National Aeronautics and
Space Administration

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

January 30, 2024

Reply to Attn of: RE-24-022

New Mexico Environment Department
Attn: Ricardo Maestas, Acting Bureau Chief
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: Response to Approval with Modifications of the NASA WSTF Work Plan for Abandonment of NASA WSTF Well BLM-1-435 and Replacement with Monitoring Well 600C-003-GW

NASA submitted the Work Plan (WP) for Abandonment of NASA WSTF Well BLM-1-435 and Replacement with Monitoring Well 600C-003-GW on April 27, 2023. On November 27, 2023, NMED provided an approval with modifications and directed NASA to address two comments and submit the revised WP by January 31, 2024.

Enclosure 1 includes a printed response table addressing NMED's comments. Enclosure 2 includes printed replacement pages for the revised WP, and Enclosure 3 includes a CD-ROM with electronic copies of the response table, final WP, and a redlined-strikeout version of the WP.

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.

If you have any questions or comments concerning this submittal, please contact Antonette Doherty of my staff at 575-202-5406.

TIMOTHY DAVIS

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Date: 2024.01.30 13:36:54 -07'00'

Timothy J. Davis
Chief, Environmental Office

3 Enclosures

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

Work Plan for Abandonment of NASA WSTF Well BLM-1-435 and Replacement with Monitoring Well 600C-003-GW

Introduction and Background	In the February 21, 2022, *Approval with Modifications Periodic Monitoring Report Second Quarter 2021*, the New Mexico Environment Department (NMED) expressed concern about declining water levels at White Sands Test Facility (WSTF) (Figure 1) groundwater monitoring wells 300-C-128, 400-C-118, 400-C-143, BLM-1-435, and PL-3-453 (NMED, 2022a). NMED indicated that NASA could continue to evaluate these wells. In the April 29, 2022, WSTF Groundwater Monitoring Plan (GMP) update for 2022, NASA indicated that well BLM-1-435 would be plugged due to continued groundwater level drop and inability to sufficiently sample the well (NASA, 2022, pg. 20). On October 31, 2022, NMED approved the GMP with modifications (NMED, 2022b) and indicated that well BLM-1-435 must be replaced and a work plan submitted for the plugging of BLM-1-435 and subsequent drilling of the replacement well (NMED, 2022b, pg. 2). This abbreviated work plan was developed in accordance with the Hazardous Waste Permit (Permit, 2023), Section 6.2, and incorporates requirements specified in Section 5.3 of the Permit. The well is located within the southern Jornada del Muerto Basin alluvial aquifer northeast of the WSTF Plume Front Treatment System (PFTS; Figure 2).
Primary Purpose	NASA proposes to plug and abandon existing monitoring well BLM-1-435 and install replacement monitoring well 600C-003-GW adjacent to the abandoned well. Well 600C-003-GW is expected to be completed as a single zone conventional monitoring well (Figure 3). Target screened interval in the replacement well approximately mirror monitoring zones within current monitoring well BLM-1-435 at 435 ft bgs. The placement of the screened intervals within the well will be refined during drilling and/or follow-on borehole logging.
Plugging and Abandonment of Well BLM-1-435	NASA will plug and abandon existing groundwater monitoring well BLM-1-435 in accordance with WSTF Hazardous Waste Permit (Permit) Section 5.3 (NMED, 2023, pg. 78) and 19.27.4.30 New Mexico Administrative Code (NMAC). Well BLM-1-435, completed in November 1987, is equipped with 8-inch (in.) steel surface casing that extends to a depth of 32 feet (ft) below ground surface (bgs). The 8-in. diameter borehole extends from surface casing to a total depth of 500 ft bgs. The conventional portion of the monitoring well consists of 4-in. stainless-steel casing that extends from ground surface to 451 ft bgs (Figure 4). NASA proposes to plug the well by lowering tremie pipe to the bottom of the open borehole. Portland cement grout will be emplaced using a tremie pipe upward from the bottom of the borehole to the ground surface. Any discharge of fluids will be managed in accordance with the Waste Management and Characterization Section. The steel surface casing will be cut at least 6 in. bgs and a concrete cap will be emplaced over the borehole. A brass cap will be embedded in the concrete surface completion and all pertinent well information will be stamped into the brass cap. NASA will prepare a well plugging plan for well BLM-1-435 and submit the plan to the New Mexico Office of the State Engineer (NMOSE) in accordance with 19.27.4.30 NMAC. The well drilling contractor will provide NASA and NMOSE with the

	required completed well plugging record. NASA will in turn provide NMED with a copy of the completed well plugging record.
Hydrogeologic and Geochemical Objectives	The primary objective of proposed monitoring well 600C-003-GW is to provide groundwater chemical analytical data to supplement data previously obtained from well BLM-1-435, which is identified as a Main Plume monitoring well in the GMP (NASA, 2022, pg. 82). Analytical results from 600C-003-GW will also be used to supplement data collected from other wells within the WSTF groundwater monitoring system, particularly those wells in close proximity such as BLM-9-419, PFE-5, and BLM-8-418. Additional objectives are to further characterize hydrostratigraphy at the proposed location and monitor groundwater elevation.
Conceptual Model	The original location of well BLM-1-435 was chosen to support characterization of the WSTF groundwater contaminant plume (Figure 5). Replacement well 600C-003-GW will continue to serve that role in the WSTF groundwater assessment program and inform the conceptual site model. In addition to providing analytical data concerning the main plume of the WSTF groundwater plume, well 600C-003-GW will also provide water level data that will be used to inform hydrogeologic decisions. Information collected from the new well will be incorporated into the WSTF conceptual groundwater model when appropriate. Existing well BLM-1-435 was completed within the Santa Fe Alluvium; however, the borehole penetrated andesitic bedrock at approximately 457 ft bgs (Figure 6). All monitoring zones are completed within alluvium, which is generally characterized as an unconsolidated to semi-consolidated, poorly to moderately sorted, pebbly polygenetic conglomerate. Limestone and igneous clasts in the conglomerate originate from the San Andres Mountains, located to the east of WSTF. Clay lenses are also present and likely represent fine grain sediments of the distal portion of buried coalescent alluvial fan deposits. As early as April 1998, well BLM-1-435 camera logging indicated a potential crack in the stainless-steel casing at a joint located at 421 ft below the top of casing and above the screened interval at 435 – 445 ft bgs (Figure 4). To ensure that sampling activities specifically targeted the screened interval, an inflatable packer was installed approximately 2 ft above the top of the screen to isolate the screen and dedicated low-flow bladder pump from the water column above the screened interval. On March 6, 2006, technicians noted extremely slow recovery rates in the well's screened interval. By April 23, 2020, field sampling records indicated that the well would no longer produce enough water to ensure that all stagnant water was purged from the dedicated bladder pump and pump tubing, preventing the monitoring and stabilization of indicator parameters prior to sample collection. In July 2020, NASA evaluated well BLM-1-435 and determined that sampling from the existing screen was not feasible. Because there are no viable options for reconfiguration, the well must be abandoned and replaced with a monitoring well capable of providing representative groundwater samples at or near this location in the aquifer. Replacement well 600C-003-GW will be located approximately 30 ft to the south of existing well BLM-1-435. Well 600C-003-GW will be completed in the alluvial basin-fill and is expected to have similar lithology to that encountered at comparable depths in the existing well. Aquifer conditions at the proposed location are expected to be unconfined. The groundwater flow direction in the area is generally west-southwest.

	Based on recent measurements at well BLM-1-435, NASA expects to encounter groundwater at approximately 409 ft bgs (Figure 5).
Drilling Approach	NASA will drill and install monitoring well 600C-003-GW in accordance with the requirements of Permit Section 5.1 and 5.2 (NMED, 2023, pg. 71). NASA expects to advance a minimum 12-in. borehole to the top of bedrock at approximately 457 ft bgs. NASA is considering two options for installation of the well. The preferred method is air rotary casing advance (ARCA), and the alternative method is mud rotary. The final determination of drilling method will be made following consultation with the knowledgeable drilling contractors during the competitive procurement process required by the Federal Acquisition Regulations (48 Code of Federal Regulations [CFR] Part 6). The advantages and disadvantages of both options are presented below. **Air Rotary Casing Advance** The ARCA method drives casing 1 or 2 ft above the drill bit, thereby casing off the borehole as it is drilled. The method stabilizes the formation and prevents collapse of the borehole walls through the installation of casing while drilling. Borehole diameters are necessarily greater for this method and start at 20 to 22 in. from the surface. The borehole and casing sizes are telescoped down as the borehole is advanced over regular intervals to 18 in., 16 in., and finally 14 in. to the total depth of the borehole (diameters are approximate and may vary between drilling contractors). The ARCA method requires only minor use of polymeric or bentonite additives to aid in lifting cuttings out of the borehole. Following well casing installation, the drive casing is removed as the well is completed. Advantages include: • Stabilization of the borehole • No drilling mud is required so development of individual monitoring zones is more likely to be successful • Lithologic cuttings are of better quality for characterization of the alluvium • Formation water can be identified and sampled for characterization Disadvantages of the ARCA method include: • Because steel casing remains in the borehole until well installation, geophysical logging of the borehole is limited to gamma ray and neutron porosity, making it difficult to identify formation changes and productive zones • The method has proved costly in the past, especially if casing becomes stuck and cannot be removed except by cutting Geophysical logging of a borehole that is drilled entirely in alluvium is not considered essential, especially since it is possible to quantify water production during ARCA drilling. The ARCA drilling method has become common and many drilling contractors are installing wells successfully using the method. The level of experience

Drilling Approach (cont.)	among contractors has increased and should preclude problems similar to those NASA encountered using this method while drilling well PL-11 in 2016. If the ARCA method of drilling is used, air supplied by an air compressor will serve as the drilling fluid. Air will be directed through an in-line filter system to prevent potential introduction of contaminants, such as entrained residual oils, into the borehole. The filter system will be inspected regularly by the drilling contractor to ensure the system is functioning properly. A cyclone separator or similar air containment/dust-suppression system is typically used to funnel the cuttings to one location instead of allowing the cuttings to discharge uncontrolled from the borehole. Particular attention will be paid to the management of cuttings. Dust will be minimized as much as possible with a clean water mist at the cyclone, if necessary. **Mud Rotary Drilling** Mud rotary is a standard drilling method used when penetrating alluvium or unconsolidated formation. Advantages include: • Relatively rapid and efficient drilling and installation of the borehole (reduced cost) • A full suite of geophysical logs can be run in a mud filled borehole • The borehole diameter is smaller at 16 to 17 in. • Drilling mud has been effective in stabilizing deep boreholes drilled in alluvium at WSTF • Monitoring zones have been successfully developed in mud drilled wells at WSTF Disadvantages to the mud rotary method are as follows: • The bentonite drilling mud has the potential to adversely affect the hydrologic properties and geochemistry of the aquifer immediately surrounding the borehole • Past experience at WSTF indicates it is difficult and time-consuming to develop monitoring zones in a mud-drilled well • Drilling fluid waste management and disposal costs can be substantially higher than those for ARCA-installed wells If the planned ARCA drilling method is not successful, and mud rotary is required to install the borehole, the appropriate mud dispersion agents will be utilized to aid in the removal of residual drilling mud during borehole/well development. Mud rotary drilling will only be considered as a last resort to advance the borehole and the decision to switch to this method will only occur with the approval of the NMED.
Groundwater Occurrence and Detection	Data from existing well BLM-1-435 indicates regional groundwater is expected to occur at a depth of approximately 409 ft bgs. Perched groundwater is not expected in alluvium. Methods for groundwater detection may include drilling observations, water level measurements, or borehole geophysics. The first identification of groundwater

