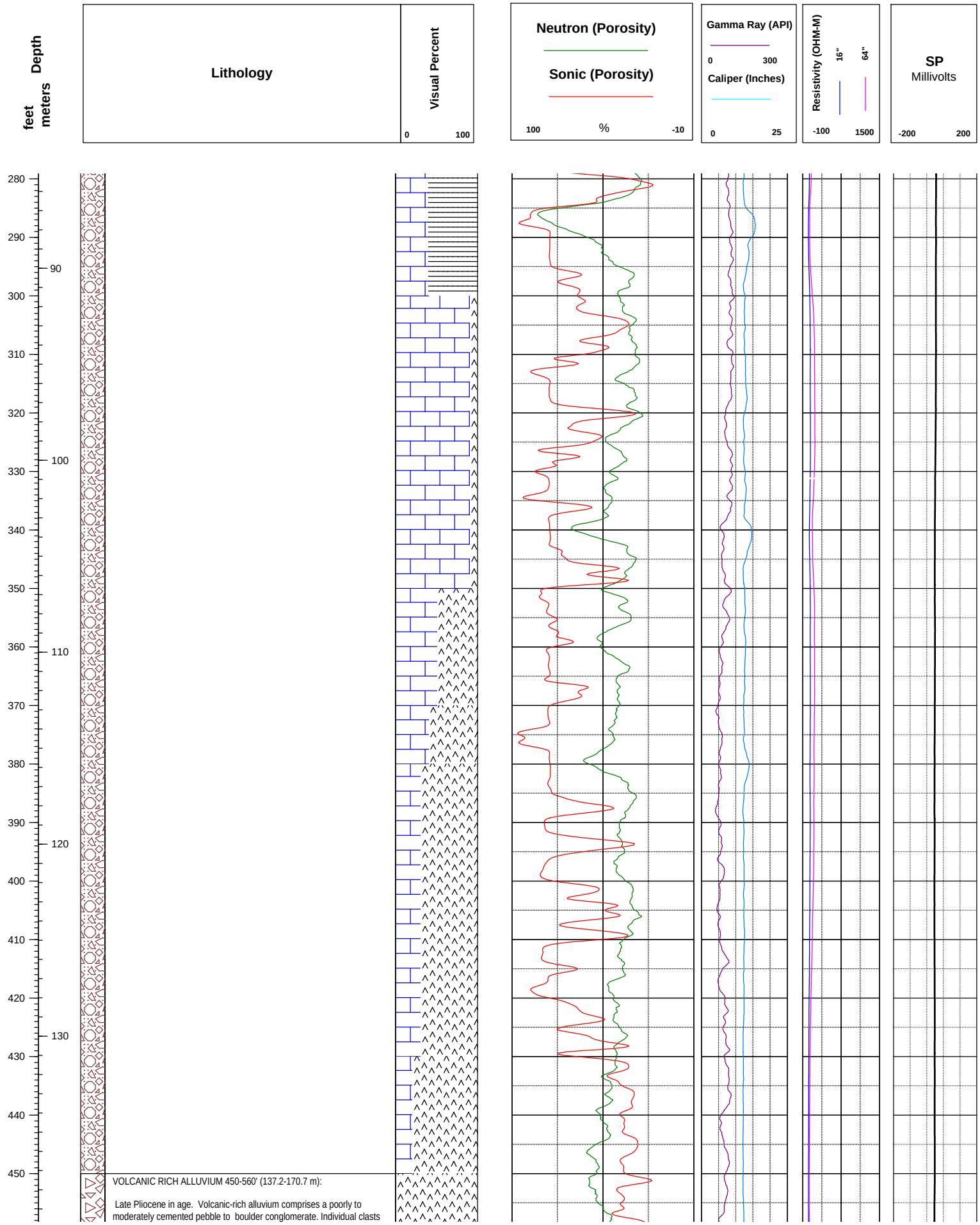




ALLUVIUM 0-450' (0-137.2 m):

