National Aeronautics and
Space Administration

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

February 25, 2016

Reply to Attn of: RE-16-036

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

Subject: 200 and 600 Area Vapor Intrusion Assessment Work Plan

Enclosed is the 200 and 600 Area Vapor Intrusion Assessment Work Plan as required by NMED's November 30, 2015 Approval with Modifications of NASA's June 29, 2015 *NASA WSTF 200 Area Phase II Investigation Report* (Report). This submittal includes an Executive Summary as Enclosure 1, a paper copy of the report as Enclosure 2, and a CD-ROM with the complete report in PDF as Enclosure 3.

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

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

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

Executive Summary

Soil vapor contaminants at the 200 and 600 Area Hazardous Waste Management Units (HWMUs) have been defined by previous vadose zone investigations performed by NASA and approved with modifications by New Mexico Environment Department (NMED). Subsequent monitoring of 200 and 600 Areas soil vapor distribution has been performed through contemporaneous sampling events for all accessible multiport soil vapor monitoring ports within these areas. Comparison of analytical results to potentially applicable screening levels (NMED Vapor Intrusion Screening Level [VISLs] and White Sands Test Facility (WSTF) risk-based concentrations [RBCs]) indicates that industrial/occupational workers could be exposed to VOCs derived from the migration of subsurface soil vapor through vadose zone pore space and building foundations into indoor air. In NASA's 200 Area Phase II Investigation Report (IR) submitted on June 29, 2015, NASA proposed a vapor intrusion assessment of the complete vapor pathway for Building 200 near the location of the former Clean Room underground storage tank (UST); also known as the 200 Area west closure HWMU. NMED agreed with NASA's intent to address potential complete vapor intrusion pathway in an approval with modifications provided on November 30, 2015.

The evaluation of potential vapor intrusion in the 600 Area was added to this Vapor Intrusion Assessment Work Plan (VIAWP) following communications between NASA and NMED. NASA has performed several vadose zone investigations at the 600 Area HWMU, and concluded that the source of soil vapor contaminants beneath the 600 Area HWMU is the underlying groundwater. In a November 25, 2015 letter to NMED, NASA proposed an assessment of the 600 Area. Building 637, located southeast of the 600 Area HWMU, is the closest structure and constitutes the primary target that could experience a pathway for potential receptor exposure. The approach of utilizing Buildings 200 and 637 for the same assessment will ensure consistent evaluation of the vapor intrusion pathway at the 200 west Closure and 600 Area HWMUs.

The VIAWP forms part of a tiered evaluation process. Vadose zone soil and shallow groundwater concentrations have previously been compared to available NMED Soil Screening Levels and WSTF groundwater cleanup levels defined in the Groundwater Monitoring Plan (GMP) in accordance with the Permit. Soil vapor samples have also been collected from the network of vapor monitoring wells installed in the 200 and 600 Areas and the soil vapor results screened against NMED VISLs and WSTF RBCs. The two locations most likely to present the greatest potential for vapor intrusion comprise the 200 Area immediately adjacent to, and below the foundation of the west side of Building 200 at the location of the former Clean Room tank HWMU, and 600 Area Building 637 located near the 600 Area Surface Impoundments HWMU.

This VIAWP evaluates the potential for a complete pathway between soil vapor in the vadose zone and industrial/occupational indoor air by addressing the first two steps of the tiered approach. Steps three and four are dependent on the results of the investigation described in this VIAWP.

- Step 1: compare the maximum detected concentrations for vadose zone soil vapor to the corresponding NMED VISL and/or WSTF RBC using the latest available information.

- Step 2: evaluate the vapor intrusion pathway to characterize potential subsurface sources based on additional lines of evidence including evaluation of the building foundation, determination of any preferential pathways, identification of building ventilation systems, collecting shallow vadose zone samples from adjacent soil vapor wells, and collecting grab samples from indoor and outdoor air at the buildings of concern.

- Step 3: additional investigative measures may be proposed following VIAWP data evaluation if NMED concurrence is not reached.

- Step 4: if it is established that vapor intrusion can potentially impact human health, a human health risk assessment and potential remedial activity may be required.

It is preferable that NMED VISLs and WSTF RBCs are both considered during the screening process. WSTF site-specific RBCs will be updated to incorporate new toxicity data and exposure factors, as well as the effects of mutagenicity with the most recent 2016 data. Following NMED approval of the RBCs, they will be utilized as part of the screening criteria to determine if residual soil vapor contaminants in the vadose zone have infiltrated the adjacent buildings at unacceptable levels. Where multiple contaminants are detected, the cumulative effects of those contaminants will be considered as described in the NMED guidance. If COPC concentrations exceed the cleanup levels for direct exposure routes under the construction worker scenario for either of the 200 Area or 600 Area building locations, a corrective measures evaluation phase may be required. Alternately, a "Corrective Action Complete" status determination may be considered. If this VIAWP does not determine the nature and extent of contamination, additional site characterization may be required.

Adjacent to the 200 Area Clean Room Tank HWMU, soil vapor samples will be collected from shallow soil vapor ports in wells 200-SV-05 at 9 feet (ft) below ground surface (bgs), 200-SV-09 at 19 ft bgs, and 200-LV-150 at 34 ft bgs. All three wells are located within 85 ft of the west side of Building 200. In the 600 Area soil vapor samples will be collected from shallow soil vapor ports in wells 600-SGW-1 at 12.5 ft bgs, 600-SGW-2 at 12.5 ft bgs, and 600-SGW-5 at 7.5 ft bgs. All three wells are located within 240 ft of Building 637.

Indoor and outdoor air samples will be collected simultaneously with the well samples from indoor airspace within individual building rooms. In the 200 Area, indoor samples will be collected at locations in Building 200 above and adjacent to the subsurface footprint of the former 200 Area Clean Room Tank HWMU along with outdoor air samples adjacent to Building 200 at upgradient locations relative to the prevailing wing direction. In the 600 Area, indoor air samples will be collected in Building 637 within the single room along with outdoor air samples at an adjacent upgradient location relative to the prevailing wind direction. Sample collection activities are proposed as two single semi-annual events in the summer and winter to address potential seasonal air pressure fluctuations that could affect vapor intrusion (start date pending NMED approval of this VIAWP). Vadose zone, indoor air, and outdoor air samples will be collected on the same day in each area. Samples in the 200 and 600 Areas will be collected on consecutive days if feasible. Indoor and outdoor air sampling procedures will being performed to best differentiate the effects of vapor intrusion from other indoor and ambient sources. Soil vapor samples will be analyzed using EPA Method TO-15 in order to achieve the VIAWP DQOs.

Three primary investigation phases are proposed: 1) pre-assessment planning and preparation; 2) execution of the field assessment activities; and 3) data assessment and preparation of the assessment report (AR) detailing the findings of the assessment. WSTF soil vapor RBCs will be updated to 2016 values contemporaneously with the performance of pre-assessment planning and preparation activities. Following NMED approval of the RBCs, NASA will perform the field assessment activities and utilize the RBCs in conjunction with NMED VISLs during the data review process and development of the final report. Planning and preparation activities are anticipated to require approximately four months. Field assessment activities will take approximately six months due to the performance of two semi-annual soil vapor sampling events performed in consecutive summer and winter seasons. The results of the second vapor intrusion assessment sampling event should be received within 30 days of the sampling event and incorporated into an AR for submittal to NMED two months following the receipt of soil vapor sample results.

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200 Area and 600 Area

Vapor Intrusion Assessment Work Plan

February 2016

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

200 and 600 Area Vapor Intrusion Assessment Work Plan

February 2016

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.

Timothy J. Davis
Chief, Environmental Office

2/25/16
Date

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zone samples from adjacent soil vapor wells, and collecting grab samples from indoor and outdoor air at the buildings of concern.

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Table of Contents

Executive Summary iii
Table of Contents vi
List of Figures and Tables ix
List of Acronyms x
1.0 Introduction 1
1.1 Objectives and Scope 2
1.2 Approach 3
1.2.1 Screening Levels 3
1.2.2 Vapor Intrusion Pathway 4
1.3 Implementation 4
1.4 Regulatory Requirements 5
1.5 Other Considerations 5
1.5.1 Comparison between NMED VISLs and WSTF RBCs 5
1.5.2 NMED Vapor Intrusion Screening Options 6
1.5.3 HWMU Closure Integrity 6
2.0 Background 6
2.1 Operational History 8
2.1.1 200 Area 8
2.1.2 600 Area 9
2.2 Contaminants of Concern 9
2.3 Preliminary Site Conceptual Exposure Model 9
2.3.1 Contamination Sources 10
2.3.2 Release Mechanisms 10
2.3.3 Exposure Pathways 10
2.3.4 Potential Receptors 10
3.0 Site Conditions 10
3.1 HWMU Description 11
3.1.1 200 Area Clean Room Tank HWMU Description 11
3.1.2 600 Area HWMU Description 11
3.2 Surface Conditions 11
3.3 Subsurface Conditions 12
3.3.1 200 Area 12
3.3.2 600 Area 13
4.0 Scope of Activities 13
4.1 Data Quality Objective Process 14

4.1.1 Problem Statement 14
4.1.2 Decision Statement and Alternative Actions 14
4.1.3 Decision Inputs 15
4.1.4 Study Boundaries 15
4.1.5 Study Constraints 15
4.1.6 Decision Rule 15
4.2 Sampling Tasks 16
4.2.1 Sample Location Description 16
4.2.2 Vadose Zone Soil Vapor Sample Locations and Schedule 16
4.2.3 Indoor and Outdoor Air Sample Locations and Schedule 17
5.0 Assessment Methods 18
5.1 Vadose Zone Soil Vapor Sampling 18
5.2 Building Foundation Evaluations 18
5.3 Indoor and Outdoor Air Sampling 19
5.3.1 Pre-Sampling Inspection 19
5.3.2 Preparation of Building 19
5.3.3 Sampling Requirements 20
5.4 Sampling Procedures and Requirements 20
5.5 Analytical Tasks 21
5.6 Health and Safety 22
6.0 Decontamination of Field Screening Instruments 23
7.0 Field Documentation Procedures 23
8.0 Investigation-Derived Waste Management Plan 24
9.0 Data Management Tasks 24
9.1 Project Documentation and Records 24
9.1.1 Sample Collection and Field Measurements Data 24
9.1.2 Off-site Laboratory Data 24
9.2 Data Assessment, Review, and Corrective Action Procedures 24
9.3 Assessment and Response Actions 25
9.4 Data Review Process 25
9.5 Data Review Elements 25
10.0 Current Monitoring and Sampling Programs 26
11.0 Schedule 26
12.0 References 27
Figures 30
Tables 41

Appendix A Investigation-Derived Waste Management Plan A-1
Appendix B Building Inspection Form B-1