	will likely be apparent if the ARCA method is used to install the borehole. However, the mud rotary method may mask the presence of water in the formation.
Lithological Sampling	If the borehole is drilled using ARCA, lithological samples will be collected from the cyclone discharge at a minimum of 10-ft intervals. Drill cuttings may be collected using a stainless-steel handheld screen placed in the flow of the discharged cuttings or other methods selected by the field geologist, as appropriate. Cuttings samples will be archived in chip trays for future reference. If the borehole is installed using the mud rotary method, lithologic samples will be collected directly from the drilling mud discharge location, or from the solids-separation unit (shaker table), if utilized, at a minimum of 10-ft intervals. Drill cuttings may be collected using a stainless-steel handheld screen placed in the flow of the discharged mud, by placing a shovel in the mud discharge trough to intercept cuttings, or other methods selected by the field geologist, as appropriate. Cuttings samples will be archived for future reference.
Groundwater Screening and Characterization Sampling	Based on groundwater monitoring performed at BLM-1-435, the aquifer at the proposed 600C-003-GW location is expected to be within the WSTF groundwater contaminant plume. For verification purposes and potential waste characterization, groundwater screening samples will be attempted during drilling immediately upon intercepting the water table and at least every 100 ft thereafter. Chemical analytical results from screening samples collected will be used to support the identification of potential monitoring zones, as applicable. Screening samples will be analyzed for volatile organic compounds (VOC) by the current revision of SW-846 Method 8260, semi-volatile organic compounds (SVOC) by the current revision of SW-846 Method 8270C, and N-nitrosodimethylamine (NDMA) by Modified Environmental Protection Agency (EPA) Method 607M or an acceptable low-level analytical method. Groundwater samples will be collected, if possible, utilizing a decontaminated non-dedicated bailer. If a bailer is not feasible, grab samples may be attempted through the cyclone at the surface discharge point. All samples will be managed in accordance with the WSTF GMP (NASA, 2022, pp. 36-38). Following well development and sampling system installation, groundwater characterization samples will be collected from each of the sampling zone(s) of the completed wells. Samples will be collected for the analysis of VOCs by the current revision of SW-846 Method 8260, SVOCs by the current revision of SW-846 Method 8270C, NDMA by Modified EPA Method 607M, or WSTF's current low-level analytical method, and a variety of metals by the most effective laboratory-selected analytical method. Samples will be collected and managed in accordance with the GMP (NASA, 2022).
Geophysical Logging	The potential use of the ARCA drilling method may allow for effective geophysical logging of the 600C-003-GW borehole. If the borehole remains open during and after drilling, a complete suite of open borehole geophysical logs would be attempted as a single event to aid in the selection of the potential monitoring zone. Open borehole logging would be performed by a qualified geophysical contractor and would include gamma, neutron porosity, formation resistivity, spontaneous potential, optical imaging, and caliper/borehole deviation logs. The use of drive casing with the ARCA and dual rotary drilling methods will preclude geophysical logging in the 600C-003-GW borehole. Geophysical logging would be

	performed if the borehole is deemed competent enough to remain open with the drive casing removed.
Well Completion	Well 600C-003-GW will be constructed in accordance with Permit Section 5.2 (NMED, 2023, pg. 71), with nominal 5-in. Schedule 80 PVC casing and screen, which allows for the use of a 4-in. diameter downhole pump for well development. A single monitoring zone is planned in the well to replace the zone previously monitored by well BLM-1-435. Because recent water levels under unconfined aquifer conditions at BLM-1-435 are reported at approximately 409 ft bgs and the screened zone was positioned between 435 – 445 with limited production, replacement well 600C-003-GW could potentially yield water from above the former BLM-1-435 screen. As a result, the screened interval is anticipated to be located at a depth between 420 – 460 ft bgs. The location of the screened interval for replacement monitoring well 600C-003-GW will target a depth in the unconfined aquifer that is expected to provide sufficient groundwater for development and sampling activities for a period of at least ten years. A 10-foot length of 0.020-in. slotted Schedule 80 PVC screen will be positioned at a depth indicated as a favorable monitoring zone in accordance with field screening of borehole lithology and borehole geophysical logs, if performed. The annular seal for the screened sampling zones will be comprised of bentonite chips or pellets. The general well construction configuration is presented in Figure 3 and is subject to change dependent on conditions encountered in the field or by recommendations made by the drilling contractor. NASA will prepare a final well construction diagram for the well for NMED review and approval immediately prior to well installation. Annular materials will be emplaced using a 1 to 2-in. inner diameter tremie pipe. A 10/20 or similar silica sand filter pack will be placed to a height of 2 ft above and below the monitoring screen. Three feet of fine silica sand, such as 20/40 or similar, will be used to grade from the sand pack to a 10-ft bentonite seal composed of hydrated bentonite chips or pellets. The interval above the upper screen from the top of the hydrated bentonite chip seal to 10 ft below ground surface will be comprised of bentonite grout with at least 20% solids. The upper 10 ft of the borehole and well pad will be completed with Type II Portland cement. Figure 3 provides a diagram of the preliminary well design with annular materials.
Well Development	The well will be developed in accordance with the requirements of Section 5.2 of the Permit (NMED, 2023, pg. 71). Drilling contractor personnel will operate equipment used to develop the well under the supervision of Environmental contractor personnel. It is anticipated that initial development for the sampling zone may consist of jetting (to facilitate mud removal following mud rotary), mechanical bailing, swabbing, and pumping using a submersible pump. During development activities, Environmental contractor personnel will monitor discharged development water for parameters that will include pH, specific conductance (conductivity), temperature, and turbidity. Well development will be considered complete when measured water quality parameters are relatively stable (vary less than 10%) and turbidity is below 5 nephelometric turbidity units. Following well development, NASA expects to install a dedicated low-flow bladder pump the PVC well casing, with pump intakes located at or slightly above the midpoint of the screened interval.

Hydraulic Testing and Groundwater Sampling	Hydraulic testing will be considered during the development of monitoring well 600C-003-GW. Additional information such as drawdown and specific capacity will be recorded if this testing is conducted. Groundwater sampling following installation and development of the well will be performed using dedicated low-flow bladder pumps. Groundwater samples will be collected and managed as described in the WSTF GMP (NASA, 2022, pg. 34-38).
Investigation-Derived Waste Characterization and Management	In accordance with the NASA WSTF Hazardous Waste Permit, Section 4.3.10 (NMED, 2023), a discussion of IDW generated is provided in this work plan. All IDW will be properly managed and disposed of in accordance with NASA procedures and state and federal regulations. Information related to the characterization, management, and disposition of waste generated during this project is provided in this section. Waste characterization is conducted in accordance with Section 4.3.10 (Collection and Management of Investigation Derived Waste) of the Permit (NMED, 2023, pg. 59-60). All waste will be properly managed and disposed of in accordance with NASA procedures and state and federal regulations. The waste streams that will be generated during the abandonment of well BLM-1-435 and drilling and installation of groundwater monitoring well 600C-003-GW include: • **Drill cuttings.** Unsaturated drill cuttings are defined as soil cuttings or rock fragments generated from the vadose zone that have not come in contact with groundwater. Unsaturated cuttings are not hazardous waste. Saturated drill cuttings are defined as soil cuttings or rock fragments generated from below the water table that have come in contact with contaminated groundwater. This environmental media potentially contains listed hazardous waste constituents from the WSTF groundwater plume. • **Drilling fluids.** Drilling fluids generated during drilling in the vadose zone are impacted with only added non-chlorinated native water from the WSTF potable water supply wells and are non-hazardous solid waste. Drilling fluids from below the water table potentially contain listed hazardous waste constituents that are present in the WSTF groundwater plume. • **Groundwater.** Groundwater produced from within the WSTF groundwater plume during well drilling and development is characterized as environmental media containing listed hazardous waste. • **Decontamination fluids.** Decontamination fluids such as water and soap solutions used to wash and decontaminate equipment generated during drilling above the water table are non-hazardous solid waste. Decontamination fluids generated by cleaning equipment that has contacted potentially contaminated soil, cuttings, or fluids generated when drilling below the water table is characterized as hazardous waste. • **Contact waste.** Contact waste, or debris, such as used disposable sampling equipment, personal protective equipment, plastic sheeting, and other debris generated during drilling above the water table is non-hazardous solid waste. Contact debris contaminated with soil, cuttings, or fluids that were generated when drilling below the water table is characterized as hazardous waste.

Investigation-Derived Waste Characterization and Management (cont.)	• **Petroleum Contaminated Debris and Environmental Media.** Debris such as rags and wipes may be contaminated with petroleum products during routine drilling equipment maintenance. While every precaution will be taken, petroleum contaminated environmental media may also be generated during an unexpected drilling equipment failure. The petroleum contaminated debris and environmental media will be characterized as hazardous waste with the D018 hazardous waste code. Groundwater is known to be contaminated at concentrations above the applicable regulatory levels at well BLM-1-435. The EPA has established that groundwater, and other environmental media, is not solid waste, but is subject to regulation as if it were hazardous waste when it contains listed waste (EPA, 1991). Because groundwater and other environmental media is subject to regulation when it contains listed hazardous waste (EPA, 1991), waste generated after reaching the water table will be managed as hazardous waste. By application of the EPA Contained-In Policy, groundwater removed from the contaminated portion of the WSTF plume has been characterized as F001 and F002 listed hazardous waste. As a result, any other material classified as solid waste that comes into contact with contaminated groundwater is regulated hazardous waste or hazardous debris. Drill cuttings and drilling fluids generated from the vadose zone will not contain listed hazardous waste and will not meet the definition of a hazardous waste. Vadose zone drill cuttings, and if necessary, drilling fluids, will be managed in intermediate bulk containers, bulk containers, or earthen pits at the surface as required for project implementation. If earthen pits are used, appropriate regulatory authorization will be obtained prior to their use, and they will be backfilled at the completion of the project. Drill cuttings and drilling fluids generated below the water table will be managed as hazardous waste. Drill cuttings will be separated from drilling fluids during the drilling process. Drill cuttings below the water table will be managed in 1-cubic yard Super Sack®[1] containers, roll-off containers, or other appropriate waste container. Waste drilling fluids will be managed in intermediate bulk Containers or tanker trailer containers. Hazardous waste generated below the water table will be containerized and managed in accordance with 20.4.1.300 NMAC and 40 CFR 262.17. The as-generated waste will be sampled and analytical data used to further characterize the waste. Waste characterization samples will be analyzed for VOC by the current revision of SW-846 Method 8260, NDMA by Modified EPA Method 607M, and RCRA metals using the current revision of EPA Method 1311 (Toxicity Characteristic Leaching Procedure) and the current revision of EPA Method 6010, or equivalent. NASA will request a “contained-in” determination from the NMED if the analytical data indicates drill cuttings and drilling fluids generated below the water table do not contain listed hazardous waste or exhibit characteristics of a hazardous waste. If the analytical data indicate the presence of listed waste or the waste exhibits characteristics of a hazardous waste, the waste will be properly treated and disposed of at a RCRA permitted treatment, storage, and disposal facility (TSDF). If possible, contaminated water may be decanted from this waste stream prior to shipment off-site and transferred to the MPITS for treatment and discharge.

[1] Super Sack is a registered trademark of Better Agricultural Goals Corporation DBA/ B.A.G. Corp.

Investigation-Derived Waste Characterization and Management (cont.)	Contaminated groundwater generated during drilling, development, and purging, and contaminated water generated during decontamination of equipment that has come into contact with contaminated groundwater or hazardous debris from below the water table, will be accumulated in appropriately sized containers and managed as hazardous waste. The containers will be managed in accordance with requirements of 20.4.1.300 NMAC and 40 CFR 262.17. Within permissible accumulation time limits, contaminated water will be transferred to the MPITS for treatment and discharge. Contact waste, or hazardous debris, that has come into contact with contaminated groundwater will be collected at the end of each working shift and transferred to an appropriate container. All hazardous waste containers will be managed on-site in accordance with the requirements of 20.4.1.300 NMAC and 40 CFR 262.17. If analytical results from drill cuttings and fluids are favorable, this waste stream may be included in a "contained-in" determination request. If analytical results indicate the drill cuttings and fluids contain hazardous waste, or the NMED determines the waste still contains hazardous waste, this debris will be shipped off-site for treatment and disposal at a RCRA permitted TSDF within the permissible accumulation time limits. As discussed previously, NASA may request a contained-in determination for individual waste streams initially characterized as containing listed hazardous wastes, should analytical data from the as-generated waste support such a request. The chemical analytical data may be compared to the Applicability of Treatment Standards 40 CFR Part 268.40, NMED Soil Screening Levels (SSLs; NMED, 2022c), and the concentrations listed in 40 CFR Part 261.24 Subpart C (Table 1), if applicable, to determine whether the material poses an unacceptable risk. If NMED finds contaminant concentrations do not pose an unacceptable risk, then NMED may allow the wastes included in the request to be managed as non-hazardous solid waste that no longer contains listed waste and does not exhibit the characteristic of hazardous waste. A separate letter from NMED will be required to document such a determination. For waste that is characterized as hazardous waste, land disposal restriction notifications, disposal facility profiles, and hazardous waste manifests will be completed as required. Hazardous waste manifested off-site will be transported for treatment and disposal at a permitted RCRA TSDF. Contaminated groundwater and decontamination water generated during the project will be managed at the MPITS. If that system is not capable of receiving the waste, it will be disposed of at a permitted RCRA TSDF.
Schedule	It is anticipated that drilling of proposed well 600C-003-GW will commence following NMED approval of this work plan. The anticipated schedule for completing wells is as follows: • Eight to 10 weeks for project and procurement planning, well site preparation, and drilling contractor scheduling. • Six to eight weeks for contractor mobilization, plugging and abandonment of well BLM-1-435, installation of the 600C-003-GW borehole, and conventional well installation in 600C-003-GW borehole. Additional time may be required during drilling if unexpected field or geological conditions slow the drilling process.