Santa Fe Group: Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth
feet
meters
Lithology
Visual Percent
0
100
Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
100-110' (30.5-33.5 m): Volcanics, limestone, siltstone, and cemented alluvium are present.
120-260' (36.6-79.2 m): Clay is variable light brown (5YR 6/4) to moderate brown (5YR 4/4) and gummy with suspended angular to subrounded (<1 mm-1 cm) formation grains.
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
40
50
60
70
80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feet
meters
Lithology
Visual Percent
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Neutron (Porosity)
Sonic (Porosity)
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%
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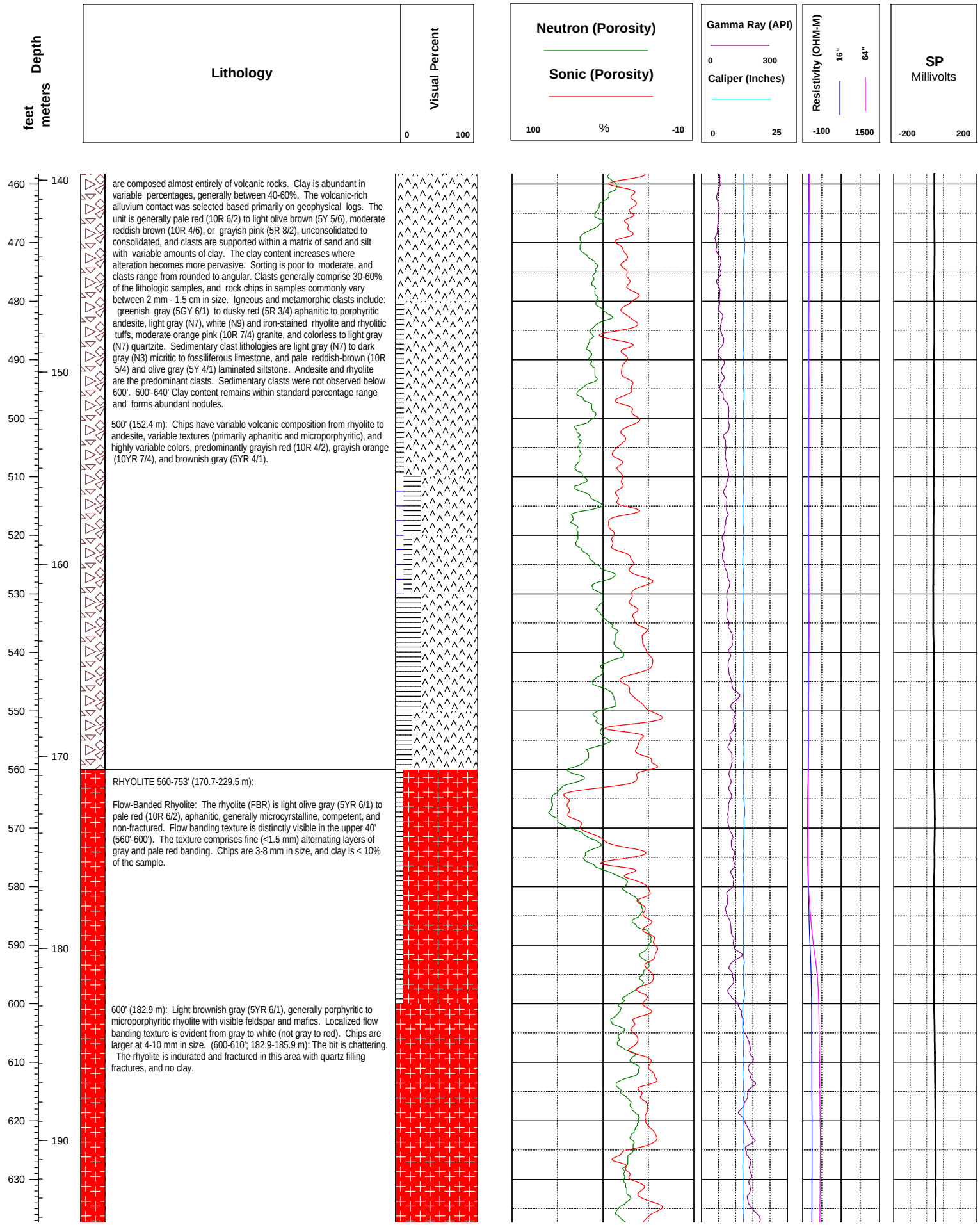
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
90
100
110
120
130
VOLCANIC RICH ALLUVIUM 450-560' (137.2-170.7 m):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts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feet
meters
Lithology
Visual Percent
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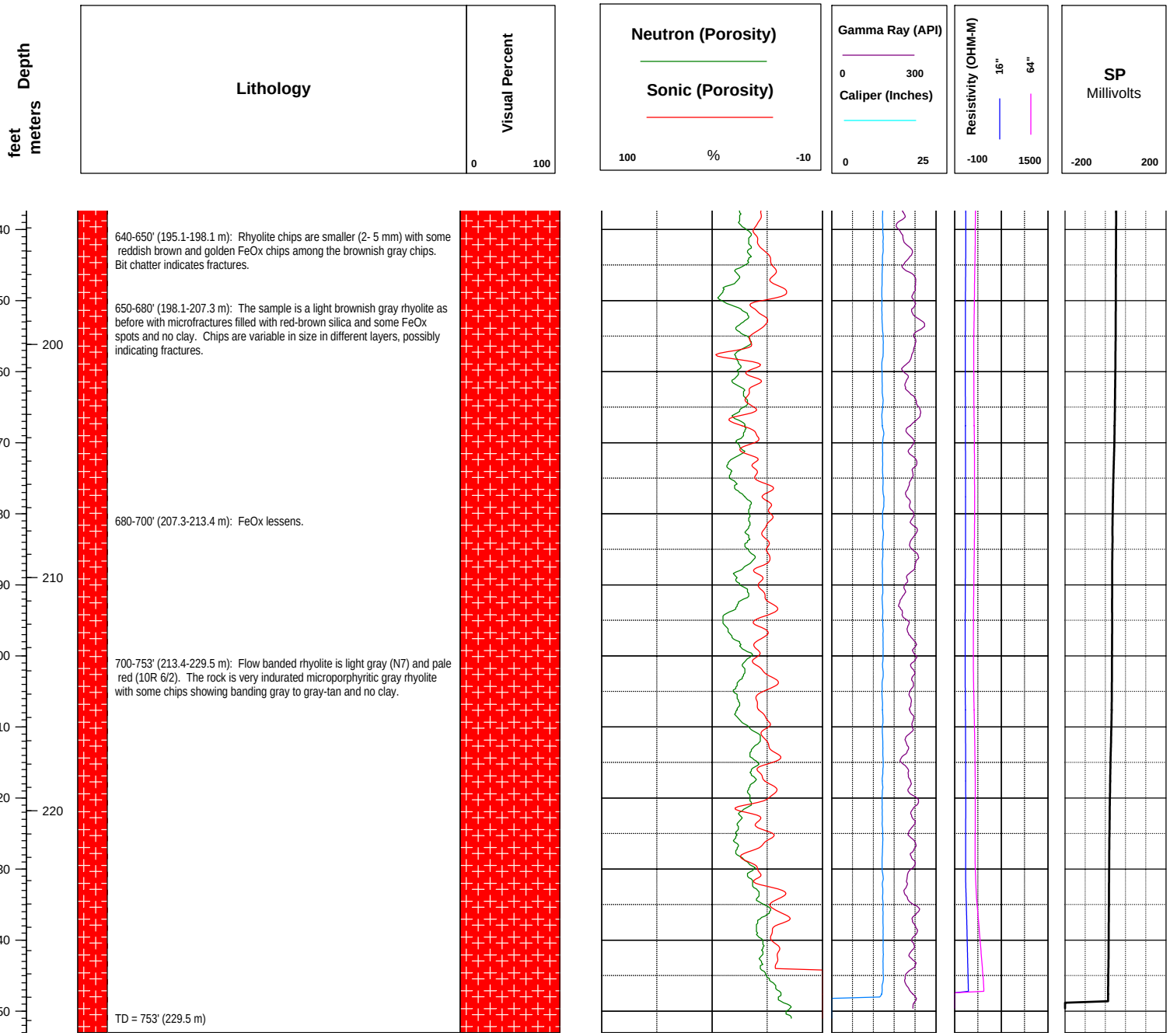
100
Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
460
470
480
490
500
510
520
530
540
550
560
570
580
590
600
610
620
630
140
150
160
170
180
190
are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages, generally between 40-60%. The volcanic-rich alluvium contact was selected based primarily on geophysical logs. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts. Sedimentary clasts were not observed below 600'. 600'-640' Clay content remains within standard percentage range and forms abundant nodules.
500' (152.4 m): Chips have variable volcanic composition from rhyolite to andesite, variable textures (primarily aphanitic and microporphyritic), and highly variable colors, predominantly grayish red (10R 4/2), grayish orange (10YR 7/4), and brownish gray (5YR 4/1).
RHYOLITE 560-753' (170.7-229.5 m):
Flow-Banded Rhyolite: The rhyolite (FBR) is light olive gray (5YR 6/1) to pale red (10R 6/2), aphanitic, generally microcyrstalline, competent, and non-fractured. Flow banding texture is distinctly visible in the upper 40' (560'-600'). The texture comprises fine (<1.5 mm) alternating layers of gray and pale red banding. Chips are 3-8 mm in size, and clay is < 10% of the sample.
600' (182.9 m): Light brownish gray (5YR 6/1), generally porphyritic to microporphyritic rhyolite with visible feldspar and mafics. Localized flow banding texture is evident from gray to white (not gray to red). Chips are larger at 4-10 mm in size. (600-610'; 182.9-185.9 m): The bit is chattering. The rhyolite is indurated and fractured in this area with quartz filling fractures, and no clay.