List of Figures and Tables

Figure 1.1 WSTF Location Map 31

Figure 1.2 Vapor Intrusion Assessment Building Locations 32

Figure 2.1 Freon 113 Soil Vapor and Groundwater Concentrations (October 2014) 33

Figure 2.2 TCE Soil Vapor and Groundwater Concentrations (October 2014) 34

Figure 2.3 PCE Soil Vapor and Groundwater Concentrations (October 2014) 35

Figure 2.4 Site Conceptual Exposure Model 36

Figure 3.1 Building 200 Site Conditions 37

Figure 3.2 Building 637 Site Conditions 38

Figure 4.1 West Building 200 Soil Vapor and Air Sampling Locations 39

Figure 4.2 Building 637 Soil Vapor and Air Sampling Locations 40

Table 1.1 Comparison of Vapor Concentration Guidance Levels 42

Table 4.1 Proposed Soil Vapor Monitoring Well Sampling Locations 43

Table 4.2 Proposed Indoor and Outdoor Air Sampling Locations 44

µg	microgram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
AOI	Area of Interest
AR	Assessment Report
bgs	below ground surface
CAP	RCRA Corrective Action Program
CFR	Code of Federal Regulations
CH_4	Methane
CO_2	Carbon Dioxide
CoC	Chain-of-custody
COPC	Contaminant of potential concern
DQOs	Data Quality Objectives
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
Freon 11	Trichlorofluoromethane
Freon 113	1,1,2-Trichloro-1,2,2-Trifluoroethane)
ft	Feet/foot
GCL	Geosciences Consultants, Ltd.
GCL	Geosciences Consultants, Ltd.
GMP	Groundwater Monitoring Plan
GSA	Gardner Spring Arroyo
HAZWOPER	Hazardous Waste Operations and Emergency Response
HIS	Historical Information Summary
HVAC	Heating, Ventilation, and Air Conditioning
HWB	Hazardous Waste Bureau
HWMU	Hazardous Waste Management Unit
HWTL	Hazardous Waste Transmission Line
IDW	Investigation-derived waste
in.	Inch(es)
IR	Investigation Report
IWP	Investigation Work Plan
JDMB	Jornada del Muerto Basin
JSC	Johnson Space Center
m	meter
MSVGM	Multiport Soil Vapor and Groundwater Monitoring
MSVM	Multiport Soil Vapor Monitoring
NASA	National Aeronautics and Space Administration
NMED	New Mexico Environment Department
O_2	Oxygen
ODEQ	Oregon Department of Environmental Quality
OSHA	Occupational Safety and Health Administration
PCC	Post-Closure Care
PCE	Tetrachloroethene
PDF	Portable Document File
PEL	Permissible Exposure Limit(s)
PID	Photoionization Detector

PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RBC	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SAM	San Andres Mountains
SCEM	Site Conceptual Exposure Model
SDS	Safety Data Sheet(s)
SHP	Safety and Health Plan
SOP	Standard Operating Procedure
sq ft	Square foot/feet
SSL	Soil Screening Level
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbons
UST	Underground Storage Tank
VIAWP	Vapor Intrusion Assessment Work Plan
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compounds
WSTF	White Sands Test Facility

1.0 Introduction

The National Aeronautics and Space Administration (NASA) Johnson Space Center (JSC) White Sands Test Facility (WSTF) is located at 12600 NASA Road in central Doña Ana County, New Mexico. The site is approximately 12 miles northeast of Las Cruces, New Mexico and 65 miles north of El Paso, Texas (Figure 1.1). The WSTF U.S. Environmental Protection Agency (EPA) Facility Identification Number is NM8800019434. The facility has supported testing of space flight equipment and hazardous materials since 1964. WSTF contains five closed hazardous waste management units (HWMUs) that are under post-closure care (PCC) and 37 solid waste management units (SWMUs) within the 200, 300, 400, and 600 Areas. PCC requirements are specified by the NASA WSTF Hazardous Waste Permit (Permit) issued by the New Mexico Environment Department (NMED; NMED, 2009a). Specific regulatory requirements are discussed in Section 1.4.

The concentrations and distribution of soil vapor contaminants at the 200 and 600 Area HWMUs have been defined by previous comprehensive vadose zone investigations (NASA, 2011; 2013a; 2015b) that have all been approved with modifications by NMED (NMED, 2011a; 2013b; 2015b; 2015c). Subsequent monitoring of 200/600 Area soil vapor distribution has been performed through contemporaneous semi-annual sampling of all accessible multiport soil vapor monitoring ports in the 200 and 600 Areas along with groundwater sampling at underlying or nearby locations (NASA, 2012a; 2012d; 2013b; 2015b).

NASA submitted the results of the *200 Area Phase II Investigation Report* (IR; NASA, 2015b) on June 29, 2015. The IR described the most recent phase of a comprehensive 200 Area vadose zone investigation and included the results of the latest comprehensive soil vapor sampling event in the 200 and 600 Areas conducted in October 2014. Based on the results of the IR, NASA proposed a quantitative assessment of the complete vapor intrusion pathway for the Building 200 foundation near the location of the former Clean Room underground storage tank (UST; also known as the 200 Area west closure HWMU). NMED agreed with NASA's intent to address potential complete vapor intrusion pathways in their approval with modifications for the IR on November 30, 2015 (NMED, 2015c).

The assessment of potential vapor intrusion in the 600 Area was proposed following recent written communications between NASA and NMED. On April 16, 2015, NASA submitted the *600 Area Perched Groundwater Extraction Pilot Test Interim Status Report – Project Year 2* for NMED review (NASA, 2015a). NMED approved the report with modifications on July 15, 2015, and required further investigation of the source of contamination at or near the HWMU (NMED, 2015b). NASA has already performed several investigations at the 600 Area HWMU, and concluded there is not a continuing source of contamination in the vadose zone beneath the HWMU. In a November 25, 2015 letter to NMED (NASA, 2015d), NASA included a summary of the environmental investigations performed at the 600 Area HWMU, the findings of those investigations, and the NMED responses to NASA's conclusions.

Based on the comprehensive sampling of soil, soil vapor, and groundwater and the strong correlations between groundwater and soil vapor concentrations at the 600 Area HWMU, NASA has demonstrated that the source of soil vapor contaminants beneath and adjacent to the HWMU is the underlying groundwater. NMED indicated their concurrence with these conclusions based on the approval of these investigation reports. However, it has yet to be determined whether the presence of volatile organic compounds (VOCs) in soil vapor presents a risk to human health or the environment, or if there are complete exposure pathways between the 600 Area HWMU and human receptors. Building 637, located southeast of the Closure, is the closest potential structure that could provide a pathway for receptor exposure. Inclusion of the 600 Area will ensure a consistent evaluation of vapor intrusion at the 200 and 600 Area HWMUs and resolve the currently undetermined risk and pathway issues for the 600 HWMU.

1.1 Objectives and Scope

The process to assess and remediate vapor intrusion in buildings involves a tiered approach. Firstly, source area vadose zone soil and groundwater VOC concentrations are compared to available regulatory standards; the NMED Soil Screening Levels (SSLs; NMED, 2015a) and WSTF groundwater cleanup levels (Groundwater Monitoring Plan [GMP]; NASA, 2015b). Secondly, concentrations of VOCs in soil vapor are compared to NMED Vapor Intrusion Screening Levels (VISLs; NMED 2015a) and WSTF Risk-Based Concentrations (RBCs; NASA, 2012c). Both of these comparisons have been performed in the 200 and 600 Areas. Because specific samples in the 200 Area were identified that exceeded soil vapor levels during both soil vapor screening processes (NASA, 2015c), NASA and NMED agreed that the next step in the investigation process will be a vapor intrusion assessment focused on the areas of greatest potential concern.

The objective of this 200 Area and 600 Area Vapor Intrusion Assessment Work Plan (VIAWP) is to perform a complete evaluation of the vapor intrusion pathways at the priority locations within the 200 and 600 Areas that present the most likely routes for vapor intrusion based on previous investigations (Figure 1.2). These locations can be described specifically as follows.

- The 200 Area immediately adjacent to, and below the foundation of Building 200 above the location of the former Clean Room tank HWMU, and adjacent to soil borings 200-SB-05 (well 200-SV-05), 200-SB-06 (well 200-LV-150), and 200-SB-09 (well 200-SV-09). This location provided the highest soil vapor concentrations in the 200 Area vadose zone for 1,1,2-trichloro-1,2,2-trifluoroethane (Freon®[1] 113), trichloroethene (TCE), and tetrachloroethene (PCE) during the October 2014 comprehensive soil vapor sampling event (NASA, 2015c). According to the *NMED Risk Assessment Guidance for Site Investigations and Remediation* (NMED, 2015a), this location exceeds NMED industrial/occupational VISLs for Freon 113, TCE, and PCE, WSTF's RBC for TCE at a location that is immediately adjacent to a building, and falls into the "complete pathway" category for vapor intrusion.
- The 600 Area between the 600 Area HWMU and Building 637 located 150 feet (ft) to the southeast, near soil borings 600-SB-02 (multiport soil vapor monitoring [MSVM] well 600-SGW-02), 600-SB-05 (MSVM well 600-SGW-05), and 600-SB-06 (MSVM well 600-SGW-06). This location provided the highest soil vapor concentrations in the 600 Area vadose zone for TCE and some of the highest for Freon 113 during the October 2014 comprehensive soil vapor sampling event (NASA, 2015c). Building 637 is the most proximal structure to the southeast side of the 600 Area HWMU. This location also exceeds NMED industrial/occupational soil vapor VISLs for TCE and falls into the "complete pathway" category for vapor intrusion.

The scope of the VIAWP is to evaluate the potential for a complete pathway between soil vapor in the vadose zone and industrial/occupational indoor air in the adjacent buildings in accordance with NMED guidance (NMED, 2015a). The following steps are planned; Steps 1 and 2 will be performed as part of this assessment.

- Step 1: compare the maximum detected concentrations for vadose zone soil vapor and indoor/outdoor air to the corresponding NMED VISL and NMED-approved WSTF RBC.
- Step 2: evaluate the vapor intrusion pathway to characterize potential subsurface sources based on multiple lines of evidence. Reviews of site history and potential sources, the comparison of

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

groundwater and soil vapor concentrations to NMED VISLs (NMED, 2015a) and WSTF RBCs (NASA, 2012c), and monitoring of vapor migration and attenuation in the vadose zone have already been performed. Additional activities that will be completed in accordance with the VIAWP include evaluation of the building foundations and determination of any preferential pathways, identification of the building ventilation systems, and the collection of shallow soil vapor samples in nearby MSVM and multiport soil vapor and groundwater monitoring (MSVGM) wells in conjunction with indoor and outdoor air sampling at the two building locations being evaluated.

- Step 3: additional investigative measures may be proposed following VIAWP data evaluation if NMED concurrence is not reached (NMED, 2015a).
- Step 4: if it is established that vapor intrusion can potentially impact human health, a human health risk assessment and potential remedial activity may be required.