	• Six to eight weeks for well development fieldwork, sampling system design and procurement, and sampling system installation. • Eight to 12 weeks for groundwater sampling, data validation and verification, and preparation of the well completion report. The well completion report will be submitted to the NMED in accordance with Section 5.4 of the Permit (NMED, 2023, pg. 79-80).
References	Adoption of 40 CFR Part 262, Environmental Improvement Board, 20.4.1.300 NMAC (12-01-18). EPA (Environmental Protection Agency). (1991, March 26). N.t. (EPA Publication Number RO 11593). Washington, DC. Retrieved from https://yosemite.epa.gov/osw/rcra.nsf/ NASA Johnson Space Center White Sands Test Facility. (2022, April 29). *NASA WSTF Groundwater Monitoring Plan Update for 2022*. Las Cruces, NM. Navarro Research and Engineering, Inc. (2020d, July 5). *FY 2020 Evaluation of Select WSTF Wells for Rehabilitation, Plugging and Abandonment, or Continued Use*. Las Cruces, NM. NMED Hazardous Waste Bureau. (2022a, February 21). *Approval with Modifications Periodic Monitoring Report Second Quarter 2021*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2022b, October 31). *Approval with Modifications White Sands Test Facility Groundwater Monitoring Plan*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2022c, November). *Risk Assessment Guidance for Site Investigations and Remediation Volume I Soil Screening Guidance for Human Health Risk Assessments*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2023, April 27). *Hazardous Waste Permit No. NM8800019434*. Santa Fe, NM. Well Drilling – Non-Artesian (Unconfined) Well Requirements, Office of the State Engineer, 19.27.4.30 NMAC (6-30-17).

Figures

Figure 1 **WSTF Location Map**

(SEE NEXT PAGE)

Figure 2 **Proposed Location for 600C-003-GW**

(SEE NEXT PAGE)

Figure 3 General 600C-003-GW Well Design

(SEE NEXT PAGE)

Figure 4 **BLM-1-435 Well Completion Diagram**

(SEE NEXT PAGE)

Figure 5 **Proposed Well Location with Plume Extent**

(SEE NEXT PAGE)

Figure 6 **BLM-1-435 Borehole Lithology Log**

(SEE NEXT PAGE)

Comments for Approval with Modification of Drilling Work Plan for PL-3-453 Replacement

NMED Comment Number	NMED Comments	NASA Revisions/Responses/Discussion
1. Conceptual Model, Page 2	**Permittee Statement:** "Based on recent measurements at well BLM-1-435, NASA expects to encounter groundwater at approximately 409 ft bgs [feet below ground surface]. **NMED Comment:** Figure 4, BLM-1-435 Well Completion Diagram, indicates that the screened interval extends from approximately 435 to 445 ft bgs and the well was completed with four-inch stainless steel casing in alluvium in an unconfined aquifer. Given the available historical well completion information, the reported hydrogeologic conditions, and the estimated depth to groundwater (409 ft bgs) at BLM-1-435, it would be expected that over thirty-feet of water column would be present at any given time prior to purging the well for sampling. Based on this information alone, it would appear that dry well conditions may not be an issue at this well and further evaluation prior to well abandonment is warranted. To address this apparent information discrepancy, further clarify the rationale for the proposed monitoring well abandonment (e.g., well recharge issues, inaccurate historical well completion information, etc.). If additional well evaluation supports other solutions for continued use of BLM-1-435 this may be addressed during subsequent reporting. Revise the Work Plan accordingly and provide replacement pages, as necessary, with the response letter.	As requested, additional information to provide rationale for the plugging and abandonment of well BLM-1-435 has been provided from the BLM-1-435 monitoring well files and sampling notes. As early as April 1998 well BLM-1-435 camera logging indicated a potential crack in the stainless steel casing at a joint located at 421 ft below the top of casing and above the screened interval at 435 – 445 ft bgs. To ensure that sampling activities specifically targeted the screened interval, an inflatable packer was installed approximately two feet above the top of the screen to isolate the screen and dedicated low-flow bladder pump from the water column above the screened interval. On March 6, 2006 technicians noted extremely slow recovery rates in the well's screened interval. By April 23, 2020, field sampling records indicated that the well would no longer produce enough water to ensure that all stagnant water was purged from the dedicated bladder pump and pump tubing, preventing the monitoring and stabilization of indicator parameters prior to sample collection. In July 2020, NASA evaluated well BLM-1-435 and determined that sampling from the existing screen was not feasible. Because there are no viable options for reconfiguration, the well must be abandoned and replaced with a monitoring well capable of providing representative groundwater samples at or near this location in the aquifer.
2. Well Completion, Pages 5 and 6	**NMED Comment:** The placement of the proposed screened interval for replacement monitoring well 600C-003-GW must be at a depth in the unconfined aquifer that will provide sufficient groundwater for purging and	Because recent water levels under unconfined aquifer conditions at BLM-1-435 are reported at approximately 409 ft bgs and the screened zone was positioned between 435 – 445 with limited production, replacement well 600C-003-

NMED Comment Number	NMED Comments	NASA Revisions/Responses/Discussion
	representative data collection for a period of at least ten years, to the extent practicable. Revise the discussion to specify this requirement and provide a replacement page(s) with the response letter.	GW could potentially yield water from above the former BLM-1-435 screen. As a result, the screened interval is anticipated to be located at a depth between 420 – 460 ft bgs. The location of the screened interval for replacement monitoring well 600C-003-GW will target a depth in the unconfined aquifer that is expected to provide sufficient groundwater for development and sampling activities for a period of at least ten years. The discussion in the Well Completion section of the Work Plan has been revised to include this information and the replacement pages provided.

Work Plan for Abandonment of NASA WSTF Well BLM-1-435 and Replacement with Monitoring Well 600C-003-GW

Introduction and Background	In the February 21, 2022, *Approval with Modifications Periodic Monitoring Report Second Quarter 2021*, the New Mexico Environment Department (NMED) expressed concern about declining water levels at White Sands Test Facility (WSTF) (Figure 1) groundwater monitoring wells 300-C-128, 400-C-118, 400-C-143, BLM-1-435, and PL-3-453 (NMED, 2022a). NMED indicated that NASA could continue to evaluate these wells. In the April 29, 2022, WSTF Groundwater Monitoring Plan (GMP) update for 2022, NASA indicated that well BLM-1-435 would be plugged due to continued groundwater level drop and inability to sufficiently sample the well (NASA, 2022, pg. 20). On October 31, 2022, NMED approved the GMP with modifications (NMED, 2022b) and indicated that well BLM-1-435 must be replaced and a work plan submitted for the plugging of BLM-1-435 and subsequent drilling of the replacement well (NMED, 2022b, pg. 2). This abbreviated work plan was developed in accordance with the Hazardous Waste Permit (Permit, 2023), Section 6.2, and incorporates requirements specified in Section 5.3 of the Permit. The well is located within the southern Jornada del Muerto Basin alluvial aquifer northeast of the WSTF Plume Front Treatment System (PFTS; Figure 2).
Primary Purpose	NASA proposes to plug and abandon existing monitoring well BLM-1-435 and install replacement monitoring well 600C-003-GW adjacent to the abandoned well. Well 600C-003-GW is expected to be completed as a single zone conventional monitoring well (Figure 3). Target screened interval in the replacement well approximately mirror monitoring zones within current monitoring well BLM-1-435 at 435 ft bgs. The placement of the screened intervals within the well will be refined during drilling and/or follow-on borehole logging.
Plugging and Abandonment of Well BLM-1-435	NASA will plug and abandon existing groundwater monitoring well BLM-1-435 in accordance with WSTF Hazardous Waste Permit (Permit) Section 5.3 (NMED, 2023, pg. 78) and 19.27.4.30 New Mexico Administrative Code (NMAC). Well BLM-1-435, completed in November 1987, is equipped with 8-inch (in.) steel surface casing that extends to a depth of 32 feet (ft) below ground surface (bgs). The 8-in. diameter borehole extends from surface casing to a total depth of 500 ft bgs. The conventional portion of the monitoring well consists of 4-in. stainless-steel casing that extends from ground surface to 451 ft bgs (Figure 4). NASA proposes to plug the well by lowering tremie pipe to the bottom of the open borehole. Portland cement grout will be emplaced using a tremie pipe upward from the bottom of the borehole to the ground surface. Any discharge of fluids will be managed in accordance with the Waste Management and Characterization Section. The steel surface casing will be cut at least 6 in. bgs and a concrete cap will be emplaced over the borehole. A brass cap will be embedded in the concrete surface completion and all pertinent well information will be stamped into the brass cap. NASA will prepare a well plugging plan for well BLM-1-435 and submit the plan to the New Mexico Office of the State Engineer (NMOSE) in accordance with 19.27.4.30 NMAC. The well drilling contractor will provide NASA and NMOSE with the

	required completed well plugging record. NASA will in turn provide NMED with a copy of the completed well plugging record.
Hydrogeologic and Geochemical Objectives	The primary objective of proposed monitoring well 600C-003-GW is to provide groundwater chemical analytical data to supplement data previously obtained from well BLM-1-435, which is identified as a Main Plume monitoring well in the GMP (NASA, 2022, pg. 82). Analytical results from 600C-003-GW will also be used to supplement data collected from other wells within the WSTF groundwater monitoring system, particularly those wells in close proximity such as BLM-9-419, PFE-5, and BLM-8-418. Additional objectives are to further characterize hydrostratigraphy at the proposed location and monitor groundwater elevation.
Conceptual Model	The original location of well BLM-1-435 was chosen to support characterization of the WSTF groundwater contaminant plume (Figure 5). Replacement well 600C-003-GW will continue to serve that role in the WSTF groundwater assessment program and inform the conceptual site model. In addition to providing analytical data concerning the main plume of the WSTF groundwater plume, well 600C-003-GW will also provide water level data that will be used to inform hydrogeologic decisions. Information collected from the new well will be incorporated into the WSTF conceptual groundwater model when appropriate. Existing well BLM-1-435 was completed within the Santa Fe Alluvium; however, the borehole penetrated andesitic bedrock at approximately 457 ft bgs (Figure 6). All monitoring zones are completed within alluvium, which is generally characterized as an unconsolidated to semi-consolidated, poorly to moderately sorted, pebbly polygenetic conglomerate. Limestone and igneous clasts in the conglomerate originate from the San Andres Mountains, located to the east of WSTF. Clay lenses are also present and likely represent fine grain sediments of the distal portion of buried coalescent alluvial fan deposits. As early as April 1998, well BLM-1-435 camera logging indicated a potential crack in the stainless –steel casing at a joint located at 421 ft below the top of casing and above the screened interval at 435 – 445 ft bgs (Figure 4). To ensure that sampling activities specifically targeted the screened interval, an inflatable packer was installed approximately 2 ft above the top of the screen to isolate the screen and dedicated low-flow bladder pump from the water column above the screened interval. On March 6, 2006, technicians noted extremely slow recovery rates in the well's screened interval. By April 23, 2020, field sampling records indicated that the well would no longer produce enough water to ensure that all stagnant water was purged from the dedicated bladder pump and pump tubing, preventing the monitoring and stabilization of indicator parameters prior to sample collection. In July 2020, NASA evaluated well BLM-1-435 and determined that sampling from the existing screen was not feasible. Because there are no viable options for reconfiguration, the well must be abandoned and replaced with a monitoring well capable of providing representative groundwater samples at or near this location in the aquifer. Replacement well 600C-003-GW will be located approximately 30 ft to the south of existing well BLM-1-435. Well 600C-003-GW will be completed in the alluvial basin-fill and is expected to have similar lithology to that encountered at comparable depths in the existing well. Aquifer conditions at the proposed location are expected to be unconfined. The groundwater flow direction in the area is generally west-southwest.