Depth
feet
meters
Lithology
Visual Percent
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Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
640
650
660
670
680
690
700
710
720
730
740
750
200
210
220
640-650' (195.1-198.1 m): Rhyolite chips are smaller (2- 5 mm) with some reddish brown and golden FeOx chips among the brownish gray chips. Bit chatter indicates fractures.
650-680' (198.1-207.3 m): The sample is a light brownish gray rhyolite as before with microfractures filled with red-brown silica and some FeOx spots and no clay. Chips are variable in size in different layers, possibly indicating fractures.
680-700' (207.3-213.4 m): FeOx lessens.
700-753' (213.4-229.5 m): Flow banded rhyolite is light gray (N7) and pale red (10R 6/2). The rock is very indurated microporphyritic gray rhyolite with some chips showing banding gray to gray-tan and no clay.
TD = 753' (229.5 m)

WELL COMPLETION DIAGRAM

RETROFIT WESTBAY® MONITORING WELL

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

Location ID: **JER-2**

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

Township and Range: **NE 1/4 SE 1/4 SE 1/4 Sec. 29, T20S, R3E**
NM State Plane Coordinates (NAD 83-meters): **170181.35N 462465.97E**
Elevation (Brass Cap): **1385.75 m**
Elevation (Top of Casing): **1386.19 m AMSL**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **C. Brunson**
Total Depth of Borehole (bgs): **756' (230.4 m)**
Borehole Diameter: **17 1/2" (0'-70'); 12 1/4" (70'-756')**
Depth to Bedrock (bgs): **394' (120.1 m); Rhyolite**
Depth to Groundwater: **476.66' (145.29 m) TOC (1/11/04)**
Total Depth Surface Casing (bgs): **69' (21.0 m)**
Diameter and Type Surface Casing: **13 1/2" ID; 14" OD Steel**
Date(s) Well Installed: **10/16/03 - 1/14/04**
Date(s) Well Developed: **CW = 12/7/03-12/23/03; WB = 3/23/04-3/29/04**

Field Representative(s): **Canavan, Giles, Hunnicutt-Mack, Pearson, Stepro**
Total Depth Well Casing(s) (bgs): **CW = 718.5' (219.0 m); WB = 713.47' (217.47 m)**
Type of Casing(s): **CW = CertainTeed SDR 17 PVC; WB = PVC**
Diameter Well Casing(s): **CW = 5.728" ID; 6.625" OD; WB = 2.25" ID; 2.9" OD**
Casing Schedule: **CW = Standard Dimension Ratio 17**
CW Screened Zone(s)(bgs): **503.5-513.5' (153.5-156.5 m); 583.5-593.5' (177.8-180.9 m); and 683.4-693.4' (208.3-211.3 m)**
WB Sampling Zone(s)(bgs): **508.18' (155.55 m); 586.86' (179.49 m); 688.51' (210.39 m)**
WB Packer Zone(s)(bgs): **497.89-517.97' (152.41-158.53 m); 581.49-596.65'; (177.85-182.48 m); and 678.22-698.30' (207.27-213.35 m)**
Comments: **AMSL = Above Mean Sea Level**
CW = Conventional Well WB = Westbay Well
bgs = below ground surface TOC = Top of Casing
CW casing was slotted in middle 10' of 20' blank casing

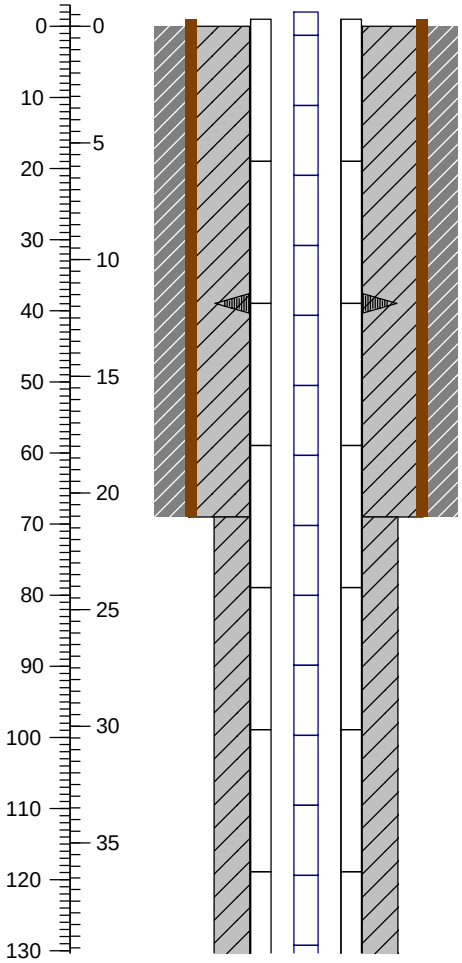
Casing Explanation:

- Surface Casing **14" Steel**
- Conventional Casing **6.625" OD CertainTeed PVC**
- Conventional Screen **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Westbay® Well Stick-Up = ~2' at installation (0.6 m); 0.45 m surveyed
Conventional Well Stick-Up = ~1' (0.3 m)
Well completed with ~3' x ~3' cement pad, barrier posts, and locking steel well cap surrounding the casings above ground surface

Steel Centralizer Bolted on at Joint = 38.96' (11.9 m)

14" OD Steel Surface Casing Depth = 69' (21.0 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of Bentonite Grout (Grout Well DF) = 0'

17 1/2" Diameter Borehole Cemented to 70' (21.3 m)

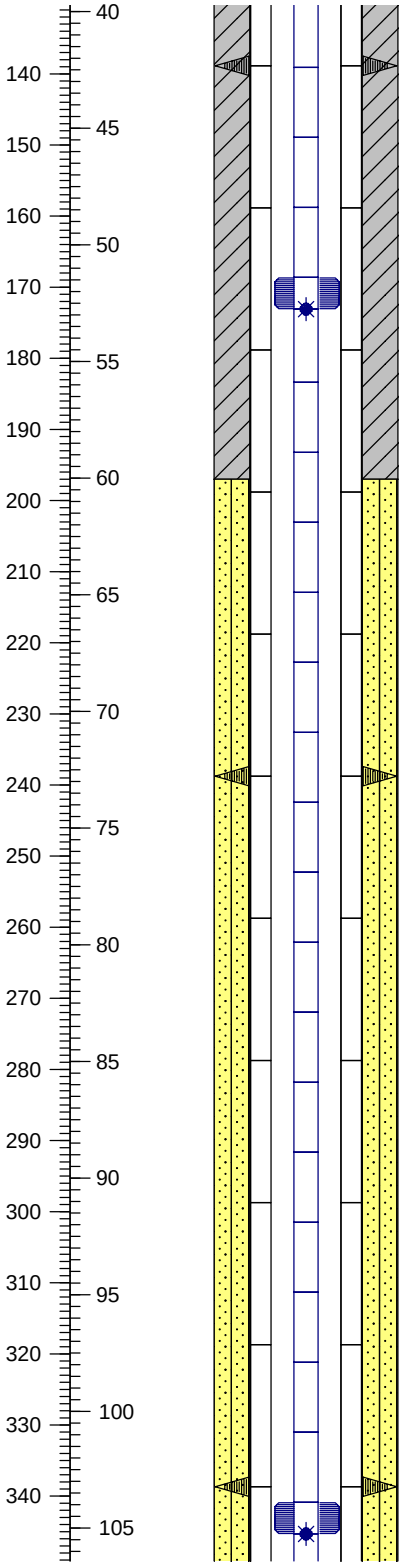
Casing Explanation:

- Surface Casing **14" Steel**
- Conventional Casing **6.625" OD CertainTeed PVC**
- Conventional Screen **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Steel Centralizer Bolted on at Joint = 138.86' (42.3 m)

Stabilizing Packer Depth = 168.61'-173.08' (51.4-52.8 m)
MP Depth (with Filter Sock) = 173.08' (52.8 m)

Steel Centralizer Bolted on at Joint = 238.76' (72.8 m)

Steel Centralizer Bolted on at Joint = 338.68' (103.2 m)
Stabilizing Packer Depth = 340.86'-345.33' (103.9-105.3 m)
MP Depth (with Filter Sock) = 345.33' (105.3 m)

Annular/Borehole Descriptions
All depths listed are bgs

Top of 10/20 Sand/Bentonite Mix = 197' (60.0 m)

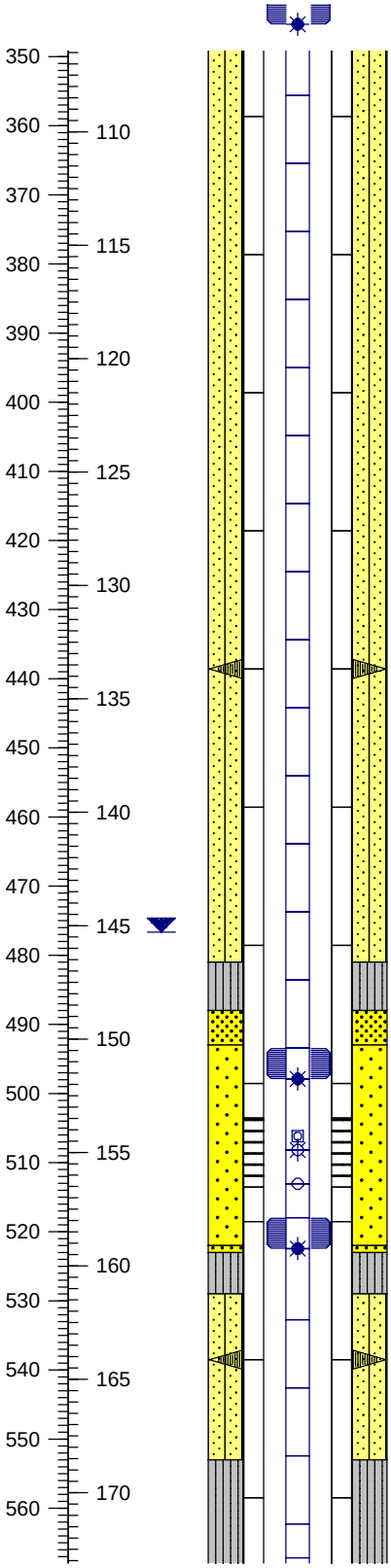
Casing Explanation:

- Surface Casing — **14" Steel**
- Conventional Casing — **6.625" OD CertainTeed PVC**
- Conventional Screen — **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap — **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Steel Centralizer Bolted on at Joint = 438.59' (133.7 m)

NOTE: depth-o-port is the official depth in meters calculated from actual peizometric levels at the port.

Water Table = 476.66' (145.28 m) (TOC - Measured 1/11/04 in conventional casing before Westbay® Casing Installation)

Packer Depth = 493.42-497.89' (151.05-152.41 m)

MP Depth (with Filter Sock) = 497.89' (152.41 m)

Top of 6.625" OD CertainTeed SDR 17 PVC 0.020"-Slot Screen = 503.54' (153.5 m)(Slotted in middle 10' of 20' joint)

Magnetic Collar Depth = 506.18' (154.04 m)

Sampling MP Depth = 508.18' (155.55 m)

PP Depth = 513.16' (157.04 m)

Bottom of 6.625" OD CertainTeed SDR 17 PVC 0.020"-Slot Screen = 513.54' (156.5 m)

Packer Depth = 517.97-522.44' (158.53-159.89 m)

MP Depth (with Filter Sock) = 522.44' (159.89 m)

Steel Centralizer Bolted on at Joint = 538.50' (164.1 m)

Annular/Borehole Descriptions
All depths listed are bgs

Volcanic Bedrock Depth = 394' (120.1 m)

Top of Upper Bentonite Seal = 481' (146.6 m)

Top of Upper 30/70 Sand = 488' (148.7 m)

Top of 10/20 Sand = 493' (150.3 m)

Top of Lower 30/70 Sand = 522' (159.1 m)

Top of Lower Bentonite Seal = 523' (159.4 m)

Top of 10/20 Sand/Bentonite Mix = 529' (161.2 m)

Top of Upper Bentonite Seal = 553' (168.6 m)

Top of Upper 30/70 Sand = 569'

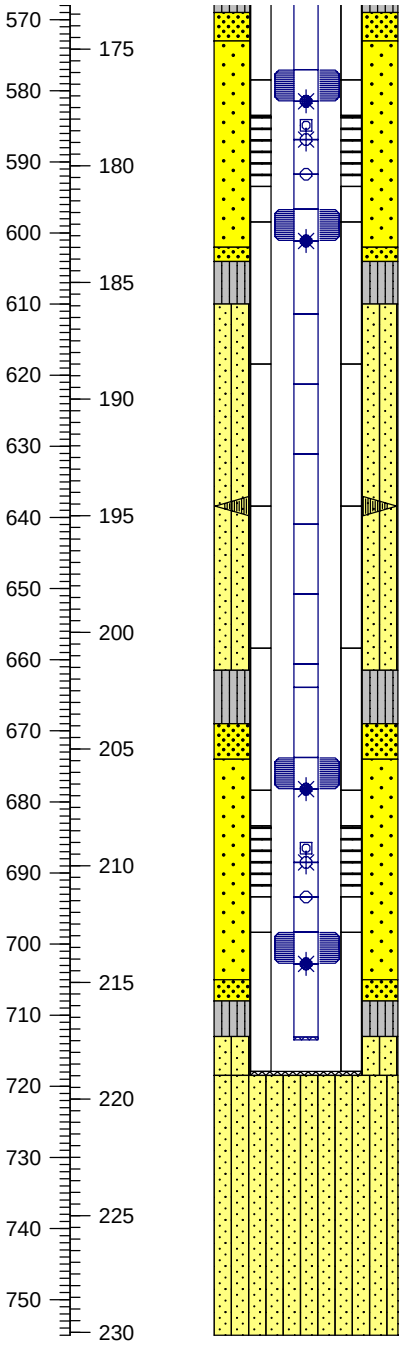
Casing Explanation:

- Surface Casing **14" Steel**
- Conventional Casing **6.625" OD CertainTeed PVC**
- Conventional Screen **6.625" OD CertainTeed PVC 0.020"-slot**
- Conventional End Cap **6.625" OD CertainTeed PVC**
- **Bolted Steel Centralizers**
- Water Table
- **2.25" ID MP55 Casing**
- **2.25" ID MP55 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

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)

Packer Depth = 577.02-581.49' (176.49-177.85 m)
MP Depth (with Filter Sock) = 581.49' (177.85 m)
Top of 6.625" OD CertainTeed SDR 17 PVC 0.020"-Slot Screen = 583.46' (177.8 m)(Slotted in middle 10' of 20' joint)
Magnetic Collar Depth = 584.86' (178.88 m)
Sampling MP Depth = 586.86' (179.49 m)
PP Depth = 591.74' (180.98 m)
Bottom of 6.625" OD CertainTeed SDR 17 PVC 0.020"-Slot Screen = 593.46' (180.9 m)
Packer Depth = 596.65-601.12' (182.48-183.84 m)
MP Depth (with Filter Sock) = 601.12' (183.84 m)

Steel Centralizer Bolted on at Joint = 638.40' (194.6 m)

Packer Depth = 673.75-678.22' (205.91-207.27 m)
MP Depth (with Filter Sock) = 678.22' (207.27 m)
Top of 6.625" OD CertainTeed SDR 17 PVC 0.020"-Slot Screen = 683.36' (208.3 m)(Slotted in middle 10' of 20' joint)
Magnetic Collar Depth = 686.51' (209.78 m)
Sampling MP Depth = 688.51' (210.39 m)
PP Depth = 693.39' (211.88 m)
Bottom of 6.625" OD CertainTeed SDR 17 PVC 0.020"-Slot Screen = 693.36' (211.3 m)
Packer Depth = 698.30-702.77' (213.35-214.71 m)
MP Depth (with Filter Sock) = 702.77' (214.71 m)

Westbay® MP 55 Casing TD = 713.47' (217.5 m)

Conventional 6.625" CertainTeed SDR 17 PVC Well TD = 718.46' (219.0 m)

Annular/Borehole Descriptions
All depths listed are bgs

(173.4 m)
Top of 10/20 Sand = 573' (174.7 m)

Top of Lower 30/70 Sand = 602' (183.5 m)
Top of Lower Bentonite Seal = 604' (184.1 m)
Top of 10/20 Sand/Bentonite Mix = 610' (185.9 m)

Top of Upper Bentonite Seal = 661.5' (201.6 m)
Top of Upper 30/70 Sand = 669' (203.9 m)
Top of 10/20 Sand = 674' (205.4 m)

Top of Lower 30/70 Sand = 705' (214.9 m)
Top of Lower Bentonite Seal = 708' (215.8 m)
Top of 10/20 Sand/Bentonite Mix = 713' (217.3 m)

Top of Slough = 750' (228.6 m)(from Geophysical Log)

BOREHOLE LITHOLOGIC LOG

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

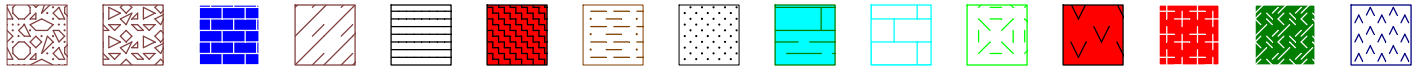
Location ID: **JER-2**

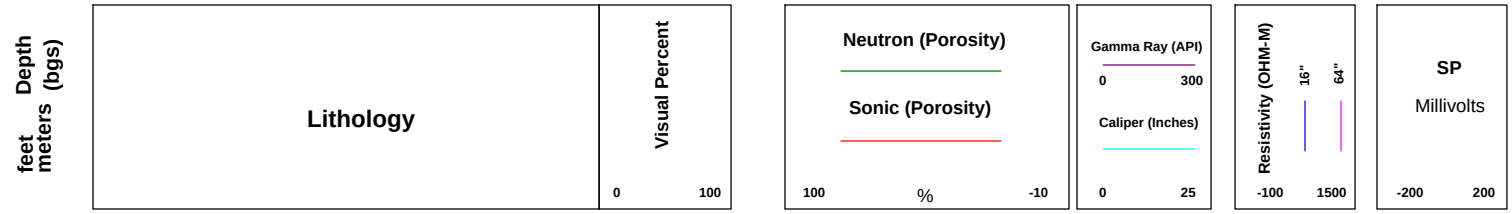
Site ID: **NASA-WSTF, Doña Ana County, NM**