1.2 Approach

1.2.1 Screening Levels

WSTF industrial/occupational workers could be exposed to VOCs derived from the migration of subsurface soil vapor and/or groundwater through pore spaces in the vadose zone and building foundations into indoor air. The NMED *Risk Assessment Guidance for Investigations and Remediation* (NMED, 2015a) provides preliminary criteria to determine when vapor intrusion pathways must be evaluated:

- If there are compounds present in subsurface media that are sufficiently volatile and toxic, and
- If there are existing or planned buildings where exposure could occur.

"A chemical is considered to be sufficiently volatile if its Henry's law constant is 1×10^{-5} atm-m^3/mole or greater and its molecular weight is approximately 200 g/mole or less. A chemical is considered to be sufficiently toxic if the vapor concentration of the pure component poses an incremental life time cancer risk greater than 1E-05 or the noncancer hazard index is greater than 1.0."

It is important to note that NMED guidance states that VISLs are not designed to be used as action standards or cleanup levels, but can be used as a tool to estimate potential cumulative risks and/or hazards from exposure to volatile and toxic chemicals and to determine if further evaluation may be needed using site-specific data. NMED (2015a) indicates that VISLs can be used as a first tier screening assessment under certain circumstances including; the absence of shallow groundwater, no shallow soil contamination within 10 ft of the foundation base, no buildings with subsurface openings, no significant vadose zone advective transport (from landfills producing methane or industrial sites with applicable vapor density), and no leaking vapors from gas transmission lines. If site conditions are not favorable for using VISLs, a site specific evaluation must be conducted (NMED, 2015a). NMED VISLs are used for first tier screening due to the following:

- The 200 and 600 Areas have relatively deep groundwater sources (greater than 100 ft) below the building foundation levels.
- Shallow soil contamination resulting in vapor sources was not identified during previous investigations, although samples are greater than 10 ft from the building foundations. The closest soil sample to Building 200 was in soil boring 200-SB-05 located 18 ft from the building at a depth of 8 to 10 ft bgs. The closest soil sample to Building 637 was collected below the 600 Area Closure cap in soil boring 600-SB-05 located 181 ft from the building at a depth of 8 to 10 ft bgs.

- Buildings do not have significant known openings to the subsurface (no sumps or earthen floors) nor significant preferential pathways.
- No known sources exist for advective transport (no vapor-forming chemicals released within an enclosed space where vapors could migrate downward through cracks and openings in floors and into the vadose zone).
- No known leaking gas transmission lines exist at WSTF.

In addition to NMED VISLs, WSTF soil vapor RBCs are also preferred relative to the screening and evaluation of soil vapor intrusion (NASA, 2012c). Site-specific WSTF RBCs represent the maximum VOC concentrations allowed in soil vapor for a complete vapor intrusion pathway. First developed in 2012, these RBCs were based on EPA ambient air regional screening levels. The WSTF RBC calculations were completed for multiple depths in the vadose zone to provide a direct comparison to soil vapor samples collected at the equivalent depths. In accordance with an NMED suggestion (NMED, 2015c), NASA will update the existing RBCs using available 2016 data in conjunction with the pre-assessment planning and preparation activities for this vapor intrusion assessment. Updated RBCs will then be available for use as a component for the vapor intrusion screening assessment. To provide the best understanding of potential exposure, soil vapor and air concentrations will be referenced and compared to the latest NMED VISLs, updated WSTF RBCs, and Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) for air contaminants (Table 1.1).

1.2.2 Vapor Intrusion Pathway

No significant VOCs were detected in vadose zone soil samples collected during the 200 Area or 600 Area investigations (NASA, 2015c, 2011). In the 200 Area, organic compounds with more than one detection in soil samples were limited to traces of toluene and acetone at concentrations several orders of magnitude below the applicable NMED SSLs. Traces of acetone were considered an artifact of the sampling and analytical processes. The random horizontal and vertical distribution of trace concentrations of toluene do not support a vadose zone contaminant source. In the 600 Area, traces of trichlorofluoromethane (Freon 11), Freon 113, TCE, and PCE were rarely reported in soil samples, again at concentrations orders of magnitude below applicable NMED SSLs. NMED approved No Longer Contained in Determinations for all soils from the 200 Area and 600 Area investigations (NMED, 2009b, 2011b, 2014a, 2014b). Soils were redistributed at surface in the vicinity of the soil borings from which they were derived (NASA, 2015c, 2011). VOCs were detected above the applicable NMED VISLs in soil vapor and above the TCE cleanup level for groundwater samples collected in conjunction with the soil samples.

Two types of vapor sampling data will be collected for the assessment of the vapor intrusion pathway: passive and active. Passive vadose zone soil vapor samples from MSVM and MSVGM wells will be used to confirm the presence of VOCs and their relative concentrations at specific depths in the vadose zone. Active vapor samples from indoor and outdoor air within the target buildings are required for quantitative risk assessments. Chemicals that should be considered for the vapor intrusion pathway include both volatile and toxic constituents (NMED, 2015a). For each of the 200 and 600 Area building assessments, the vapor intrusion pathway will be considered: 1) incomplete and no action required; 2) potentially complete and a qualitative evaluation required; or 3) complete and quantitative evaluation required.

1.3 Implementation

The VIAWP incorporates the following activities:

- Project planning and preparation; NASA will develop the required internal planning documents and coordinate the assignment of on and off-site resources for the assessment.
- Assessment activities, including soil vapor sample collection from MSVM and MSVGM wells and indoor and outdoor air sample collection at and adjacent to target buildings.
- Investigation-derived waste (IDW) management as described in the IDW Management Plan (Appendix A).
- Data evaluation to determine if there are contaminants of potential concern (COPC) concentrations above screening levels for vadose zone soil vapor or indoor and outdoor air at the target buildings. If COPCs are detected at concentrations above screening levels, the data may be used to guide remedial action, if necessary.
- Development and submittal of the 200 Area and 600 Area Vapor Intrusion Assessment Report (AR) to NMED.

1.4 Regulatory Requirements

The Permit requires that NASA investigate and address historical releases of hazardous waste and hazardous constituents that may have occurred at sites throughout WSTF as part of the Resource Conservation and Recovery Act (RCRA) corrective action process (CAP). The CAP consists of investigation, characterization, and, if necessary, cleanup. The principal components of the CAP are:

- RCRA Facility Assessment.
- RCRA Facility Investigation.
- Interim Corrective Measures (if necessary).
- Corrective Measures Study (if necessary).
- Corrective Measures Implementation (if necessary).

Sections V.B.6.a.i through V.B.6.a.v of the Permit (NMED, 2009a) address activities related to investigation of the 200 Area and V.B.6d.i through V.B.6.d.v activities related to the investigation of the 600 Area. These activities have been completed. The Permit (NMED, 2009a) does not include cleanup standards for soil vapor. However, NMED has issued the *Risk Assessment Guidance for Site Investigations and Remediation Volume I* (NMED, 2015a) and has requested that NASA use this guidance to provide specific information on the development of screening levels for soil vapor contaminants and for evaluating exposure pathways and receptors. NMED guidance requires that a quantitative vapor intrusion pathway assessment be performed where a “complete pathway” category exists (NMED, 2015a). If the 200 Area and 600 Area assessment indicates a complete pathway and unacceptable risk is present at either of the two target building locations in the 200 and 600 Areas, NASA expects to work with NMED to perform a corrective measures evaluation in accordance with Section VII.J of the Permit.

1.5 Other Considerations

1.5.1 Comparison between NMED VISLs and WSTF RBCs

Screening criteria for soil vapor are essential to effectively define areas of concern and implement corrective actions for soil vapor at WSTF. NMED VISLs from the recent guidance (NMED, 2015a) were compared to Site-specific WSTF RBCs (NASA, 2012c) to focus on the differences between the two potentially applicable criteria (Table 1.1).

- NMED VISLs comprise a single conservative value that is not depth sensitive (NMED 2015a); whereas WSTF RBCs are depth sensitive (vapor concentrations in multiport wells are compared to the RBCs for the equivalent depth). Elevated COPC concentrations at depths more proximal to the groundwater table are therefore not taken into account by the VISLs.
- NMED VISLs are between one to two orders of magnitude lower than the corresponding WSTF RBCs for primary soil vapor COPCs in the vadose zone.
- WSTF RBCs serve to isolate specific target vadose zone locations; whereas NMED VISLs identify a significantly broader area. In general terms, specific NMED VISLs (e.g., TCE) have distributions coincident with the footprint of the WSTF source area groundwater plume (Section 2.0).

1.5.2 NMED Vapor Intrusion Screening Options

NMED presented the available vapor intrusion screening assessment criteria alternatives in their November 30, 2015 200 Area Phase II Approval with Modifications (NMED, 2015c). Each of these criteria will be considered during the evaluation of data generated during the assessment described in the VIAWP.

- NMED VISLs (NMED, 2015a) should be used during the initial screening process.
- Option – update the 2012 WSTF RBCs (NASA, 2012c) to incorporate new toxicity data, new exposure factors, and effects of mutagenicity with the most recent data. Following the update, NMED approval is required prior to their application.
- Option – consider modifying the NMED VISLs with site-specific data. Following the modifications, NMED approval is required prior to their application.

1.5.3 HWMU Closure Integrity

The field assessment activities presented in this VIAWP will not compromise the integrity of the 200 Area former Clean Room Tank HWMU. The original closure cap was removed when the building extension was constructed. The 200 Area former Clean Room Tank excavation cannot be accessed as it is located under Building 200 which is still in operation. A MSVM well (200-SV-05) and MSVGM well (200-LV-150) are located adjacent to the building and any additional sampling will not affect the closure cap.

Activities in the 600 Area will not compromise the integrity of the 600 Area closure cap, as MSVM wells 600-SGW-2, 600-SGW-5, and 600-SGW-6 were installed through or adjacent to the cap during previous investigations. Any unintentional damage to either of the HWMU closures will be identified during a post-assessment evaluation of closure conditions. If any repairs are required, a mitigation plan will be prepared and submitted to NMED for approval.

2.0 Background

Concentrations of soil vapor contaminants in the WSTF source areas vadose zone are widespread and have been identified and delineated during previous soil vapor surveys (Geosciences Consultants, Ltd. [GCL], 1986; NASA, 2013a). The first shallow soil vapor survey performed at WSTF (GCL, 1986) incorporated all WSTF source areas and areas topographically and hydrologically downgradient to the west. A strong correlation between the footprint of the groundwater contaminant plume and the overlying soil vapor contaminant plume within the vadose zone was observed. Soil vapor concentrations decreased

to the west as the depth to the groundwater table increased from approximately 140 ft in the source areas to over 400 ft in the Jornada del Muerto Basin (JDMB), which was consistent with a groundwater source.

The most recent 200 Area vadose zone investigation that included a soil vapor survey was performed using a phased approach with fieldwork and laboratory testing activities completed between June 2012 and January, 2013 (Phase I) and June 2014 through January 2015 (Phase II). NMED requested that NASA report the 200 Area Phase I investigation results separately prior to implementing Phase II of the investigation (NMED, 2012). This allowed NMED to evaluate the initial Phase I data and review NASA's strategy for the Phase II investigation.