	Based on recent measurements at well BLM-1-435, NASA expects to encounter groundwater at approximately 409 ft bgs (Figure 5).
Drilling Approach	NASA will drill and install monitoring well 600C-003-GW in accordance with the requirements of Permit Section 5.1 and 5.2 (NMED, 2023, pg. 71). NASA expects to advance a minimum 12-in. borehole to the top of bedrock at approximately 457 ft bgs. NASA is considering two options for installation of the well. The preferred method is air rotary casing advance (ARCA), and the alternative method is mud rotary. The final determination of drilling method will be made following consultation with the knowledgeable drilling contractors during the competitive procurement process required by the Federal Acquisition Regulations (48 Code of Federal Regulations [CFR] Part 6). The advantages and disadvantages of both options are presented below. **Air Rotary Casing Advance** The ARCA method drives casing 1 or 2 ft above the drill bit, thereby casing off the borehole as it is drilled. The method stabilizes the formation and prevents collapse of the borehole walls through the installation of casing while drilling. Borehole diameters are necessarily greater for this method and start at 20 to 22 in. from the surface. The borehole and casing sizes are telescoped down as the borehole is advanced over regular intervals to 18 in., 16 in., and finally 14 in. to the total depth of the borehole (diameters are approximate and may vary between drilling contractors). The ARCA method requires only minor use of polymeric or bentonite additives to aid in lifting cuttings out of the borehole. Following well casing installation, the drive casing is removed as the well is completed. Advantages include: • Stabilization of the borehole • No drilling mud is required so development of individual monitoring zones is more likely to be successful • Lithologic cuttings are of better quality for characterization of the alluvium • Formation water can be identified and sampled for characterization Disadvantages of the ARCA method include: • Because steel casing remains in the borehole until well installation, geophysical logging of the borehole is limited to gamma ray and neutron porosity, making it difficult to identify formation changes and productive zones • The method has proved costly in the past, especially if casing becomes stuck and cannot be removed except by cutting Geophysical logging of a borehole that is drilled entirely in alluvium is not considered essential, especially since it is possible to quantify water production during ARCA drilling. The ARCA drilling method has become common and many drilling contractors are installing wells successfully using the method. The level of experience

Drilling Approach (cont.)	among contractors has increased and should preclude problems similar to those NASA encountered using this method while drilling well PL-11 in 2016. If the ARCA method of drilling is used, air supplied by an air compressor will serve as the drilling fluid. Air will be directed through an in-line filter system to prevent potential introduction of contaminants, such as entrained residual oils, into the borehole. The filter system will be inspected regularly by the drilling contractor to ensure the system is functioning properly. A cyclone separator or similar air containment/dust-suppression system is typically used to funnel the cuttings to one location instead of allowing the cuttings to discharge uncontrolled from the borehole. Particular attention will be paid to the management of cuttings. Dust will be minimized as much as possible with a clean water mist at the cyclone, if necessary. **Mud Rotary Drilling** Mud rotary is a standard drilling method used when penetrating alluvium or unconsolidated formation. Advantages include: • Relatively rapid and efficient drilling and installation of the borehole (reduced cost) • A full suite of geophysical logs can be run in a mud filled borehole • The borehole diameter is smaller at 16 to 17 in. • Drilling mud has been effective in stabilizing deep boreholes drilled in alluvium at WSTF • Monitoring zones have been successfully developed in mud drilled wells at WSTF Disadvantages to the mud rotary method are as follows: • The bentonite drilling mud has the potential to adversely affect the hydrologic properties and geochemistry of the aquifer immediately surrounding the borehole • Past experience at WSTF indicates it is difficult and time-consuming to develop monitoring zones in a mud-drilled well • Drilling fluid waste management and disposal costs can be substantially higher than those for ARCA-installed wells If the planned ARCA drilling method is not successful, and mud rotary is required to install the borehole, the appropriate mud dispersion agents will be utilized to aid in the removal of residual drilling mud during borehole/well development. Mud rotary drilling will only be considered as a last resort to advance the borehole and the decision to switch to this method will only occur with the approval of the NMED.
Groundwater Occurrence and Detection	Data from existing well BLM-1-435 indicates regional groundwater is expected to occur at a depth of approximately 409 ft bgs. Perched groundwater is not expected in alluvium. Methods for groundwater detection may include drilling observations, water level measurements, or borehole geophysics. The first identification of groundwater

	will likely be apparent if the ARCA method is used to install the borehole. However, the mud rotary method may mask the presence of water in the formation.
Lithological Sampling	If the borehole is drilled using ARCA, lithological samples will be collected from the cyclone discharge at a minimum of 10-ft intervals. Drill cuttings may be collected using a stainless-steel handheld screen placed in the flow of the discharged cuttings or other methods selected by the field geologist, as appropriate. Cuttings samples will be archived in chip trays for future reference. If the borehole is installed using the mud rotary method, lithologic samples will be collected directly from the drilling mud discharge location, or from the solids-separation unit (shaker table), if utilized, at a minimum of 10-ft intervals. Drill cuttings may be collected using a stainless-steel handheld screen placed in the flow of the discharged mud, by placing a shovel in the mud discharge trough to intercept cuttings, or other methods selected by the field geologist, as appropriate. Cuttings samples will be archived for future reference.
Groundwater Screening and Characterization Sampling	Based on groundwater monitoring performed at BLM-1-435, the aquifer at the proposed 600C-003-GW location is expected to be within the WSTF groundwater contaminant plume. For verification purposes and potential waste characterization, groundwater screening samples will be attempted during drilling immediately upon intercepting the water table and at least every 100 ft thereafter. Chemical analytical results from screening samples collected will be used to support the identification of potential monitoring zones, as applicable. Screening samples will be analyzed for volatile organic compounds (VOC) by the current revision of SW-846 Method 8260, semi-volatile organic compounds (SVOC) by the current revision of SW-846 Method 8270C, and N-nitrosodimethylamine (NDMA) by Modified Environmental Protection Agency (EPA) Method 607M or an acceptable low-level analytical method. Groundwater samples will be collected, if possible, utilizing a decontaminated non-dedicated bailer. If a bailer is not feasible, grab samples may be attempted through the cyclone at the surface discharge point. All samples will be managed in accordance with the WSTF GMP (NASA, 2022, pp. 36-38). Following well development and sampling system installation, groundwater characterization samples will be collected from each of the sampling zone(s) of the completed wells. Samples will be collected for the analysis of VOCs by the current revision of SW-846 Method 8260, SVOCs by the current revision of SW-846 Method 8270C, NDMA by Modified EPA Method 607M, or WSTF's current low-level analytical method, and a variety of metals by the most effective laboratory-selected analytical method. Samples will be collected and managed in accordance with the GMP (NASA, 2022).
Geophysical Logging	The potential use of the ARCA drilling method may allow for effective geophysical logging of the 600C-003-GW borehole. If the borehole remains open during and after drilling, a complete suite of open borehole geophysical logs would be attempted as a single event to aid in the selection of the potential monitoring zone. Open borehole logging would be performed by a qualified geophysical contractor and would include gamma, neutron porosity, formation resistivity, spontaneous potential, optical imaging, and caliper/borehole deviation logs. The use of drive casing with the ARCA and dual rotary drilling methods will preclude geophysical logging in the 600C-003-GW borehole. Geophysical logging would be

	performed if the borehole is deemed competent enough to remain open with the drive casing removed.
Well Completion	Well 600C-003-GW will be constructed in accordance with Permit Section 5.2 (NMED, 2023, pg. 71), with nominal 5-in. Schedule 80 PVC casing and screen, which allows for the use of a 4-in. diameter downhole pump for well development. A single monitoring zone is planned in the well to replace the zone previously monitored by well BLM-1-435. Because recent water levels under unconfined aquifer conditions at BLM-1-435 are reported at approximately 409 ft bgs and the screened zone was positioned between 435 – 445 with limited production, replacement well 600C-003-GW could potentially yield water from above the former BLM-1-435 screen. As a result, the screened interval is anticipated to be located at a depth between 420 – 460 ft bgs. The location of the screened interval for replacement monitoring well 600C-003-GW will target a depth in the unconfined aquifer that is expected to provides sufficient groundwater for development and sampling activities for a period of at least ten years. A 10-foot length of 0.020-in. slotted Schedule 80 PVC screen will be positioned at a depth indicated as a favorable monitoring zone in accordance with field screening of borehole lithology and borehole geophysical logs, if performed. The annular seal for the screened sampling zones will be comprised of bentonite chips or pellets. The general well construction configuration is presented in Figure 3 and is subject to change dependent on conditions encountered in the field or by recommendations made by the drilling contractor. NASA will prepare a final well construction diagram for the well for NMED review and approval immediately prior to well installation. Annular materials will be emplaced using a 1 to 2-in. inner diameter tremie pipe. A 10/20 or similar silica sand filter pack will be placed to a height of 2 ft above and below the monitoring screen. Three feet of fine silica sand, such as 20/40 or similar, will be used to grade from the sand pack to a 10-ft bentonite seal composed of hydrated bentonite chips or pellets. The interval above the upper screen from the top of the hydrated bentonite chip seal to 10 ft below ground surface will be comprised of bentonite grout with at least 20% solids. The upper 10 ft of the borehole and well pad will be completed with Type II Portland cement. Figure 3 provides a diagram of the preliminary well design with annular materials.
Well Development	The well will be developed in accordance with the requirements of Section 5.2 of the Permit (NMED, 2023, pg. 71). Drilling contractor personnel will operate equipment used to develop the well under the supervision of Environmental contractor personnel. It is anticipated that initial development for the sampling zone may consist of jetting (to facilitate mud removal following mud rotary), mechanical bailing, swabbing, and pumping using a submersible pump. During development activities, Environmental contractor personnel will monitor discharged development water for parameters that will include pH, specific conductance (conductivity), temperature, and turbidity. Well development will be considered complete when measured water quality parameters are relatively stable (vary less than 10%) and turbidity is below 5 nephelometric turbidity units. Following well development, NASA expects to install a dedicated low-flow bladder pump the PVC well casing, with pump intakes located at or slightly above the midpoint of the screened interval.

Hydraulic Testing and Groundwater Sampling	Hydraulic testing will be considered during the development of monitoring well 600C-003-GW. Additional information such as drawdown and specific capacity will be recorded if this testing is conducted. Groundwater sampling following installation and development of the well will be performed using dedicated low-flow bladder pumps. Groundwater samples will be collected and managed as described in the WSTF GMP (NASA, 2022, pg. 34-38).
Investigation-Derived Waste Characterization and Management	In accordance with the NASA WSTF Hazardous Waste Permit, Section 4.3.10 (NMED, 2023), a discussion of IDW generated is provided in this work plan. All IDW will be properly managed and disposed of in accordance with NASA procedures and state and federal regulations. Information related to the characterization, management, and disposition of waste generated during this project is provided in this section. Waste characterization is conducted in accordance with Section 4.3.10 (Collection and Management of Investigation Derived Waste) of the Permit (NMED, 2023, pg. 59-60). All waste will be properly managed and disposed of in accordance with NASA procedures and state and federal regulations. The waste streams that will be generated during the abandonment of well BLM-1-435 and drilling and installation of groundwater monitoring well 600C-003-GW include: • **Drill cuttings.** Unsaturated drill cuttings are defined as soil cuttings or rock fragments generated from the vadose zone that have not come in contact with groundwater. Unsaturated cuttings are not hazardous waste. Saturated drill cuttings are defined as soil cuttings or rock fragments generated from below the water table that have come in contact with contaminated groundwater. This environmental media potentially contains listed hazardous waste constituents from the WSTF groundwater plume. • **Drilling fluids.** Drilling fluids generated during drilling in the vadose zone are impacted with only added non-chlorinated native water from the WSTF potable water supply wells and are non-hazardous solid waste. Drilling fluids from below the water table potentially contain listed hazardous waste constituents that are present in the WSTF groundwater plume. • **Groundwater.** Groundwater produced from within the WSTF groundwater plume during well drilling and development is characterized as environmental media containing listed hazardous waste. • **Decontamination fluids.** Decontamination fluids such as water and soap solutions used to wash and decontaminate equipment generated during drilling above the water table are non-hazardous solid waste. Decontamination fluids generated by cleaning equipment that has contacted potentially contaminated soil, cuttings, or fluids generated when drilling below the water table is characterized as hazardous waste. • **Contact waste.** Contact waste, or debris, such as used disposable sampling equipment, personal protective equipment, plastic sheeting, and other debris generated during drilling above the water table is non-hazardous solid waste. Contact debris contaminated with soil, cuttings, or fluids that were generated when drilling below the water table is characterized as hazardous waste.