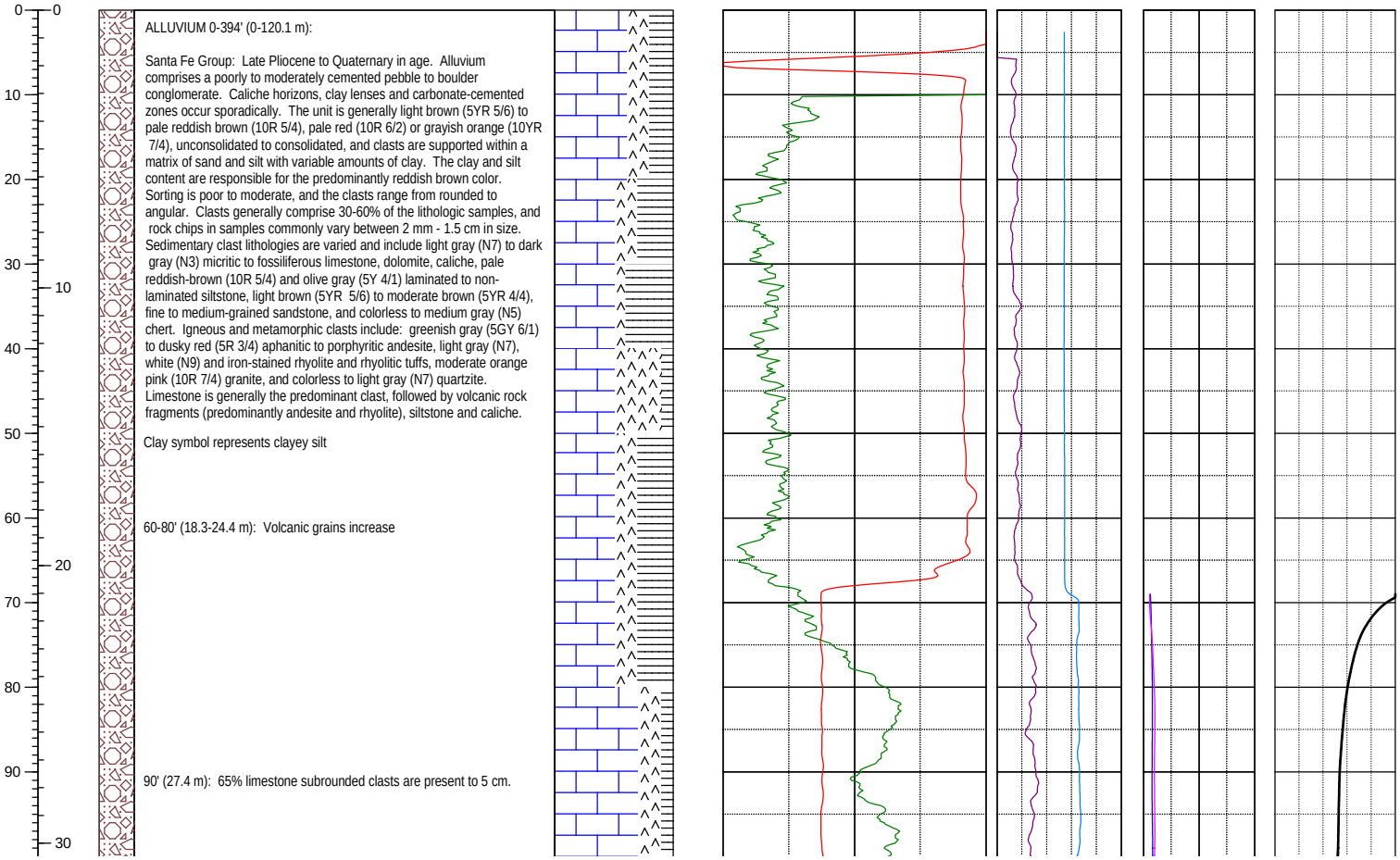
Township and Range: **NE 1/4 SE 1/4 SE 1/4 Sec 29, T20S, R3E**
NM State Plane Coordinates (NAD 83): **170181.35 N 462465.97 E**
Elevation (Brass Cap): **1385.75 m**
Total Depth of Borehole (bgs): **756' (230.4 m)**
Depth to Bedrock (bgs): **410' (125.0 m); Rhyolite**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Company**
Driller: **J. C. Brunson**

Depth to Groundwater: **476.66' (145.29 m) TOC (1/11/04)**
Surface Casing Depth and Diameter: **14" OD to 69' (21.0 m)**
Borehole Diameter: **12 1/4"**
Geologist Field Rep: **M. Canavan, G. Giles, L. Hunnicutt-Mack,**
Dates Drilling Started and Completed: **10/16/03 to 10/23/03**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **A. Henderson**
Comments: **Field Reps. continued: J. Pearson, and M. Stepro**

Explanation:







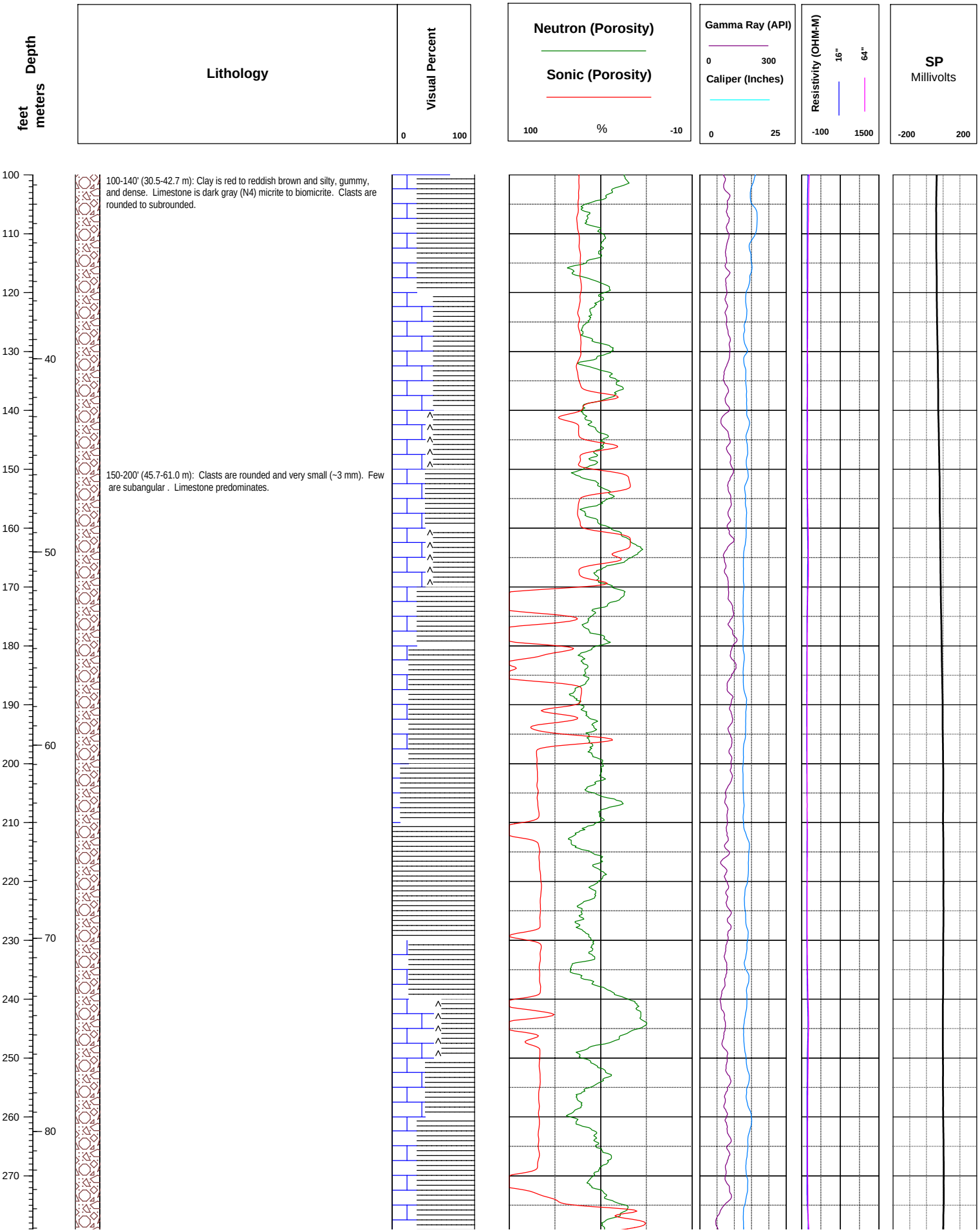
ALLUVIUM 0-394' (0-120.1 m):