The Phase I field investigation (NASA, 2013a) included the shallow soil vapor survey, which was performed on a grid across the WSTF 200 Area and portions of the adjacent 100, 600, and 800 Areas in order to derive shallow soil vapor isoconcentration maps and delineate additional areas of interest (AOIs). The survey was conducted in two sub-phases using Gore™[2] Modules emplaced at a depth of 2.5 ft bgs in a grid pattern on 250-ft centers to evaluate soil vapor adjacent to and surrounding three HWMUs (former 200 Area USTs and former 600 Area impoundments), SWMUs 4 through 9, portions of SWMU 10, SWMUs 19 and 20, and six additional targets identified in the 200 Area Historical Information Summary (HIS; NASA, 2012b). The initial survey incorporated 144 survey points. An additional 38 points were installed within the grid to further evaluate specific areas yielding the highest soil vapor concentrations. Each sample module was analyzed for a total of 45 VOCs using EPA Method 8260. Five VOCs showed consistent detections in the vadose zone: TCE; PCE; Freon 11; Freon 113; and total petroleum hydrocarbons (TPH). NASA submitted the results in the 200 Area Phase I Status Report on January 30, 2013 (NASA, 2013a). Following NMED review (NMED, 2013a), NASA submitted a revised Phase I IR on August 6, 2013 (NASA, 2013c). The revised report was approved by NMED on October 22, 2013 (NMED, 2013b).

The Phase II field investigation comprised subsurface evaluation of 200 Area HWMUs, SWMUs, AOIs outlined in the Phase I IR and additional locations required by NMED (2013b). Subsurface drilling with soil and bedrock core sampling was followed by the installation of MSVM or MSVGM wells in the boreholes, and finally soil vapor and groundwater sampling (NASA, 2015c). All targets identified for Phase II were evaluated to the depth of bedrock, with the exception of the two 200 Area HWMUs that were investigated to the upper groundwater table located at depth in fractured rock. Fieldwork and laboratory testing activities were performed between June and November 2014. The final component of the 200 Area Phase II investigation comprised a comprehensive vadose zone soil vapor sampling event (NASA, 2015c).

The concentrations of soil vapor VOCs within the 200 and 600 Areas have been declining since the inception of soil vapor monitoring at WSTF using MSVGM wells in 2000 (NASA, 2004) in conjunction with the decline in concentrations of the same contaminants in groundwater (NASA, 2016). The maximum soil vapor concentrations measured during the 2014 comprehensive survey in the newly installed 200 Area Phase II wells decreased toward the southwest through the area covered by existing 100 and 200 Area wells, and into the 600 Area HWMU along the downgradient path for groundwater plume migration and contamination. NASA submitted the results in the 200 Area Phase II IR on June 29, 2015 (NASA, 2015c). The report was approved with modifications by NMED on November 30, 2015 (NMED, 2015c).

[2] GORE is a trademark of W. L. Gore and Associates.

NASA compared these maximum soil vapor concentrations to the equivalent WSTF site-specific RBCs (NASA, 2012c; Figure 2.1 through Figure 2.3). Results indicated that the maximum Freon 113, TCE, and PCE soil vapor concentrations measured were one to three orders of magnitude lower than the proposed site-specific WSTF RBCs. TCE is the primary soil vapor VOC with respect to a 200 and 600 Area risk assessment (Figure 2.2). The most concentrated soil vapor areas for TCE exceeded both the NMED VISL and the equivalent WSTF RBCs in the 2014 soil vapor sampling event. Nine specific soil vapor points in seven different monitoring wells exceeded the RBCs and the VISL, which can be grouped into three specific locations:

- The former Clean Room UST HWMU and surrounding area located adjacent to Apollo Boulevard on the northwest side of the Building 200 Clean Room (three wells: 200-SV-05, 200-LV-150, and 200-SV-09).
- The west side of the former 200 Area Evaporation Treatment Unit near the former 200 Area Burn Pit (SWMU 9) and the hazardous waste transmission line (HWTL) temporary tanker location (part of SWMU 10). This location is approximately 300 ft from the most proximal building, and as stated above, TCE concentrations decrease in this direction (from the 200 Area southwest to the 600 Area HWMU).
- The 200-D well cluster area immediately surrounding groundwater monitoring wells 200-D-109 and 200-D-240 (three wells: 200-SV-19, 200-SG-1, and 200-SG-4). This location is approximately 1,600 ft from the most proximal building. Results were the lowest at this location.

Soil vapor concentrations at the 200 Area former Clean Room UST HWMU are of the greatest potential concern as they have the highest vapor concentrations measured within the 200 and 600 Areas and have the most proximal location adjacent to and potentially below the northwest side of Building 200. The NMED VISLs for Freon 113 (1,470,000 µg/m^3; Figure 2.1) and PCE (1,970 µg/m^3; Figure 2.3) were also exceeded by the concentrations in the soil vapor at this location.

The highest concentrations of TCE at the 600 Area HWMU were identified within the wells located near the southeast boundary of the closure (Figure 2.2), which is in the closest proximity to Building 637 (wells 600-SGW-2, 600-SGW-5, and 600-SGW-6). Although these wells exceeded the NMED VISL for TCE, they do not exceed the VISLs for Freon 11, Freon 113, or PCE. They also fall below the WSTF RBCs for all four VOCs (Table 1.1). The closure boundary is located approximately 100 ft northeast of Building 637.

2.1 Operational History

2.1.1 200 Area

The operational history of the 200 Area with photographs and descriptions of individual waste management areas are provided in the 200 Area HIS (NASA, 2012b). Descriptions are provided for the two 200 Area East Closure USTs, the two West Closure USTs, and seven SWMUs (SWMUs 4 through 10) as identified in the Permit. Six potential AOIs were identified within the HIS (the Chemistry Laboratory Acid Tank Drain Pipe, an additional Building 203 industrial drain pipe, the Chemical Storage Building 253, the 270 Area Military Transport Vehicle Fire Suppression Test Area, two additional 200 Area historical burn pits, and the 250 Area Possible Septic Tank Drainage Source). These areas were evaluated during the 200 Area Phase I shallow soil vapor field investigation.

The 200 Area became operational in 1964 to support propulsion testing facilities for the Apollo space program. The Clean Room was first used for the precision cleaning of equipment in 1967 and began to evaluate flammability and toxicity characteristics of materials used in the Apollo spacecraft. By 1970, the

Apollo program focused on materials' testing capability for oxygen and propellant-exposure environments. As materials' testing expanded at WSTF, five test facilities were developed, four within or near the 200 Area: the Chemistry and Metallurgical Laboratories (200 Area), the High-Flow Components Facility (250 Area), Hazardous Hypervelocity and Detonation Facilities (270 and 272 Areas), and the Materials Test Facility (800 Area). The 800 Area Materials Test Facility was completed between 1975 and 1979, the 250 High-Flow Components Area was completed between 1989 and 1990, and the 270 and 272 Hypervelocity and Detonation Areas were completed between 1987 and 1991.

In a pollution abatement report to NASA headquarters in June 1984, NASA proposed constructing aboveground evaporation tanks at WSTF to store hazardous waste in order to cease using the 200 Area USTs and the 600 Area impoundments (which were not specifically designed for hazardous waste disposal). In the interim, NASA proposed constructing a hazardous waste drain line that would transport (by gravity) 200 Area hazardous wastes directly to the 600 Area impoundments. On April 22, 1986, it was discovered that the 8-inch (in.) long vertical carbon steel nozzle on the Clean Room tank (II) had corroded away, and there was an elliptical breach approximately 8 in. by 10 in. in the top of the Clean Room tank (II). Both Clean Room tanks were removed and the remaining tanks were drained in November 1986. During tank removal, it was discovered that the bottom portion of tank II had completely corroded away.

2.1.2 600 Area

The operational history of the 600 Area is summarized in the 600 Area Closure Investigation Work Plan (IWP; NASA, 2009). In the mid-1960s, the 600 Area Surface Impoundments (HWMU) were designed to contain the saltwater backwash produced from regenerating the zeolite beds in the WSTF water softening plant located to the south. The impoundments received the saltwater backwash through an 8-in diameter pipeline from 1964 to 1984.

From 1968 to 1986, 4,000 to 12,000 gallons of hazardous waste were transported by tanker truck from the 200 Area Clean Room and Chemistry Laboratory Tanks to the surface impoundments per week. White Sands Missile Range's High Energy Laser System Test Facility also contributed process waste from September 1983 to June 1984. The Hazardous Waste Transmission Line (SWMU 10) was constructed in May of 1986 to transport waste from the 200 Area Laboratories to the 600 Area Impoundments. One month later, on June 13, 1986, the 600 Area impoundments were closed (per EPA order), and the pipeline was re-routed to nearby stainless steel tankers for transportation of wastes to an off-site RCRA disposal facility.

2.2 Contaminants of Concern

VOCs known to have been managed in the 200 Area USTs and potentially discharged at SWMUs during historical operations include: TCE; PCE; Freon11; Freon 113; 2-butanone (methyl ethyl ketone); 1,1,1-trichloroethane; chloroform; benzene; ethylbenzene; toluene; xylenes; acetone; and 2-propanol (isopropyl alcohol). Waste management practices at WSTF have been continually modified and improved through time to effectively minimize, document, store, and dispose of wastes. Wastes generated in the 200 Area were transported to the 600 Area impoundments (HWMU). The VOCs placed in the 600 Area impoundments were identical to those stored in 200 Area USTs.

2.3 Preliminary Site Conceptual Exposure Model

A preliminary site conceptual exposure model (SCEM) was developed (Figure 2.4) to provide an understanding of the potential for exposure to hazardous contaminants at the site based on the source of contamination, the release mechanism, the exposure pathway, and the potential receptor(s).

2.3.1 Contamination Sources

The former UST locations at the 200 Area Clean Room tanks and the 600 Area Surface Impoundments were the primary contaminant sources. Secondary sources include groundwater directly impacted by releases and soil vapor derived from groundwater that filled fractures within bedrock and pore space within the overlying soils. Subsurface vadose zone soils in the 200 and 600 Areas that were once impacted by the releases have been evaluated through sampling extensively. The soils have been shown to be non-hazardous in nature and are not considered a continuing source of contaminants to groundwater (NASA 2015c, 2011).

2.3.2 Release Mechanisms

The 200 Area Clean Room HWMU and 600 Area Surface Impoundments HWMU are the result of the release of hazardous constituents into the vadose zone between 1964 and 1986. Release mechanisms comprised the infiltration of liquid-phase contaminants into the vadose zone, downward to the groundwater table by the hydrodynamic processes of gravity and precipitation, and infiltration of the vadose zone pore space as vapor-phase contamination.

2.3.3 Exposure Pathways

The potential exposure pathway for WSTF industrial/occupational site personnel is the inhalation of volatile contaminants derived from soil vapor and indoor air. Soil vapor contamination has been identified from past investigations in the vadose zone near WSTF industrial area buildings (NASA, 2015c, 2011).