Investigation-Derived Waste Characterization and Management (cont.)	• **Petroleum Contaminated Debris and Environmental Media.** Debris such as rags and wipes may be contaminated with petroleum products during routine drilling equipment maintenance. While every precaution will be taken, petroleum contaminated environmental media may also be generated during an unexpected drilling equipment failure. The petroleum contaminated debris and environmental media will be characterized as hazardous waste with the D018 hazardous waste code. Groundwater is known to be contaminated at concentrations above the applicable regulatory levels at well BLM-1-435. The EPA has established that groundwater, and other environmental media, is not solid waste, but is subject to regulation as if it were hazardous waste when it contains listed waste (EPA, 1991). Because groundwater and other environmental media is subject to regulation when it contains listed hazardous waste (EPA, 1991), waste generated after reaching the water table will be managed as hazardous waste. By application of the EPA Contained-In Policy, groundwater removed from the contaminated portion of the WSTF plume has been characterized as F001 and F002 listed hazardous waste. As a result, any other material classified as solid waste that comes into contact with contaminated groundwater is regulated hazardous waste or hazardous debris. Drill cuttings and drilling fluids generated from the vadose zone will not contain listed hazardous waste and will not meet the definition of a hazardous waste. Vadose zone drill cuttings, and if necessary, drilling fluids, will be managed in intermediate bulk containers, bulk containers, or earthen pits at the surface as required for project implementation. If earthen pits are used, appropriate regulatory authorization will be obtained prior to their use, and they will be backfilled at the completion of the project. Drill cuttings and drilling fluids generated below the water table will be managed as hazardous waste. Drill cuttings will be separated from drilling fluids during the drilling process. Drill cuttings below the water table will be managed in 1-cubic yard Super Sack®[1] containers, roll-off containers, or other appropriate waste container. Waste drilling fluids will be managed in intermediate bulk Containers or tanker trailer containers. Hazardous waste generated below the water table will be containerized and managed in accordance with 20.4.1.300 NMAC and 40 CFR 262.17. The as-generated waste will be sampled and analytical data used to further characterize the waste. Waste characterization samples will be analyzed for VOC by the current revision of SW-846 Method 8260, NDMA by Modified EPA Method 607M, and RCRA metals using the current revision of EPA Method 1311 (Toxicity Characteristic Leaching Procedure) and the current revision of EPA Method 6010, or equivalent. NASA will request a “contained-in” determination from the NMED if the analytical data indicates drill cuttings and drilling fluids generated below the water table do not contain listed hazardous waste or exhibit characteristics of a hazardous waste. If the analytical data indicate the presence of listed waste or the waste exhibits characteristics of a hazardous waste, the waste will be properly treated and disposed of at a RCRA permitted treatment, storage, and disposal facility (TSDF). If possible, contaminated water may be decanted from this waste stream prior to shipment off-site and transferred to the MPITS for treatment and discharge.

[1] Super Sack is a registered trademark of Better Agricultural Goals Corporation DBA/ B.A.G. Corp.

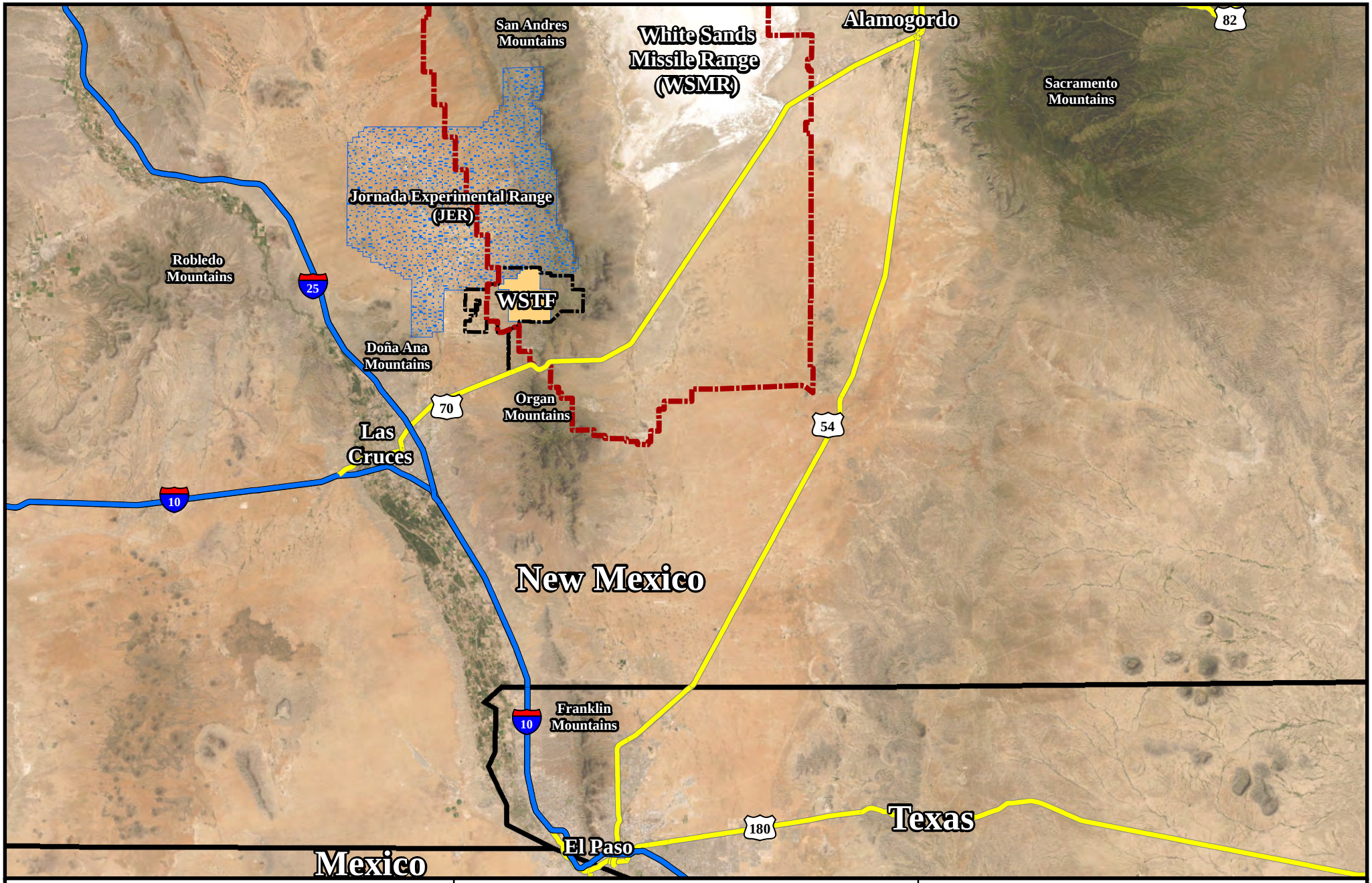
Investigation-Derived Waste Characterization and Management (cont.)	Contaminated groundwater generated during drilling, development, and purging, and contaminated water generated during decontamination of equipment that has come into contact with contaminated groundwater or hazardous debris from below the water table, will be accumulated in appropriately sized containers and managed as hazardous waste. The containers will be managed in accordance with requirements of 20.4.1.300 NMAC and 40 CFR 262.17. Within permissible accumulation time limits, contaminated water will be transferred to the MPITS for treatment and discharge. Contact waste, or hazardous debris, that has come into contact with contaminated groundwater will be collected at the end of each working shift and transferred to an appropriate container. All hazardous waste containers will be managed on-site in accordance with the requirements of 20.4.1.300 NMAC and 40 CFR 262.17. If analytical results from drill cuttings and fluids are favorable, this waste stream may be included in a "contained-in" determination request. If analytical results indicate the drill cuttings and fluids contain hazardous waste, or the NMED determines the waste still contains hazardous waste, this debris will be shipped off-site for treatment and disposal at a RCRA permitted TSDF within the permissible accumulation time limits. As discussed previously, NASA may request a contained-in determination for individual waste streams initially characterized as containing listed hazardous wastes, should analytical data from the as-generated waste support such a request. The chemical analytical data may be compared to the Applicability of Treatment Standards 40 CFR Part 268.40, NMED Soil Screening Levels (SSLs; NMED, 2022c), and the concentrations listed in 40 CFR Part 261.24 Subpart C (Table 1), if applicable, to determine whether the material poses an unacceptable risk. If NMED finds contaminant concentrations do not pose an unacceptable risk, then NMED may allow the wastes included in the request to be managed as non-hazardous solid waste that no longer contains listed waste and does not exhibit the characteristic of hazardous waste. A separate letter from NMED will be required to document such a determination. For waste that is characterized as hazardous waste, land disposal restriction notifications, disposal facility profiles, and hazardous waste manifests will be completed as required. Hazardous waste manifested off-site will be transported for treatment and disposal at a permitted RCRA TSDF. Contaminated groundwater and decontamination water generated during the project will be managed at the MPITS. If that system is not capable of receiving the waste, it will be disposed of at a permitted RCRA TSDF.
Schedule	It is anticipated that drilling of proposed well 600C-003-GW will commence following NMED approval of this work plan. The anticipated schedule for completing wells is as follows: • Eight to 10 weeks for project and procurement planning, well site preparation, and drilling contractor scheduling. • Six to eight weeks for contractor mobilization, plugging and abandonment of well BLM-1-435, installation of the 600C-003-GW borehole, and conventional well installation in 600C-003-GW borehole. Additional time may be required during drilling if unexpected field or geological conditions slow the drilling process.

	• Six to eight weeks for well development fieldwork, sampling system design and procurement, and sampling system installation. • Eight to 12 weeks for groundwater sampling, data validation and verification, and preparation of the well completion report. The well completion report will be submitted to the NMED in accordance with Section 5.4 of the Permit (NMED, 2023, pg. 79-80).
References	Adoption of 40 CFR Part 262, Environmental Improvement Board, 20.4.1.300 NMAC (12-01-18). EPA (Environmental Protection Agency). (1991, March 26). N.t. (EPA Publication Number RO 11593). Washington, DC. Retrieved from https://yosemite.epa.gov/osw/rcra.nsf/ NASA Johnson Space Center White Sands Test Facility. (2022, April 29). *NASA WSTF Groundwater Monitoring Plan Update for 2022*. Las Cruces, NM. Navarro Research and Engineering, Inc. (2020d, July 5). *FY 2020 Evaluation of Select WSTF Wells for Rehabilitation, Plugging and Abandonment, or Continued Use*. Las Cruces, NM. NMED Hazardous Waste Bureau. (2022a, February 21). *Approval with Modifications Periodic Monitoring Report Second Quarter 2021*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2022b, October 31). *Approval with Modifications White Sands Test Facility Groundwater Monitoring Plan*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2022c, November). *Risk Assessment Guidance for Site Investigations and Remediation Volume I Soil Screening Guidance for Human Health Risk Assessments*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2023, April 27). *Hazardous Waste Permit No. NM8800019434*. Santa Fe, NM. Well Drilling – Non-Artesian (Unconfined) Well Requirements, Office of the State Engineer, 19.27.4.30 NMAC (6-30-17).