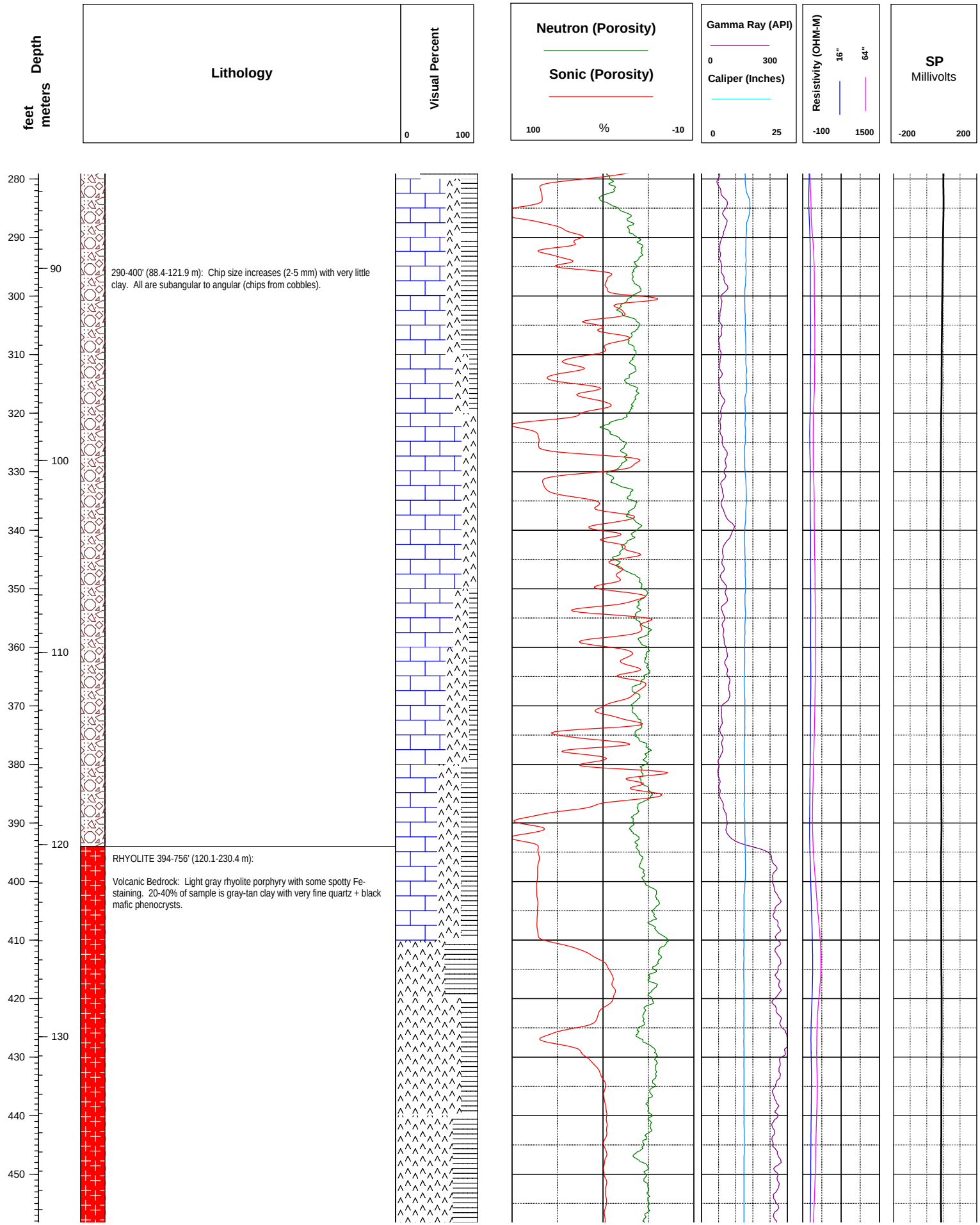
Santa Fe Group: Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