There are no current or future residential land use scenarios anticipated in the vicinity of the 200 or 600 Area vapor intrusion assessment. WSTF is a controlled test site located on the U.S. Army White Sands Missile Range. There are no encroaching residential areas and no complete exposure pathways identified for residential land use scenarios in this SCEM. Because soil samples collected adjacent to Building 200 and in the vicinity of Building 637 have been shown to be non-hazardous based on the results of previous investigations (NASA, 2013a, 2015c, 2011), soil contamination is also not considered an exposure pathway for industrial/occupational workers.

The groundwater underlying much of the WSTF industrialized source areas is known to be contaminated and its future use and potential risk to receptors are part of ongoing site-wide evaluations and corrective actions. The water supply wells for WSTF (including the 200 and 600 Areas) that are located several miles to the west of the investigation areas are not contaminated, and are monitored regularly for the presence of any site-source contaminants. A groundwater assessment will not be conducted specifically as part of the vapor intrusion assessment. Groundwater is regularly assessed in NASA's quarterly Periodic Monitoring Reports (NASA, 2016). This data is also available for review in conjunction with results of the VIAWP.

2.3.4 Potential Receptors

Potential receptors of contaminated indoor air identified in the vicinity of the 200 Area Clean Room Tank HWMU and the 600 Area Closure HWMU are industrial/occupational workers who occupy buildings in the adjacent areas while performing their daily duties.

3.0 Site Conditions

The topography at WSTF is typical of the Basin and Range physiographic province of the southwestern United States which formed as a result of late Tertiary extensional tectonism, with linear mountain ranges separated by broad intermontaine basins in a northwest-trending direction. The adjacent San Andres

Mountains (SAM) adjacent and east of WSTF represent an uplifted northwest-trending mountain block that is separated from adjacent mountain ranges to the west by the southern JDMB. WSTF is located on the alluvial-covered bedrock pediment slope that separates the eastern foothills of the SAM from the JDMB.

3.1 HWMU Description

3.1.1 200 Area Clean Room Tank HWMU Description

A detailed description of the 200 Area Clean Room Tank located in Building 200 is provided in NASA (2012b). Activities in the 200 Area Clean Room included the precision cleaning of propulsion system components using solvents and degreasers. Wastes included dilute solutions of organic solvents, heavy metals, inorganic salts and various formulations of Oakite Brand cleaning solutions. Wastes generated from cleaning activities were gravity fed through single-walled stainless steel pipes to the UST located west of the former front of Building 200, in front of the laboratories complex.

The original Clean Room tank (I) had a 2,000-gallon capacity, was 14 ft long by 5 ft in diameter, and was installed in 1964. Drawings for this tank do not show corrosion protection. This original Clean Room tank (I) was used until late 1978 or early 1979 and abandoned in place. A new underground Clean Room tank (II) was installed in late 1978 or early 1979 approximately 50 ft to the west of the original tank (I). This carbon steel tank had a 4,000-gallon capacity and was 19 ft long, 6 ft in diameter with a $^{5}/_{16}$-in. thick shell. This new tank is believed to have contained external corrosion protection. Wastes were gravity-drained from 50-gallon sinks and the sump of the outdoor Clean Room pad to the tank using 3-in. diameter, schedule 10, grade 304 stainless steel lines. The tank was connected to the drain lines using 3-in. schedule 40 carbon steel. Prior to 1968, excess wastes from the original Clean Room tank (I) were discharged to grade. This process was discontinued in 1968, and the Clean Room tank was used as temporary storage.

3.1.2 600 Area HWMU Description

A detailed description of the 600 Area surface impoundments HWMU is provided in NASA (2011). The surface impoundments, constructed in 1964, consisted of two adjacent individual 150 ft x 350 ft x 3 ft deep cells, separated by a narrow central berm, and lined with an 8-mil polyvinyl chloride (PVC) liner. This liner was protected by an overlying layer of rip-rap, consisting of large gravel and wire mesh, and sand. The cells received saltwater backwash through an 8-in. diameter pipeline from 1964 to 1984. There is no indication that this pipeline was used at any time for hazardous waste. HWMU closure activities commenced on November 7, 1988, and following construction of the closure, vent wells were installed on May 26, 1989. Concrete lined drainage ditches were constructed along the north, south and east sides of the cap to support the drainage of surface water.

3.2 Surface Conditions

The 200 Area industrial complex is constructed on a pediment of thin alluvium (18 to 50 ft in thickness) overlying bedrock (Figure 3.1) at an elevation of approximately 4,930 ft above mean sea level. Pennsylvanian limestone crops out approximately 1,000 ft to the east on the east side of Gardner Spring Arroyo (GSA). The 200 Area is located immediately west of and is bound on the south by the GSA drainage as it diverts westward and downgradient toward the axis of the JDMB (Figure 1.2). Gardner Spring is the only natural surface water feature in the area and is located approximately 2,000 ft northeast of the 200 Area industrial complex within GSA. It is an intermittent spring and ceases to flow for long periods of up to several years between rare periods of heavy mountain-front rainfall.

The 600 Area complex in the vicinity of Building 637 is located on top of an alluvial pediment approximately 150 ft thick overlying Tertiary andesitic bedrock (Figure 3.2) at an elevation of approximately 4,755 ft above mean sea level. No significant drainages are present within the immediate area, and GSA is located approximately 1,500 ft north of the 600 Area HWMU as it travels west toward the JDMB.

Soils in the vicinity of the 200 and 600 Areas are classified as Tencee-Nickel Association Gently Sloping and Steep units (United States Department of Agriculture Soil Conservation Service, 1976). The Tencee Series is comprised of shallow, well-drained soils which formed in calcareous gravelly loamy alluvial sediments on old alluvial fans. The soil is slightly hard, dry, and very friable with common interstitial pores. The soil is approximately 30 to 45% caliche and gravel, is strongly calcareous, and has nearly continuous lime coatings on all clasts. The Nickel series soils comprise deep, well-drained soils on old alluvial fans. They are gravelly, medium textured alluvial sediments with gravel contents to 50%. The Tencee-Nickel, Gently Sloping unit is approximately 65% Tencee Very Gravelly Loam and 20% Nickel Fine Sandy Loam. The soil is nearly level to gently sloping and occurs on old alluvial fans. Included within these soils are arroyo bottoms and areas of soils similar to Tencee and Nickel soils except that they contain less than 35% coarse fragments. The Tencee-Nickel, Steep unit is approximately 45% Tencee Very Gravelly Loam and 40% Nickel Fine Sandy Loam.

The area is characterized by a Chihuahuan Desert Shrub climate, which is characterized by abundant sunshine, low humidity, slight rainfall, and a large day-to-night temperature variance. The mountainous terrain in the area influences the climate by blocking the incursion of moisture laden maritime air masses. Sparse biotic resources are typical of those found in the arid southwest. The average rainfall of 10 inches per year makes it difficult to support agriculture. As is typical with all deserts and semi-arid areas, the overall species diversity is low. Vegetation includes a combination of woody shrubs and grasses. These shrubs include Louisiana white sage, creosote bush, honey mesquite, tarbush, broom snakeweed, and lotebush. Common grasses include alkali sacaton, side-oats grama, fluff grass, tobosa grass, and purple three awn. Plant species biodiversity is low relative to that in better drained upland slopes. Shrubs provide a microhabitat for warm season grasses and forbs as well as herptiles and small mammals. WSTF is considered to be a low affectability area. The facility receives little use by wildlife species because it has been physically altered by human disturbance or overgrazing.

3.3 Subsurface Conditions

The primary alluvial lithology across the area is the poorly indurated piedmont slope facies of the Camp Rice Formation (Seager, 1981). Vadose zone alluvium in the 200 and 600 Areas near the buildings of interest consists of coalescent alluvial fan deposits derived from the adjacent SAM to the east. The alluvium is an unconsolidated to locally cemented, poorly sorted polygenetic pebble to boulder conglomerate. Lenticular sandy to clayey gravels, sandy silt, and silty clays are interbedded with the conglomerate. Clast lithologies include varieties of subrounded to subangular granite, rhyolite, siltstone, and micritic limestone in sand to boulder-size clasts.

3.3.1 200 Area

Previous 200 Area vadose zone investigations have identified moderately cemented caliche horizons a few inches thick at depths ranging from 2 ft bgs to 65 ft bgs. Significant barriers to soil vapor migration have not been encountered within 200 or 600 Area soil borings (e.g., NASA, 1996, 2015c). Well-formed drainages like the GSA that drains south and subsequently west between the 200 Area and 600 Area HWMUs host younger piedmont slope alluvium, characterized by unconsolidated silt, sand, gravel, and loam within the arroyo floor. Alluvial fan materials visible in cut sections of the GSA are indicative of irregular channeled morphologies with grain sizes ranging from clay to well-graded sandy gravel.

Alluvium overlies Pennsylvanian to Permian age limestone bedrock (Figure 3.1), which occurs at variable depths due to faulting in the area and irregular erosion of the pre-alluvial bedrock surface. The 200 Area bedrock has been fractured pervasively, predominantly on an orthogonal system, with one fracture set trending northeast-southwest and the other fracture set trending northwest-southeast. The shallowest bedrock in the industrialized 200 Area is located in the vicinity of SWMU 4, the Clean Room Discharge Pipe (14 ft bgs), southwest across Road L at well 200-F (17 ft bgs), and at the adjacent 200 Area Clean Room Tank across Apollo Boulevard to the east (18 ft bgs). This accounts for the primary bedrock high in the vicinity of the 200 Area West Closure.

3.3.2 600 Area

Alluvium in the vicinity of the 600 Area HWMU is between 140 and 160 ft thick and overlies poorly fractured Tertiary Orejon Andesite bedrock (Figure 3.2). Fracturing is sparse based on the observation of camera logs recorded in 600 Area HWMU boreholes, with individual calcite-filled hairline fractures often separated by several tens of feet. Permian limestone is topographically and hydrologically upgradient, juxtaposed against the andesite along the Hardscrabble Hill Fault which lies east of the 600 Area HWMU and Building 637.

4.0 Scope of Activities

This section includes the activities that will be performed as part of the vapor intrusion assessment at the west side of 200 Area Building 200 adjacent to the Clean Room Tank HWMU and 600 Area Building 637 in the vicinity of the 600 Area Surface Impoundments HWMU. Some of the preliminary required vapor intrusion activities identified in Steps 1 and 2 of Section 1.1 have already been performed as part of previous investigations in the 200 and 600 Areas (NASA, 2013a, 2015c, 2011).

- Identification of the appropriate vadose zone soil vapor sampling locations (based on the previous 200 Area HIS, 200 and 600 Area IRs, and soil vapor sampling events in the 200 and 600 Areas).
- Determination of a representative number of soil vapor and air samples, specification of the frequency and duration of sampling, and identification of the sampling and analytical methods to be employed.
- Daily planning sessions and health and safety briefings.
- Field collection of soil vapor samples from the uppermost vadose zone located adjacent to the target buildings.
- Field collection of indoor air samples within the buildings and outdoor samples adjacent and upgradient of the buildings.
- Documentation, management, and shipment of soil vapor and indoor and outdoor air samples (including field quality control [QC] samples).
- Performance of laboratory analyses by an accredited laboratory (including laboratory QC samples), analytical reporting, and data processing using the established WSTF data management system.
- Evaluation and interpretation of technical and analytical data for use in development of a final AR.