Figures

Figure 1 **WSTF Location Map**

(SEE NEXT PAGE)



WSTF Location Map

NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

Coordinate System:
NAD 1983 StatePlane New Mexico Central FIPS 3002 Feet

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- WSMR Boundary
- WSTF Boundary
- WSTF Industrial Area
- Jornada Experimental Range (JER)

1 in = 12 miles

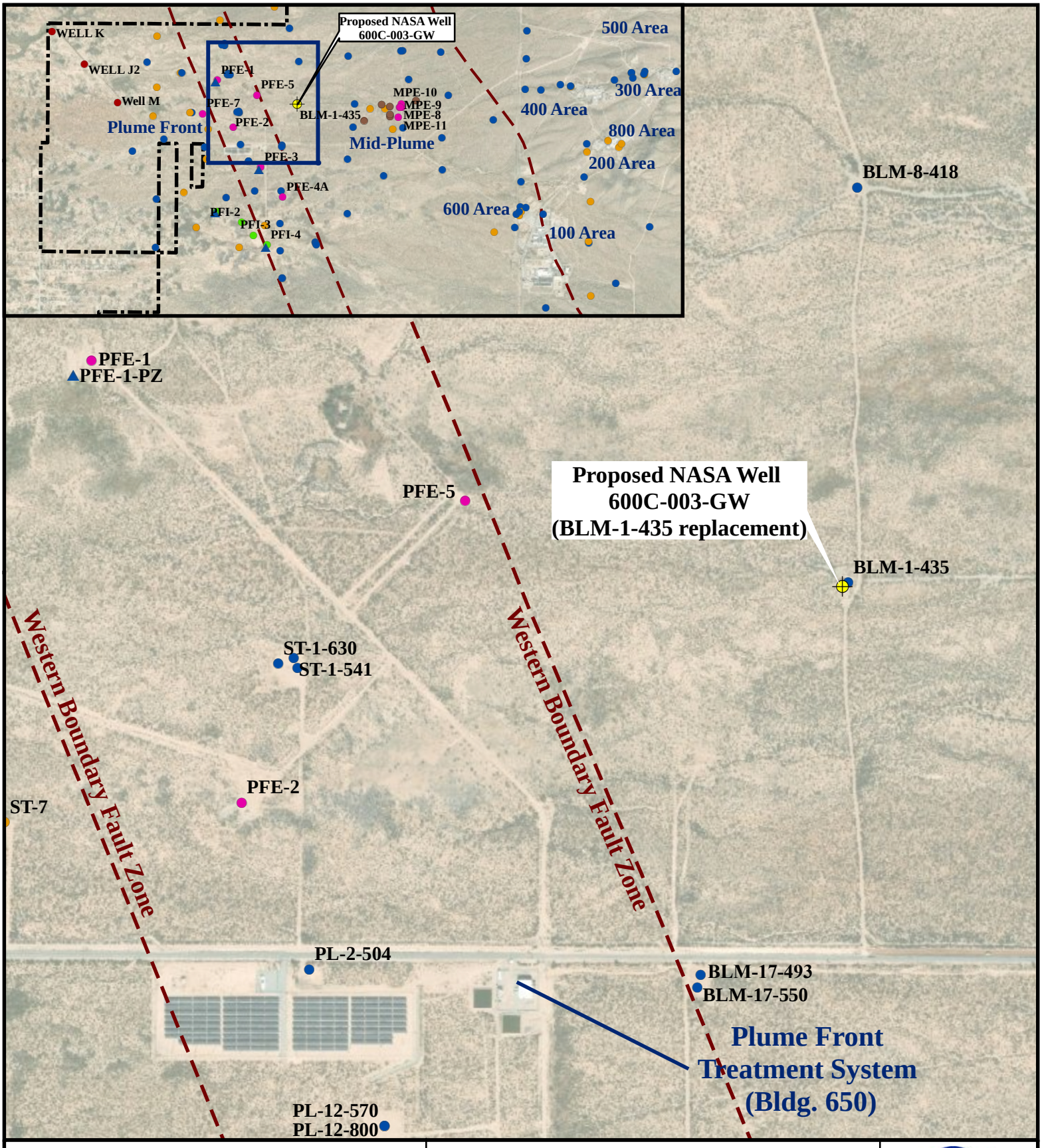
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April 2023

Figure 2 **Proposed Location for 600C-003-GW**

(SEE NEXT PAGE)



Proposed location for 600C-003-GW (BLM-1-435 Replacement)

NASA Johnson Space Center
White Sands Test Facility Las Cruces, New Mexico

Coordinate System:
NAD 1983 HARN StatePlane New Mexico Central FIPS 3002 Feet

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- Proposed Well
- Multiport Well
- Conventional Well
- Extraction Well
- Injection Well
- Piezometer
- Exploration Well
- Production Well
- Fault
- WSTF Boundary

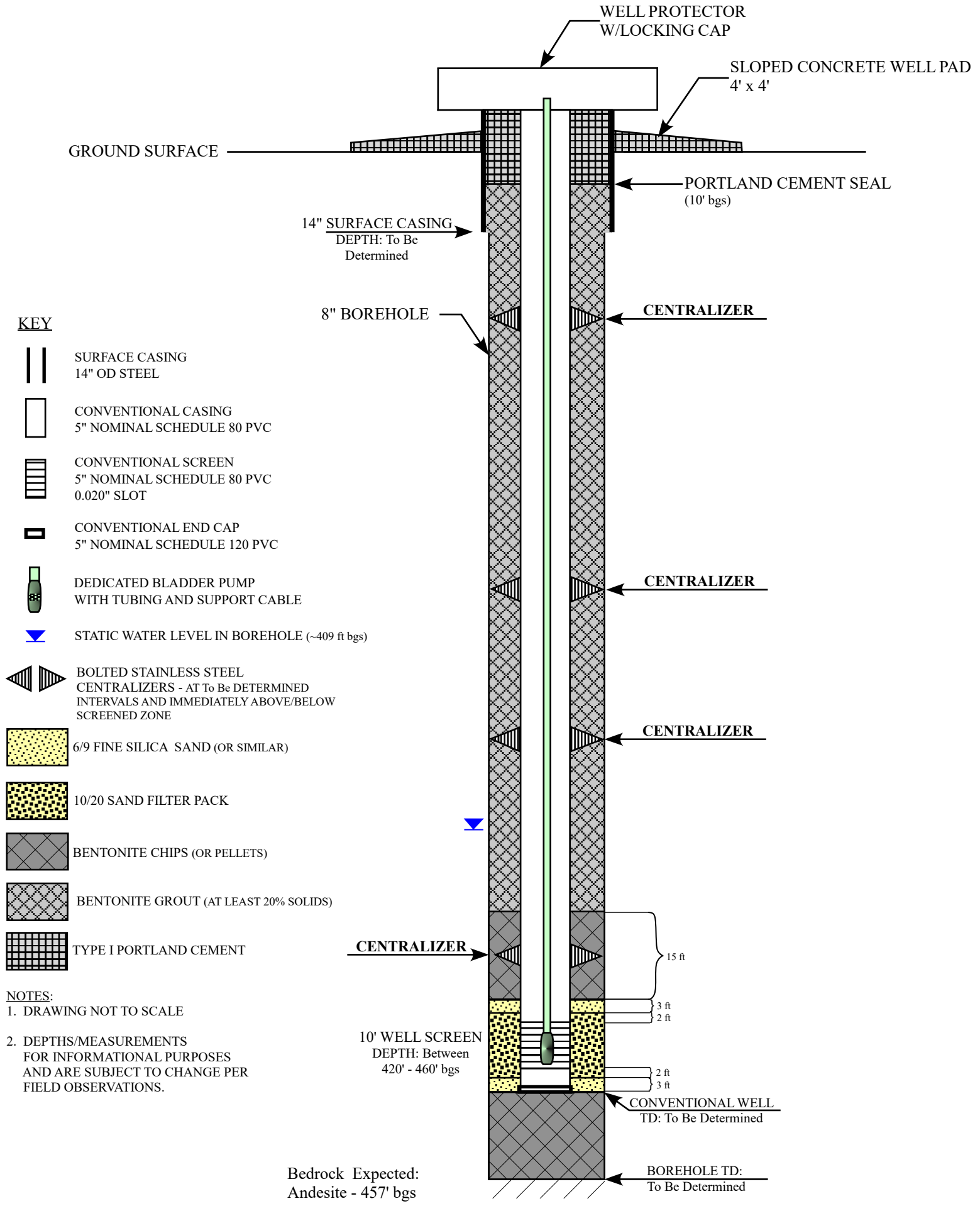
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1 inch = 600 feet
April 2023

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Figure 3 General 600C-003-GW Well Design

(SEE NEXT PAGE)



600C-003-GW WELL DESIGN: CONVENTIONAL

Figure 4 **BLM-1-435 Well Completion Diagram**

(SEE NEXT PAGE)

WELL COMPLETION DIAGRAM
MONITORING WELL

Location ID: **BLM-1-435**

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

Township and Range: **SW 1/4 NW 1/4 SW 1/4 Sec.33, T20S, R3E**
NM State Plane Coordinates (NAD 83): **168873.19N 462776.98E**
Elevation (Brass Cap): **1387.95 m AMSL**
Elevation (Top of Casing): **1388.40 m AMSL**
Drilling Contractor: **Larjon Drilling Company**
Driller: **J. Gower**
Total Depth of Borehole (bgs): **500' (152.4 m)**
Borehole Diameter: **8 3/4" to 35'; ~7 7/8 to 500' (Assumed)**
Depth to Bedrock (bgs): **457' (139.3 m); Rhyolite**
Depth to Groundwater: **398.5' (121.5 m) TOSC (10/6/87)**
Total Depth Surface Casing (bgs): **32' (9.8 m)**
Diameter and Type Surface Casing: **Nominal 8" Steel**

Date(s) Well Installed: **11/11/1987**
Date(s) Well Developed: **11/19/1987 - 3/10/1988**
Field Representative(s):**E. Morse, B. Cooper, J. Kaszuba**
Total Depth Well Casing (bgs): **451' (137.5 m)**
Type of Casing: **Stainless Steel**
Diameter Well Casing: **4"**
Casing Schedule: **SCD 5 & SCD 10**
Screened Zone (bgs): **435.3' - 445.7' (132.7 - 135.8 m)**
Comments: **Original casing was pulled on 11/9/1987 and well reinstalled on 11/11/1987. Diameter not recorded.**
AMSL = Above Mean Sea Level
bgs = below ground surface

Casing Explanation:

- Surface Casing **Nominal 8" Steel**
- Conventional Casing **Nominal 4" SCH 5 Stainless Steel**
- Conventional Casing **Nominal 4" SCH 10 Stainless Steel**
- Conventional Screen **Nominal 4" SCH 10 Stainless Steel**
- Conventional End Cap **Nominal 4" SCH 10 Stainless Steel**
- **Welded Stainless Steel Centralizers**
- Water Table

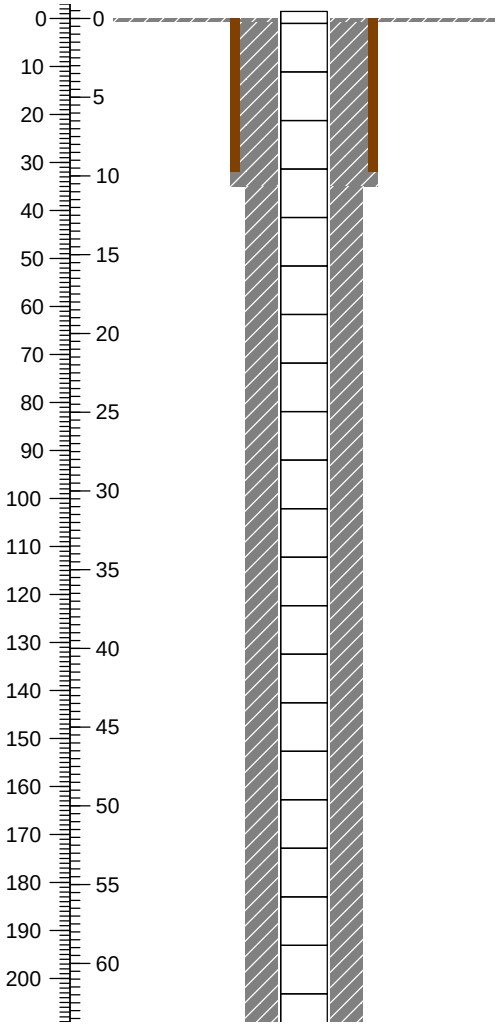
Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- Bentonite Mix
- Slough
- 8/14 Sand
- 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



Well completed with a 3' X 3' concrete slab and 4" X 2.0' stainless steel riser and locking cap.

Stick-up = 1.47' (0.45 m)

Nominal 8" steel surface casing installed to 32' (9.8 m).

0' - 397.1' (0 - 121.04 m)- Neat Cement Slurry with 5% Bentonite.

8 3/4" borehole to 35'. ~7 7/8" borehole to 500'.

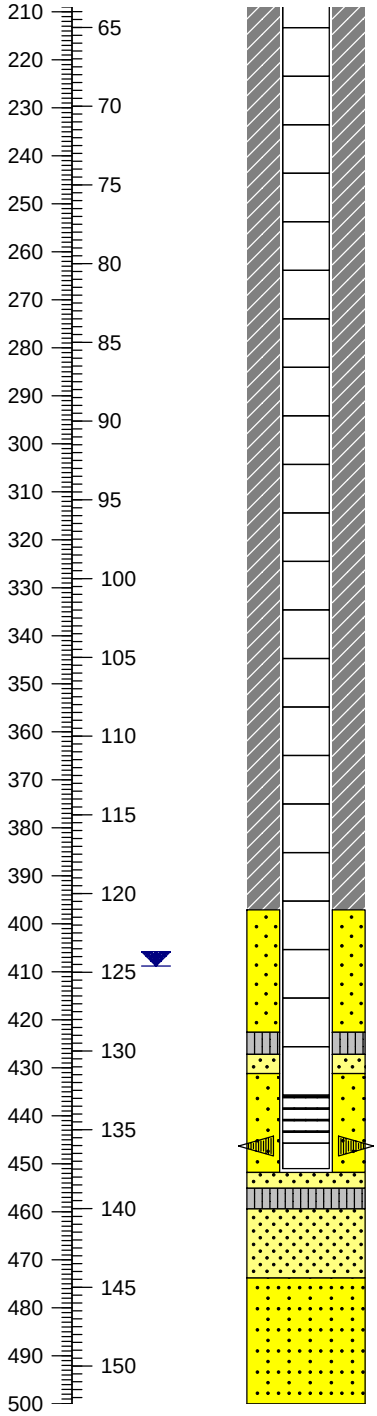
Casing Explanation:

- Surface Casing **Nominal 8" Steel**
- Conventional Casing **Nominal 4" SCH 5 Stainless Steel**
- Conventional Casing **Nominal 4" SCH 10 Stainless Steel**
- Conventional Screen **Nominal 4" SCH 10 Stainless Steel**
- Conventional End Cap **Nominal 4" SCH 10 Stainless Steel**
- **Welded Stainless Steel Centralizers**
- Water Table

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- Slough
- 1/8 Gravel
- 8/14 Sand
- 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)

All casing above 334.6' is SCH 5 Nominal 4" Stainless Steel.