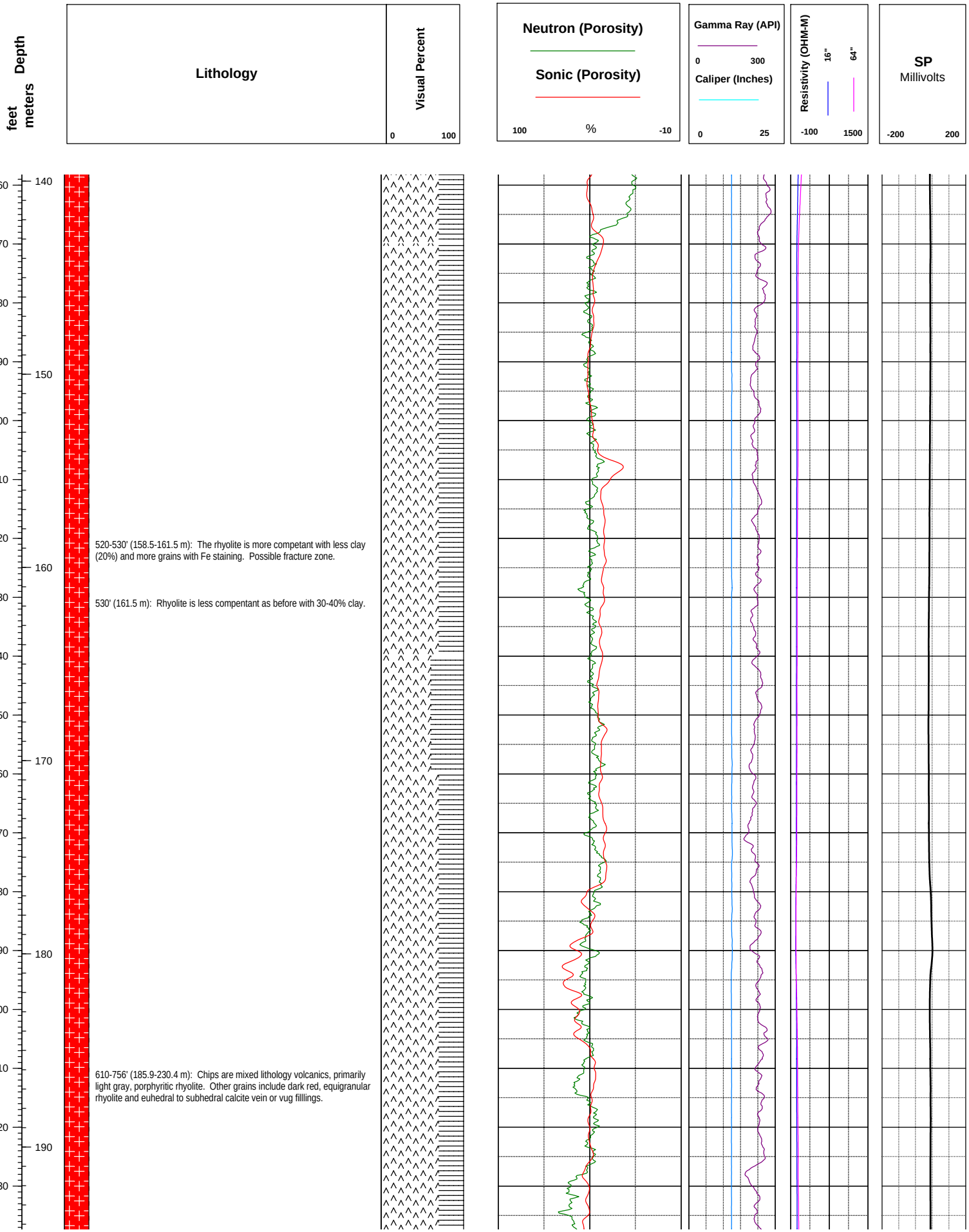
Clay symbol represents clayey silt

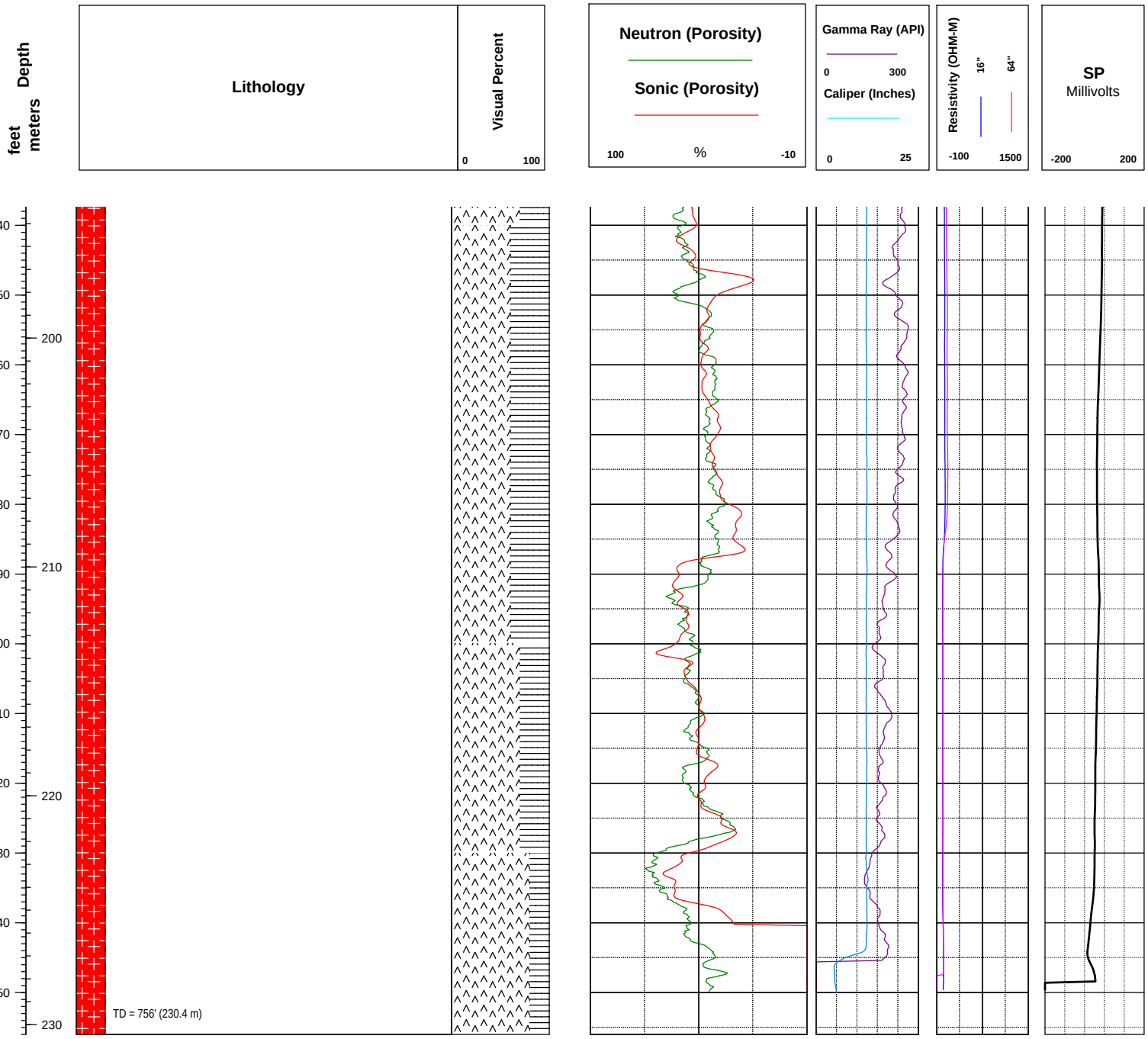
60-80' (18.3-24.4 m): Volcanic grains increase

90' (27.4 m): 65% limestone subrounded clasts are present to 5 cm.


Depth
feet
meters
Lithology
Visual Percent
0
100
Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
100-140' (30.5-42.7 m): Clay is red to reddish brown and silty, gummy, and dense. Limestone is dark gray (N4) micrite to biomicrite. Clasts are rounded to subrounded.
150-200' (45.7-61.0 m): Clasts are rounded and very small (~3 mm). Few are subangular . Limestone predominates.
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
40
50
60
70
80


Depth
feet
meters
Lithology
Visual Percent
0
100
Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
90
100
110
120
130
290-400' (88.4-121.9 m): Chip size increases (2-5 mm) with very little clay. All are subangular to angular (chips from cobbles).
RHYOLITE 394-756' (120.1-230.4 m):
Volcanic Bedrock: Light gray rhyolite porphyry with some spotty Fe-staining. 20-40% of sample is gray-tan clay with very fine quartz + black mafic phenocrysts.


Depth
feet
meters
Lithology
Visual Percent
0
100
Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
460
470
480
490
500
510
520
530
540
550
560
570
580
590
600
610
620
630
140
150
160
170
180
190
520-530' (158.5-161.5 m): The rhyolite is more competant with less clay (20%) and more grains with Fe staining. Possible fracture zone.
530' (161.5 m): Rhyolite is less compentant as before with 30-40% clay.
610-756' (185.9-230.4 m): Chips are mixed lithology volcanics, primarily light gray, porphyritic rhyolite. Other grains include dark red, equigranular rhyolite and euhedral to subhedral calcite vein or vug filllings.


Depth
feet
meters
Lithology
Visual Percent
0
100
Neutron (Porosity)
Sonic (Porosity)
100
%
-10
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
-100
1500
SP
Millivolts
-200
200
640
650
660
670
680
690
700
710
720
730
740
750
200
210
220
230
TD = 756' (230.4 m)