4.1 Data Quality Objective Process

The assessment approach was based on "Guidance on Systematic Planning Using the Data Quality Objectives Process" (DQOs; EPA, 2006), the Corrective Action Site Investigations requirements of the Permit (NMED, 2009a; Section VII.H), and Risk assessment Guidance for Site Investigations and Remediation (NMED, 2015a). The data acquisition plan (i.e., sampling design) is based on the data quality objective process. The DQOs address the qualitative and quantitative nature of the sampling data to ensure that any data collected will be appropriate for the intended purpose. Development of the DQOs considers precision, accuracy, representativeness, completeness, comparability of the data, sampling locations, laboratory analyses, detection limits, data quality, and the employment of adequate quality assurance/quality control measures. This VIAWP documents the DQO procedures that will be followed to assess the potential migration pathway between vadose zone soil vapor contamination and indoor air.

4.1.1 Problem Statement

The 200 Area Clean Room HWMU USTs leaked contaminants to the vadose zone, comprising approximately 18 ft of porous alluvial soil overlying fractured limestone bedrock. The tanks were located at a depth of between 8 and 12 ft bgs. The water table is located at a depth of 140 ft bgs. Soil samples collected during the installation of adjacent soil borings indicated that soils are non-hazardous and soil remedial action is not required (NASA, 2015c). Groundwater in the area exceeds the NMED cleanup level for TCE. Soil vapor concentrations from samples collected in adjacent MSVM wells and a MSVGM well exceeds NMED VISLs for TCE, PCE, and Freon 113 and the WSTF RBC for TCE. The HWMU is located directly below an eastern extension of Building 200 that is operated by an industrial/occupational labor force.

Contaminants from the 600 Area Impoundments HWMU may have been leaked to the vadose zone characterized by approximately 146 ft of porous alluvial soil overlying poorly-fractured andesite bedrock. A perched (and potentially temporary) water table is currently encountered at a depth of 143 ft bgs, which may be sourced from groundwater recharge during heavy rainfall and from the adjacent 600 Area Overflow Lagoons. Soil samples collected during the installation of soil borings through the Closure cap to bedrock indicate that soils are non-hazardous and soil remedial action is not required (NASA, 2011). Groundwater in the area exceeds the cleanup level for TCE. Soil vapor concentrations from samples collected in adjacent MSVM and MSVGM wells exceeds NMED VISLs for TCE, PCE, and Freon 113. The 600 Area HWMU is located approximately 160 ft from Building 637 that is operated by an industrial/occupational labor force.

Soil vapor contamination in the vicinity of either the 200 Area or 600 Area HWMUs may pose unacceptable exposure risks to site workers through the migration of vapors from the subsurface into indoor air. TCE is known to be a human carcinogen and mutagen by all routes of exposure and poses a potential human health hazard.

4.1.2 Decision Statement and Alternative Actions

The primary decision is whether additional corrective actions are warranted at these specific targets (identified through previous investigation) due to the intrusion of soil vapor VOCs from the vadose zone into nearby buildings affecting the indoor air quality. Alternative actions for the decisions include:

- Consider a "Corrective Action Complete" status determination.
- If required, perform a corrective measures evaluation for the site(s) to identify remedial options for mitigation of source(s) of continuing contamination or human health risk.

4.1.3 Decision Inputs

Previous investigations performed in the 200 and 600 Areas provide the necessary decision input for this VIAWP. The results of these previous investigations are documented within the 200 Area HIS (NASA, 2012b), the 200 Area Phase I Status Report (NASA, 2013a), the 200 Area Phase II IR (NASA, 2015c), and the 600 Area Closure IR (NASA, 2011), including:

- Detailed investigation pertinent to the establishment and operational history of the 200 Area Clean Room Tank HWMU and the 600 Area Surface Impoundments HWMU.
- Comprehensive analytical data sets for soil, soil vapor, and groundwater samples collected during previous investigations at the 200 Area Clean Room Tank HWMU and the 600 Area Surface Impoundments HWMU.

The following additional sampling activities are needed to assess the existence of a complete exposure pathway.

- Sample and evaluate VOC concentrations in soil vapor in the upper vadose zone utilizing MSVM and MSVGM well ports located in the vicinity of the buildings.
- Sample and evaluate VOC concentrations in indoor air and outdoor air.

4.1.4 Study Boundaries

The horizontal study boundaries are shown in Figure 1.2. The vapor intrusion pathway that is considered a primary potential threat and requires priority assessment is typically for buildings located within 100 ft of the vadose zone soil vapor plume that exceeds established soil vapor RBCs. In this case, NMED VISLs and WSTF RBCs were utilized to isolate the targets of greatest concern.

In the 200 Area, soil vapor from the three most proximal MSVM and MSVGM wells located within 85 ft of the former Clean Room Tanks HWMU and air from the most proximal tier of indoor rooms on the west side of Building 200 within a distance of 100 ft of the footprint of the HWMU are being investigated (Figure 4.1). In the 600 Area, soil vapor from the three most proximal MSVM wells within 240 ft of Building 637, and the indoor air within Building 637 (Figure 4.2) are being investigated. The vertical boundaries of the study are constrained between a maximum depth of 34 ft in the vadose zone as characterized by the maximum depth of upper ports in MSVM and MSVGM wells and the industrial/occupational worker breathing zone of between 3 and 5 ft above ground surface.

4.1.5 Study Constraints

The inaccessible location of the former 200 Area Clean Room UST HWMU that is now below a west extension built onto Building 200 (Figure 4.1) is the primary constraint to the vapor intrusion assessment.

4.1.6 Decision Rule

The vapor intrusion assessment addresses COPC soil vapor concentrations within the upper vadose zone surrounding the target buildings and COPC air concentrations inside the buildings. The assessment will determine if a complete pathway is present and whether contaminants are present at concentrations at or above the latest NMED VISLs (NMED, 2015a) and WSTF RBCs. Updated RBCs will be determined concurrently with the pre-assessment planning and preparation phase for this vapor intrusion assessment and approved by NMED prior to their application. Where multiple contaminants are detected, the cumulative effects of those contaminants will be considered as described in the guidance.

Although OSHA PELs are referenced in the VIAWP for comparative purposes (Table 1.1), they are not considered appropriate criteria for the final decision process of evaluating the risk associated with vapor intrusion. PELs are intended to regulate an employee's exposure to workplace air contaminants as opposed to air contaminants originating from the subsurface.

Decisions will be structured as follows.

- If the subsurface VOC contribution to indoor air VOC levels exceeds indoor air NMED VISLs and updated NMED-approved WSTF RBCs as a result of a confirmed complete exposure pathway under the industrial/occupational worker scenario, then there is an unacceptable current and future risk to building occupants. These levels must be specific to vapor intrusion as opposed to an artifact of an alternate process identified within the building. Corrective action, removal and/or remediation are necessary.

- If the vadose zone soil vapor concentrations exceed NMED VISLs and updated NMED-approved WSTF RBCs, but the subsurface contribution to indoor VOC levels is below indoor air NMED VISLs and WSTF RBCs, then current vapor intrusion risks are acceptable.

- If the vapor intrusion assessment fails to fully determine the nature, source, and extent of indoor air contamination, additional investigative measures may be required.

4.2 Sampling Tasks

4.2.1 Sample Location Description

The area of concern on the west side of Building 200 is located directly above the footprint of the 200 Area Clean Room Tank HWMU adjacent to MSVM wells 200-SV-05 and 200-SV-09, and MSVGM well 200-LV-150 (Figure 4.1). The area of concern within Building 637 is approximately 100 ft southeast of the southeast margin of the 600 Area Surface Impoundments HWMU in close proximity to MSVM wells 600-SGW-1, 600-SGW-2, and 600-SGW-5 (Figure 4.2).

4.2.2 Vadose Zone Soil Vapor Sample Locations and Schedule

Soil vapor samples will be collected from the shallowest soil vapor port within the three MSVM or MSVGM wells located closest to the 200 Area and 600 Area target buildings. In the 200 Area, the three wells are all located within 84 ft of the west side of Building 200. In the 600 Area, the three wells are all located within 260 ft of Building 637. The soil vapor wells and specific ports that will be sampled are listed below.

- Adjacent to the 200 Area Clean Room Tank HWMU (Figure 4.1, Table 4.1)
    - 200-SV-05 at 9 ft.
    - 200-SV-09 at 19 ft.
    - 200-LV-150 at 34 ft.
- Nearby the 600 Area Surface Impoundments HWMU (Figure 4.2, Table 4.1)
    - 600-SGW-1 at 12.5 ft.

- 600-SGW-2 at 12.5 ft.
- 600-SGW-5 at 7.5 ft.

A total of six vadose zone samples from the vapor monitoring well network and one duplicate sample will be collected from MSVM and MSVGM wells for each soil vapor sampling event. Additional field QC samples are provided in Section 5.4. Two semi-annual sampling events (seasonal events within the summer and winter months) will be performed to address the potential issue of seasonal building pressure gradients that can influence vapor intrusion into buildings. Indoor and outdoor air pressures will be measured during the sampling events to evaluate any pressure gradients present. VOC levels in ambient air can vary greatly over time and may fluctuate diurnally due to the ebb and flow of industrial/occupational activity, and as a result of atmospheric heating and cooling cycles, air pressure changes, and wind speed. During winter months, heated air rises within buildings and exits through the roof. This reduces indoor air pressure, may draw in soil vapor, and potentially increases vapor intrusion rates. A total of 14 vadose zone soil vapor samples will be collected.

4.2.3 Indoor and Outdoor Air Sample Locations and Schedule

The number and locations of indoor and outdoor air samples has been established based on building size, proximity to the potential intrusion source, the scale of the vadose zone vapor impact, subsurface heterogeneity, and sample purpose. Increased sample density is typical of a nearby spill or release and heterogeneity in the subsurface. Because no releases have been identified in soil, the soils are relatively homogeneous and porous, and a fractured bedrock and groundwater VOC source is inferred, sample densities may follow standard guidance (e.g., ODEQ, 2010). Typical sample densities in buildings between 1,000 square feet (sq ft) and 10,000 sq ft in size are one sample per 1,500 sq ft. The sample locations identified in this VIAWP (Figure 4.1, Figure 4.2) have a greater density than the standard guidance.

Where rooms exceed 500 sq ft in size in the case of Building 200, samples will be collected at a frequency of approximately one sample per 500 sq ft. Samples will be collected within the normal breathing zone at a height of approximately 3 to 5 ft above the building floor within the breathing zone. Ambient outdoor air samples will be collected at the same time and using the same method as the indoor samples at each of the two building locations. Indoor and outdoor air sample locations can be summarized below.