All casing and screen below 334.6' is SCH 10 Nominal 4" Stainless Steel.

408.8 (124.60 m)- Static water level in cased borehole.

435.3 (132.68 m)- Top of SCH 10 Nominal 4" Stainless Steel 0.02 slot screen.
445.7 (135.85 m)- Bottom of SCH 10 Nominal 4" Stainless Steel 0.02 slot screen.
446.3 (136.03 m)- Stainless Steel Centralizer.
451.0 (137.46 m)- Nominal 4" SCH 10 Stainless Steel casing TD.

Annular/Borehole Descriptions
All depths listed are bgs

397.1' (121.04 m)- Top of 10/20 Sand.

422.6' (128.81 m)- Top of Bentonite Plug (Pellets).
427.2' (130.21 m)- Top of 16/40 Sand.
431.2' (131.43 m)- Top of 8/20 Sand.

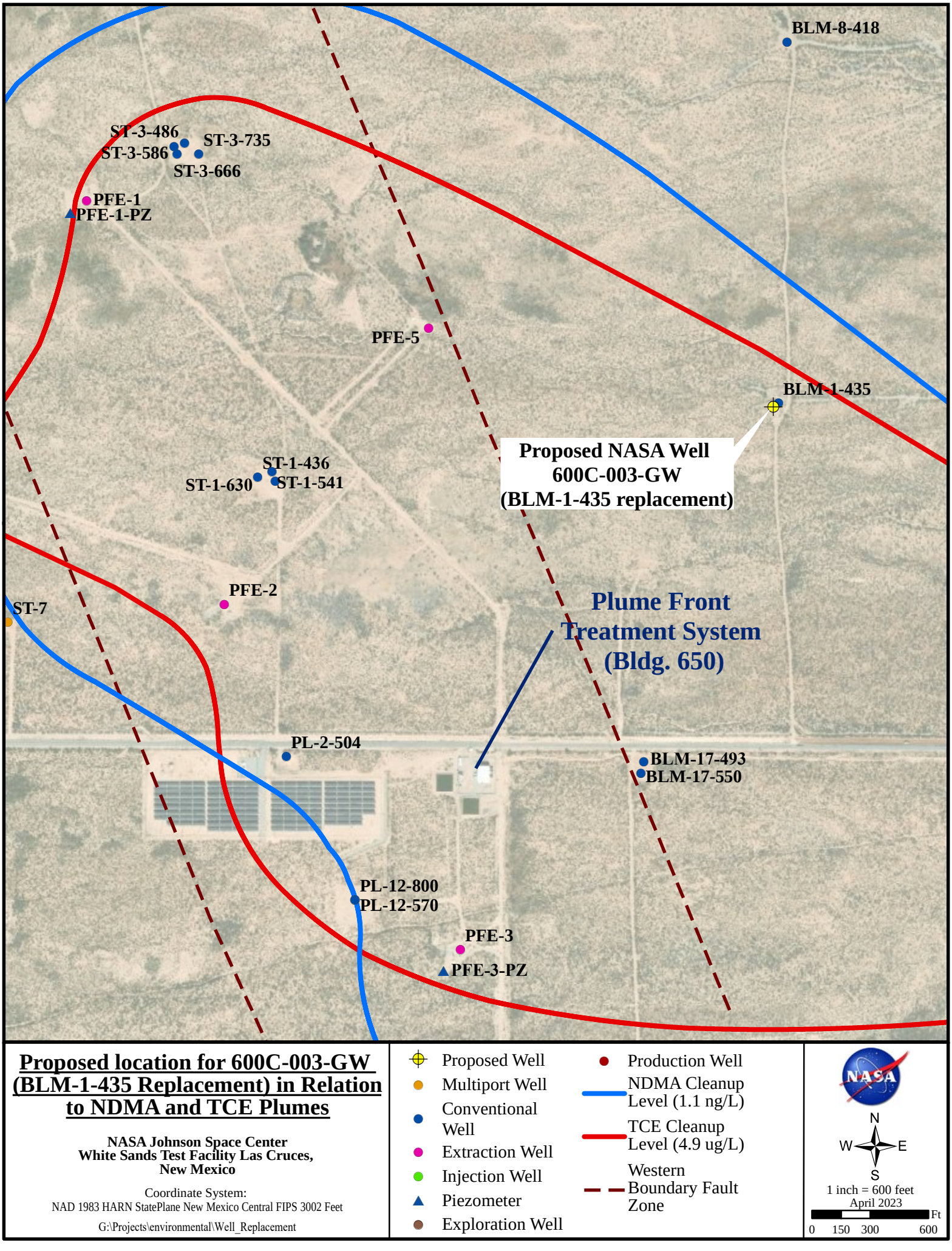
451.8' (137.71 m)- Top of 16/40 Sand.
455.1' (138.71 m)- Top of Bentonite Plug (Pellets).

459.4' (140.03 m)- Top of 16/40 Sand.
473.8' (144.41 m)- Top of 8/14 Sand.

500' (152.4 m)- ~7 7/8" Borehole TD.

Figure 5 **Proposed Well Location with Plume Extent**

(SEE NEXT PAGE)



Proposed location for 600C-003-GW (BLM-1-435 Replacement) in Relation to NDMA and TCE Plumes

NASA Johnson Space Center
White Sands Test Facility Las Cruces, New Mexico

Coordinate System:
NAD 1983 HARN StatePlane New Mexico Central FIPS 3002 Feet

G:\Projects\environmental\Well_Replacement

- Proposed Well
- Multiport Well
- Conventional Well
- Extraction Well
- Injection Well
- Piezometer
- Exploration Well
- Production Well
- NDMA Cleanup Level (1.1 ng/L)
- TCE Cleanup Level (4.9 ug/L)
- Western Boundary Fault Zone

N
W E
S

1 inch = 600 feet
April 2023

0 150 300 600 Ft

Figure 6 **BLM-1-435 Borehole Lithology Log**

(SEE NEXT PAGE)

BOREHOLE LITHOLOGIC LOG

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

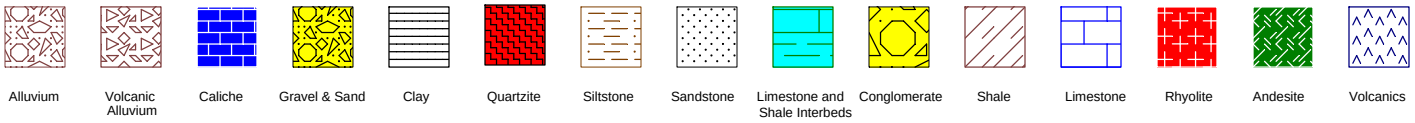
Location ID: **BLM-1-435**

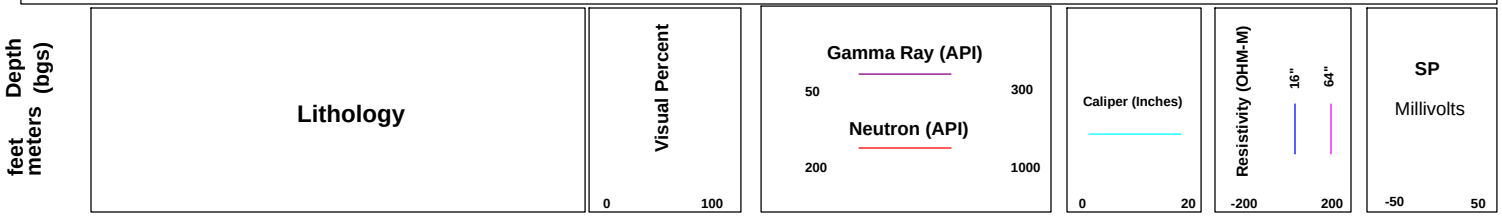
Site ID: **NASA-WSTF, Doña Ana County, NM**

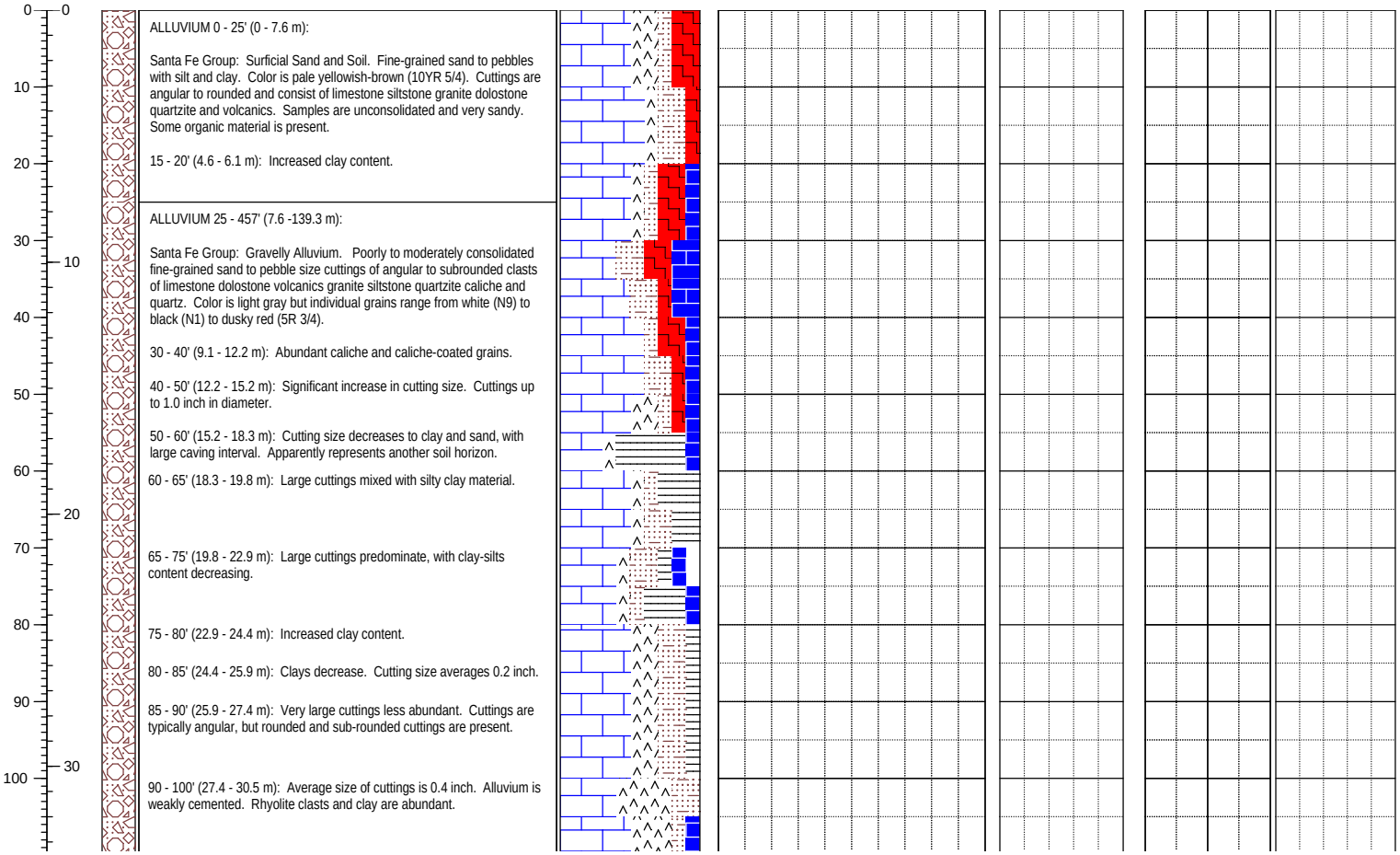
Township and Range: **SW 1/4 NW 1/4 SW 1/4 Sec.33 T20S R3E**
NM State Plane Coordinates (NAD 83): **168873.19 N 462776.98 E**
Elevation (Brass Cap): **1387.95 m AMSL**
Total Depth of Borehole (bgs): **500' (152.4 m)**
Depth to Bedrock (bgs): **457' (139.29 m); Rhyolite**
Drilling Method: **Mud/Air-Foam Rotary**
Drilling Contractor: **Larjon Drilling Company**
Driller: **J. Gower**

Depth to Groundwater: **398.5' (121.5 m) TOSC (10/6/87)**
Surface Casing Depth and Diameter: **Nominal 8" Carbon Steel to 32'**
Borehole Diameter: **8 3/4" to 35'; 7 7/8"? to 500'**
Geologist Field Rep: **E. Morse, J. Kaszuba, B. Cooper**
Dates Drilling Started and Completed: **9/23/1987 - 9/29/1987**
Geophysical Contractor: **Southwest Surveys**
Logger: **D. Pearson**
Comments: **Bedrock originally logged as andesite. Core description renamed unit as Porphyritic Latite. This is grouped as rhyolite for modeling purposes.**
AMSL = Above Mean Sea Level TOSC = Top of Surface Casing

Explanation:







ALLUVIUM 0 - 25' (0 - 7.6 m):

Santa Fe Group: Surficial Sand and Soil. Fine-grained sand to pebbles with silt and clay. Color is pale yellowish-brown (10YR 5/4). Cuttings are angular to rounded and consist of limestone siltstone granite dolostone quartzite and volcanics. Samples are unconsolidated and very sandy. Some organic material is present.