- Building 200 – Preparation Building (Figure 4.1, Table 4.2)
    - Eight indoor air samples within individual rooms in the areas above and adjacent to the subsurface footprint of the former 200 Area Clean Room Tank HWMU.
    - Two outdoor air samples adjacent to Building 200 near the former 200 Area Clean Room Tank HWMU at locations upgradient of the prevailing wind direction on the day of sampling.
    - One sample duplicate.
- Building 637 – Groundwater Assessment Building (Figure 4.2, Table 4.2)
    - Four indoor air samples in Building 637 distributed in the four quadrants of the single room building.

- Two outdoor air samples adjacent to the Building 637 on the west side that faces the 600 Area Surface Impoundments HWMU at locations upgradient of the prevailing wind direction on the day of sampling.

- One sample duplicate.

Approximately 18 indoor and outdoor air samples and two duplicate samples will be collected for each sampling event performed for a total of 18 samples during each event. Two consecutive semi-annual indoor and outdoor air sampling events are proposed concurrently with the soil vapor samples during the summer and winter seasons A total of 36 indoor and outdoor air samples will be collected.

5.0 Assessment Methods

This section describes the vadose zone soil vapor and indoor and outdoor air sampling procedures, sample collection and management requirements, analytical tasks, and health and safety requirements for the VIAWP.

5.1 Vadose Zone Soil Vapor Sampling

Soil vapor sampling will be conducted following established site procedures for each of the MSVM or MSVGM well sampling ports listed in Section 4.2.2. Critical information describing the sampling event will be recorded in the appropriate field sampling logbook(s). Vadose zone soil vapor samples will be collected in laboratory-evacuated stainless steel electropolished passivated vessels (SUMMA™[3] canisters) certified as clean and provided by the analytical laboratory selected for this assessment. The stainless steel construction ensures samples will not permeate through the vessel wall or degrade due to exposure to light during shipment to the laboratory. Standard one-liter canisters, a relatively small canister, will be used for soil vapor grab sampling from MSVM and MSVGM wells. These samples are expected to be more concentrated than the corresponding indoor and outdoor air samples.

Immediately prior to sampling, the ambient barometric pressure will be recorded and vacuum conditions within the Summa canisters verified. Three tubing volumes of air will be purged from each sampling port and stainless steel tubing using a LANDTEC GEM ™[4] 2000+ gas analyzer to ensure the removal of stagnant air. The pump on a gas analyzer will be used to purge the soil vapor well tubing for a minimum of five minutes per zone to evacuate at least three volumes of the ¼ in. tubing and soil vapor port. During purging, monitoring of methane (CH_4), carbon dioxide (CO_2), and oxygen (O_2) indicator parameters will be performed during the entire process. Each parameter is required to be stable prior to sampling; additional purging will be performed as required. A SUMMA canister will then be attached to the sampling port, opened, and filled to capacity. Field QC samples will be collected to ensure high quality data are generated during the assessment (Section 5.4).

5.2 Building Foundation Evaluations

The foundations of the west sides of Building 200 and 600 Area Building 637 will be evaluated to the extent possible for structural integrity, staining, or any other visible defects. The junction between walls

[3] SUMMA is a trademark of EMSL Analytical, Inc.

[4] Landtec GEM 2000 Plus is a trademark of Geotech Environmental Equipment, Inc.

and the building foundation will also be inspected as best possible. Any significant observations will be documented and included within the final report as part of the evaluation of the vapor intrusion pathway.

5.3 Indoor and Outdoor Air Sampling

5.3.1 Pre-Sampling Inspection

For most sites, detecting specific COPCs inside a building is not definitive evidence of vapor intrusion since VOCs can also be common contaminants in ambient air and may also have other sources inside buildings. Approximately two weeks prior to collecting indoor and outdoor air samples, a pre-sampling inspection will be performed to identify conditions that may affect or interfere with the proposed sampling, and where possible to provide temporary mitigation of these conditions. A standard building survey form (Appendix B; developed from ODEQ, 2010) will be used to evaluate the type of structure, floor layout, physical conditions, and airflow of the buildings being studied. The 200 Area building complex includes a network of laboratories and cleaning rooms that utilize several of the COPCs identified in Section 2.2 that are commonly used as laboratory chemicals (e.g., acetone, methyl ethyl keytone, isopropyl alcohol).

Potential COPC sources will be evaluated within the building by conducting a product inventory and recording the results on the building survey form. The primary objective of the product inventory is to identify potential air sampling interference by characterizing the occurrence and use of chemicals and products throughout the building. This information will help formulate the indoor environment profile. Both the Building 200 and Building 637 are single floor structures. Individual rooms within these areas will be carefully inspected for products and an inventory provided as products stored in another area of the building can affect the air of the room being tested.

Portable vapor monitoring equipment readings using a photoionization detector (PID) and a description of any odors present (e.g., solvent, moldy) will be used to help evaluate potential indoor sources. If available, chemical ingredients of interest will be recorded for each product. If the ingredients are not listed on the label, each product's exact and full name, and the manufacturer's name, address and phone number, if available will be recorded. Safety Data Sheets (SDS) will be reviewed to identify confounding sources where available.

5.3.2 Preparation of Building

To support assessment of the vapor intrusion pathway from the vadose zone into the buildings, removing as many potential cross-contaminant sources in the buildings as is feasible must be performed. The pre-sampling inspection will provide adequate advance notice to the local workforce to minimize potential background sources prior to air sampling. Potential interference from products or activities releasing volatile chemicals must be controlled. Either removing the source from the indoor environment prior to testing or at a minimum ensuring that containers are tightly sealed is required. The inability to eliminate potential interference is justification for not testing, especially when testing for similar compounds at low levels. Chemicals may adsorb onto porous materials and may take time to dissipate.

Once interfering background sources are removed, the building ventilation system will be operated under normal conditions prior to testing to eliminate residual contamination in the indoor air. Ventilation will be accomplished by operating the building's heating ventilation and air conditioning (HVAC) system. Air samples are intended to represent typical exposure in a mechanically ventilated building, and the operation of HVAC systems during sampling will be noted. It will be ensured that the building's HVAC system is operating under normal conditions, any deviations will be noted. In addition, steps will be taken

to avoid any painting, cleaning, pesticide spraying, or air freshening activities at least two weeks prior to air sampling, any exceptions will be noted.

5.3.3 Sampling Requirements

Stainless steel SUMMA canisters will be utilized for indoor and outdoor air sampling. Six-liter volume canisters (relatively large canisters) will be used due to the relatively low concentration of analytes anticipated in the indoor and outdoor samples, a proposed 8-hour sampling duration, and preferred sampling flow rate for this type of sample, and the sample volume required for the sampling period. Six-liter canisters are typically used to obtain the integrated time-weighted average ambient air samples at sampling times of up to 24 hours. High quality valves will be utilized that resist human error in sample collection activities (e.g., over tightening that potentially could cause leaks). Low-flow precision regulators will be used with each of the canisters to ensure a consistent airflow over the designated eight-hour sampling duration.

Sample collection intakes will be located to approximate the breathing zone for building occupants at heights of 3 to 5 ft above the building floor. Indoor air samples will be collected during regular working hours to be representative of typical exposure in a manner as to minimize disruptions to normal building activities. Outdoor air samples will be collected at the same times within the breathing zone for comparative purposes. Sampling technicians will not remain in the immediate area of the canisters while samples are being collected.

5.4 Sampling Procedures and Requirements

NASA has developed comprehensive internal procedures for soil vapor sample collection and management. These procedures provide specific information on sample management and related documentation, including instructions for sample custody (internal to NASA and external during shipment), storage, packaging, shipment, delivery tracking, and related recordkeeping. These procedures will be followed during this project to ensure appropriate sample management. Sampling procedures and the equipment used follows generally accepted EPA guidance (EPA, 2015). Sample collection techniques and flow rates will conform to the specifications for the appropriate EPA sample collection method. Soil vapor samples from MSVM and MSVGM wells, indoor samples, and outdoor samples for each area will be collected contemporaneously on the same day within each are to the extent possible. Samples from the 200 and 600 Areas will be collected on consecutive days, or on as tight a sampling schedule as is feasible. Any deviations will be recorded and detailed in the final AR. The following generalized procedures will be followed.

- Sampling start times and the initial vacuum gauge readings will be recorded in the field sampling logbook and on the internal chain-of-custody (CoC) form.

- For indoor and outdoor air samples, a flow-controller will be affixed to the canister prior to sampling at a rate pre-set by the laboratory to provide for collection of the samples over an 8-hour period.

- Sample valves on each canisters will be opened to perform sample collection.

- Upon the completion of vadose zone, indoor air, and outdoor air sampling, the valve on the Summa canister will be closed and the time and ending vacuum pressure recorded in the field sampling logbook and on the internal CoC form.

- Canisters and flow-controllers will be shipped back as a single shipment to the analytical laboratory for each of the two semi-annual sampling events

Disposable gloves will be worn to collect soil vapor and indoor air samples and changed between sampling locations. Gloves and other disposable materials contacting the samples will be collected and managed in accordance with the IDW Management Plan in Appendix A.

Field QC samples will be collected to ensure high quality data are generated during the assessment, and will be analyzed for the same parameters as the primary samples.

- When evaluating outdoor air data, background levels of VOCs must be considered. Two outside air samples (field blanks) will be collected using outside ambient air adjacent and upgradient of the buildings in both the 200 and 600 Areas on each sampling day, for a total of four field blanks per sampling event. The indoor and outdoor sampling periods will be identical in length, but the outdoor air samples will be initiated one to two hours before starting the indoor samples to reduce potential errors. The EPA estimates that indoor air undergoes a complete exchange every one to two hours. Initiating outdoor air sampling early will compensate for this potential lag time. Field blanks will be analyzed for the same parameters as the primary samples.

- Indoor and outdoor duplicate samples will be collected at rate of 10% of the project sampling locations (two samples per sampling event).

- Field blanks (one outdoor and one indoor for each of the two target buildings in the 200 Area and 600 Areas (four samples per sampling event).

- Trip blanks (one per sample shipment).

The samples will be managed according to established site procedures that included labeling, CoC documentation, storage, packing, and expedited overnight shipment to the analytical laboratory for analysis.

5.5 Analytical Tasks

Soil vapor samples will be analyzed using EPA Method TO-15 in order to achieve the assessment DQOs. NASA typically contracts services from off-site National Environmental Laboratory Accreditation Program-accredited analytical laboratories as required to support program and project needs. The analytical tasks required to achieve the project objectives will be awarded to the laboratory that is successful in the competitive bid process. Potential laboratories must respond to a comprehensive statement of work developed to meet the project objectives defined in this VIAWP. Analytical standard operating procedures (SOPs), laboratory quality manuals, and other laboratory-specific documentation are provided by the analytical laboratory following award of the contract and are not available in advance. These documents are retained in the project record and will be available for NMED review as required.