15 - 20' (4.6 - 6.1 m): Increased clay content.

ALLUVIUM 25 - 457' (7.6 -139.3 m):

Santa Fe Group: Gravelly Alluvium. Poorly to moderately consolidated fine-grained sand to pebble size cuttings of angular to subrounded clasts of limestone dolostone volcanics granite siltstone quartzite caliche and quartz. Color is light gray but individual grains range from white (N9) to black (N1) to dusky red (5R 3/4).

30 - 40' (9.1 - 12.2 m): Abundant caliche and caliche-coated grains.

40 - 50' (12.2 - 15.2 m): Significant increase in cutting size. Cuttings up to 1.0 inch in diameter.

50 - 60' (15.2 - 18.3 m): Cutting size decreases to clay and sand, with large caving interval. Apparently represents another soil horizon.

60 - 65' (18.3 - 19.8 m): Large cuttings mixed with silty clay material.

65 - 75' (19.8 - 22.9 m): Large cuttings predominate, with clay-silts content decreasing.

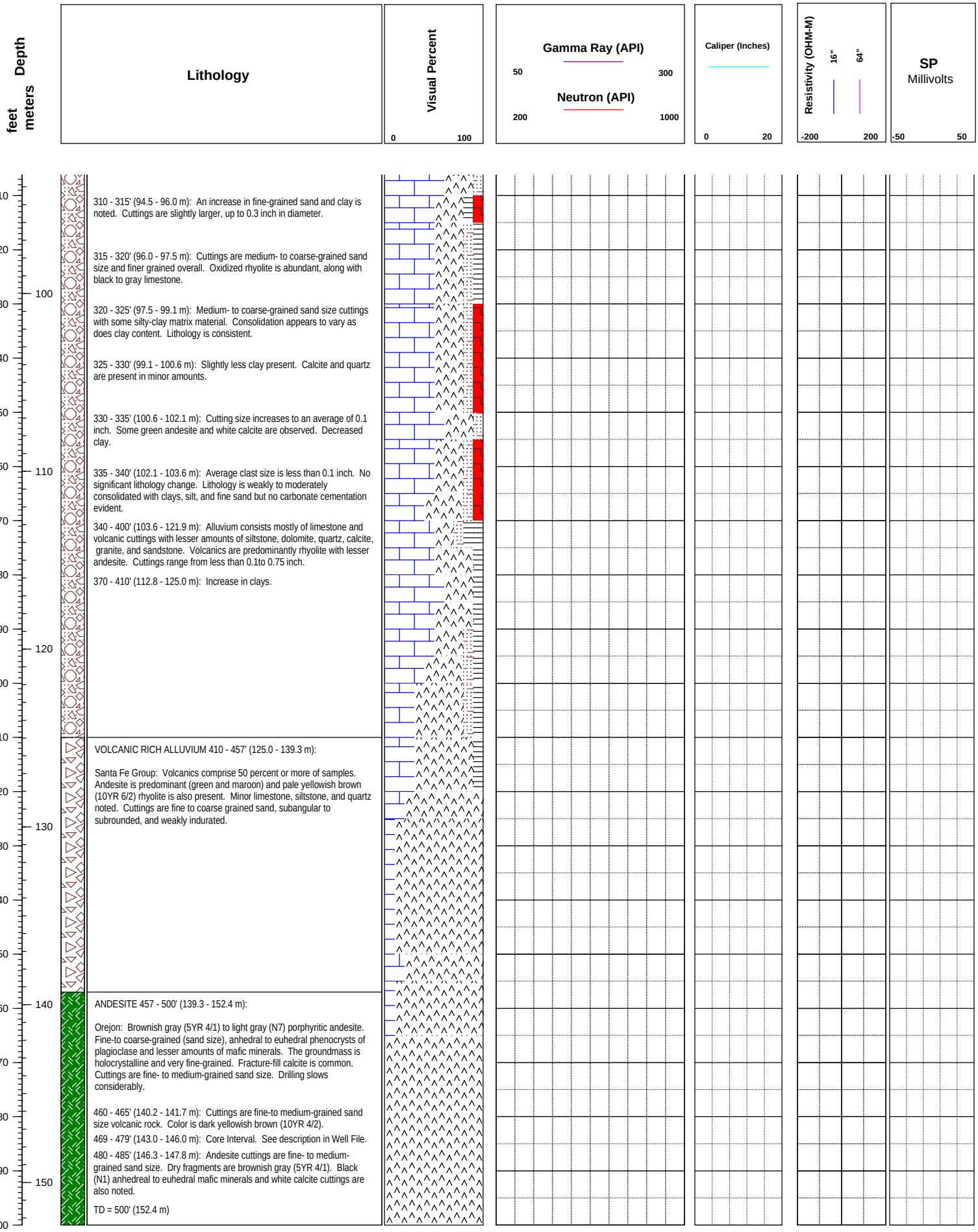
75 - 80' (22.9 - 24.4 m): Increased clay content.

80 - 85' (24.4 - 25.9 m): Clays decrease. Cutting size averages 0.2 inch.

85 - 90' (25.9 - 27.4 m): Very large cuttings less abundant. Cuttings are typically angular, but rounded and sub-rounded cuttings are present.

90 - 100' (27.4 - 30.5 m): Average size of cuttings is 0.4 inch. Alluvium is weakly cemented. Rhyolite clasts and clay are abundant.


Depth
feet
meters
Lithology
Visual Percent
0
100
Gamma Ray (API)
50
300
Neutron (API)
200
1000
Caliper (Inches)
0
20
Resistivity (OHM-M)
16"
64"
-200
200
SP
Millivolts
-50
50
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
40
50
60
70
80
90
100 - 115' (30.5 - 35.1 m): Clay decreases significantly to less than 10 percent of samples.
115 - 175' (35.1 - 53.3 m): Clay-rich zone.
175 - 180' (53.3 - 54.9 m): Clay decreases. Cuttings are medium-grained sand to pebble-size and angular. Lithologies include limestone, rhyolite, siltstone, and quartz.
180 - 185' (54.9 - 56.4 m): Cutting size increases, clay content decreases. Cuttings are up to 0.75 inch in diameter. Granite and andesite are present in low percentages.
210 - 215' (64.0 - 65.5 m): Noticeable decrease in clay content. Cuttings do not stick together as readily. Cutting size averages 0.4 inch. Cuttings consist of black to light gray limestone and dolomites, white to cream rhyolites, maroon siltstones and andesite. Trace amounts of quartz, granite, and calcite present.
215 - 220' (65.5 - 67.1 m): Cuttings range in size from 0.05 to 0.5 inch.
225 - 230' (68.6 - 70.1 m): Rhyolite and limestone make up most of the alluvium lithology.
230 - 235' (70.1 - 71.6 m): Some caliche-coated grains are present. Cuttings decrease in size to an average of less than 0.1 inch.
240 - 245' (73.2 - 74.7 m): Cuttings range from less than 0.1 to 1.0 inch and average 0.1 inch in diameter.
245 - 250' (74.7 - 76.2 m): Yellow oxidized rhyolite is common. Some caliche is present. No clays present.
250 - 255' (76.2 - 77.7 m): Cutting size decreases significantly and averages less than 0.1 inch. May indicate better consolidation of the alluvium. More white calcite is observe (fracture fill?)
255 - 260' (77.7 - 79.2 m): Cuttings increase in size to medium-grained sand and uniform.
265 - 270' (80.8 - 82.3 m): Small percent of granite cuttings noted.
275 - 280' (83.8 - 85.3 m): Cutting size increases to 1.0 to 2.0 inch (average).
285 - 290' (86.9 - 88.4 m): Cuttings are up to 0.5 inch in diameter.
290 - 295' (88.4 - 89.9 m): Slight increase in fine-grained sand and clay noted. Cuttings are less than 0.1 inch in diameter.


Depth
feet
meters
Lithology
Visual Percent
0
100
Gamma Ray (API)
50
300
Neutron (API)
200
1000
Caliper (Inches)
0
20
Resistivity (OHM-M)
16"
64"
-200
200
SP
Millivolts
-50
50
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
470
480
490
500
100
110
120
130
140
150
310 - 315' (94.5 - 96.0 m): An increase in fine-grained sand and clay is noted. Cuttings are slightly larger, up to 0.3 inch in diameter.
315 - 320' (96.0 - 97.5 m): Cuttings are medium- to coarse-grained sand size and finer grained overall. Oxidized rhyolite is abundant, along with black to gray limestone.
320 - 325' (97.5 - 99.1 m): Medium- to coarse-grained sand size cuttings with some silty-clay matrix material. Consolidation appears to vary as does clay content. Lithology is consistent.
325 - 330' (99.1 - 100.6 m): Slightly less clay present. Calcite and quartz are present in minor amounts.
330 - 335' (100.6 - 102.1 m): Cutting size increases to an average of 0.1 inch. Some green andesite and white calcite are observed. Decreased clay.
335 - 340' (102.1 - 103.6 m): Average clast size is less than 0.1 inch. No significant lithology change. Lithology is weakly to moderately consolidated with clays, silt, and fine sand but no carbonate cementation evident.
340 - 400' (103.6 - 121.9 m): Alluvium consists mostly of limestone and volcanic cuttings with lesser amounts of siltstone, dolomite, quartz, calcite, granite, and sandstone. Volcanics are predominantly rhyolite with lesser andesite. Cuttings range from less than 0.1to 0.75 inch.
370 - 410' (112.8 - 125.0 m): Increase in clays.
VOLCANIC RICH ALLUVIUM 410 - 457' (125.0 - 139.3 m):
Santa Fe Group: Volcanics comprise 50 percent or more of samples. Andesite is predominant (green and maroon) and pale yellowish brown (10YR 6/2) rhyolite is also present. Minor limestone, siltstone, and quartz noted. Cuttings are fine to coarse grained sand, subangular to subrounded, and weakly indurated.
ANDESITE 457 - 500' (139.3 - 152.4 m):
Orejon: Brownish gray (5YR 4/1) to light gray (N7) porphyritic andesite. Fine-to coarse-grained (sand size), anhedral to euhedral phenocrysts of plagioclase and lesser amounts of mafic minerals. The groundmass is holocrystalline and very fine-grained. Fracture-fill calcite is common. Cuttings are fine- to medium-grained sand size. Drilling slows considerably.
460 - 465' (140.2 - 141.7 m): Cuttings are fine-to medium-grained sand size volcanic rock. Color is dark yellowish brown (10YR 4/2).
469 - 479' (143.0 - 146.0 m): Core Interval. See description in Well File.
480 - 485' (146.3 - 147.8 m): Andesite cuttings are fine- to medium-grained sand size. Dry fragments are brownish gray (5YR 4/1). Black (N1) anhedreal to euhedral mafic minerals and white calcite cuttings are also noted.
TD = 500' (152.4 m)