The overall objective for laboratory analysis is to produce data of known and sufficient quality. Appropriate procedures and QC checks will be used so that known and acceptable levels of accuracy and precision are maintained for each data set. All samples will be analyzed by a fully qualified laboratory in accordance with the laboratory's Quality Plan, which ensures that the contract laboratory adheres to standardized analytical protocols and reporting requirements and is capable of producing accurate analytical data.

Method blanks and laboratory QC samples are prepared and analyzed in accordance with the laboratory's method-specific SOPs. The analytical results of method blanks shall be reviewed to evaluate the possibility of contamination caused by analytical procedures. At a minimum, the laboratory will analyze method blanks and laboratory control samples at a frequency of one in 20 for all batch runs.

5.6 Health and Safety

Field activities will be conducted in accordance with requirements of OSHA Standards for Hazardous Waste Operations and Emergency Response ([HAZWOPER]; 29 Code of Federal Regulations [CFR] 1910.120 [a] – [o]). The Contractor's Corporate-wide Safety and Health Plan (SHP) will be augmented with site-specific Job Hazard Analyses to address potential hazards foreseeable for the project and will be followed in accordance with applicable requirements of the standards. The augmented SHP will address safety and health issues pertaining to work activities, including known and reasonably anticipated hazards associated with project scope of work as well as contingencies for unexpected conditions. The requirements of the SHP will apply to prime and sub-tier contractors as well as personnel requesting access to controlled areas of the assessment site. Project field personnel are required to be current in HAZWOPER training. In the event that new hazards are encountered that are not addressed by the SHP, the field team will stop work and contact the contractor Health and Safety Manager to develop additional guidance on means to eliminate or mitigate any new threats. The SHP will be reviewed and approved by the contractor Health and Safety Manager. As required by 29 CFR 1910.120(b)(4), the SHP and project-specific addenda will address the following.

- A safety and health risk or hazard analysis for each site task and operation found in this VIAWP.
- Employee training assignments.
- Personal protective equipment (PPE) to be used by employees for each of the site tasks and operations being conducted.
- Medical surveillance and fitness for duty requirements (based on nature of the project scope and COPCs).
- Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration of monitoring and sampling equipment.
- Site control measures in accordance with the site control program.
- Decontamination procedures.
- An emergency response plan for safe and effective responses to emergencies, including the necessary PPE and other equipment.
- Confined space entry procedures if applicable.
- A spill containment program.
- Pre-entry briefing. The SHP shall provide for pre-entry briefings to be held prior to initiating any site activity, and at such other times as necessary to ensure that employees are apprised of the SHP and that this plan is being followed.

- Inspections shall be conducted by the Health and Safety Manager or, in the absence of that individual, another individual who is knowledgeable in occupational safety and health.

6.0 Decontamination of Field Screening Instruments

A PID will be used for indoor and outdoor air screening. Dry decontamination followed by an alcohol free moist wipe will be used for this moisture sensitive equipment. Any waste materials removed from the equipment and the wipes used will be disposed of as IDW and managed as indicated in Appendix A.

7.0 Field Documentation Procedures

The field geologist or site supervisor will ensure that details of all activities related to this assessment are documented using a field logbook, field data records, and/or any required site-specific procedural documentation. Logbook entries will include, as applicable, information such as:

- Standard Daily Header – project name, logbook number, date, weather conditions, team members present and their affiliations (including subcontractors), sample location identification, day's task(s), daily safety meeting topics, required PPE, equipment in use, and any calibration information, if applicable.
- Daily activities (time and observations recorded) – site arrival and departure, visitors and the purpose of their visit, vapor sampling information, decontamination (i.e., method, equipment cleaned), reference data sheets or maps, if applicable.
- Daily summary – action items, materials used, changes or deviations made from planned protocol, plan for next day.
- Signatures (field personnel and logbook reviewer).

At a minimum, field records will include observations of environmental conditions, sampling conditions, and sample documentation. For analytical samples, the date, location, depth, sample type, collection method, identification number, sampler, and any circumstances, events, or decisions that could impact sample quality will be documented by the on-site geologist in the project field logbook. Even though each case may be unique, the geologist must document any conditions that precipitated any decisions for the unsuitability of samples for analyses. In addition to the field logbook entries for sampling events, CoC forms will be completed for analytical samples and maintained with project documentation.

Evidential records for the entire project will be maintained in hard copy or electronic form and will consist of:

- Project VIAWP with NMED modifications or deviations redlined.
- Site-specific internal procedural documentation or plans.
- Project logbooks.
- Field data records (i.e., surveyed site location).
- Sample CoC forms.
- NMED correspondence.
- Final analytical data packages.
- Reports.

- Miscellaneous related records such as photos, maps, drawings, etc.

8.0 Investigation-Derived Waste Management Plan

As required in Permit Attachment 20 (Section 20.2.13; NMED, 2009), the IDW Management Plan for this vapor intrusion assessment is provided as Appendix A. The IDW Management Plan provides a description of the potential wastes that will be generated from the 200 and 600 Area as well as procedures for waste management, waste characterization, and waste disposition. Wastes that may be generated as part of the assessment comprise: used sampling equipment; PPE; and, alcohol free moist wipes used for equipment decontamination.

9.0 Data Management Tasks

Data management tasks include project documentation and data review and assessment. Details are outlined below.

9.1 Project Documentation and Records

All facets of this assessment will be documented in detail by the responsible project personnel. Records are retained in the WSTF Operating Record and can be accessed at any time by authorized WSTF personnel.

9.1.1 Sample Collection and Field Measurements Data

Sample information and field measurements are recorded in the field logbook by the responsible project field personnel. These are reviewed by knowledgeable project personnel on a regular basis during the assessment and are retained in the project file. They are ultimately archived in the WSTF Records Management System as part of the Operating Record. As required for reporting, these data are also transferred to and archived in operational and historical databases.

9.1.2 Off-site Laboratory Data

Data packages from off-site analytical laboratories will consist of two primary components: comprehensive reports, to be submitted as Adobe portable document files (PDF) for review and archiving; and electronic data deliverable (EDD) files to facilitate transfer of chemical analytical data into WSTF's analytical database(s). The PDF report will include a variety of information, including laboratory name, report date, sample-specific information, analyte names and Chemical Abstract Service numbers, analytical results, QC sample results, data qualifiers and narratives, pertinent analytical notes, laboratory reviewer signatures, and a variety of other information specific to the laboratory and analytical method. The EDD will include the associated electronic data and follow the same review and approval cycle as the PDF report.

9.2 Data Assessment, Review, and Corrective Action Procedures

A quality assurance (QA) and QC specialist will evaluate the sample data, field, and laboratory QC results for acceptability with respect to the project quality objectives. Chemical analytical data will be compared with the project DQOs and evaluated using the data validation guidelines contained in EPA guidance documents, the latest version of SW-846, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," and industry-accepted QA/QC methods and procedures (EPA, 2013).

When evaluating the vapor intrusion risks, vapor concentrations will be compared to the latest NMED VISLS and NMED-approved WSTF RBCs. If indoor air concentrations exceed these values, possible contributions from ambient air and indoor sources as well as potential vapor intrusion will be considered. This evaluation will be used to determine the next step in the evaluation process.

9.3 Assessment and Response Actions

The conformance of assessment activities to the VIAWP will be evaluated on an ongoing basis while field activities are in progress. Additional verification will be provided through oversight of the field activities by the site supervisor or other responsible personnel. If a specific sample cannot be collected as planned, the site supervisor will be notified and, if possible, an alternate location or sampling method may be selected. Significant deviation from the number and locations of samples indicated in the IWP will be discussed with NMED for concurrence. The assessment process will include immediate evaluation of any change to the sampling plan so that, if necessary, an alternate field procedure may be quickly established. Daily quality field assessments may be conducted during drilling and sampling activities. Field assessments will be performed by environmental professionals who are not immediate members of the field team. Following completion of field activities, a final review of field activities will be performed. Any deviations from the IWP or procedures will be documented and noted in the AR.

The contract laboratory will be required to notify NASA of significant data quality exceptions within one business day of discovery. Sample re-analysis will be performed, if possible. NASA will contact NMED as soon as practical to discuss any data quality exceptions that may affect the ability to meet the objectives of the assessment.

9.4 Data Review Process

A comprehensive review of sample analytical data will be conducted. Prior to conducting the review, the following information (where required and applicable) will be compiled and provided.

- The NMED-approved VIAWP.
- Field sampling and geologist logs.
- Laboratory reports.
- Statements of work and the laboratory Quality Management Plan.
- EDD Files.
- SOPs.
- Data tools.

9.5 Data Review Elements

Step I: Verification – Verification (review for completeness) is the confirmation by examination and provision of objective evidence that the specified requirements (sampling and analytical) have been completed (EPA, 2005).

Data verification is the process of determining whether data have been collected or generated as required by the project documents. The process consists of the following categories: 1) verifying that field sampling operations were performed as outlined in the IWP; 2) verifying that the data collection procedures and protocols were followed; 3) verifying completeness to establish that sufficient data

necessary to meet project objectives have been collected; and 4) checking that QC sample results meet control limits defined in the analytical methods.

Step II: Validation – Validation is the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Validation is a sampling and analytical process that includes evaluating compliance with method, procedure, or contract requirements and extends to evaluating against criteria based on the quality objectives developed (EPA, 2005).

The purpose of validation is to assess the performance of the sampling and analysis processes to determine the quality of specified data. Data validation consists of the following objectives: 1) verifying that measurements (field and laboratory) meet the user's needs; 2) providing information to the data user regarding data quality by assignment of individual data qualifiers based on the associated degree of variability; and 3) determining whether project DQOs were met. Data management personnel will perform data validation in accordance with the requirements in this IWP and existing WSTF procedures.

Step III: Usability Assessment – Usability assessment is the determination of the adequacy of data, based on the results of validation and verification, for the decisions being made. The usability process involves assessing whether the process execution and resulting data meet project quality objectives (EPA, 2005).

The goal of the usability assessment is to determine the quality of each data point and to identify data that are not acceptable to support project quality objectives. Data may be qualified as being unusable or rejected (R), as based on established quality review protocols. Data qualified as estimated concentrations (J) are less precise, or less accurate, than unqualified data but are still acceptable for use. The data users, with support from the contractor environmental data management staff, are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on statistical procedures and other data uses. The data reporting will include a discussion of data limitations and their effect on data interpretation activities.

10.0 Current Monitoring and Sampling Programs

The most significant current monitoring program that contributes to this VIAWP is WSTF's ongoing groundwater sampling. NASA relies on the data generated from groundwater monitoring to provide input for the development of IWPs. NASA routinely collects groundwater samples from a comprehensive network of monitoring wells at WSTF in accordance with the NMED-approved GMP (NASA, 2015b). Groundwater samples are collected for the analysis of the following primary constituents: VOCs; n-nitrosodimethylamine, bromacil, and metals. In addition to routine groundwater samples required by the GMP, samples for other chemical analyses are frequently collected at many of the groundwater monitoring wells. Because these samples are not a direct requirement of the GMP, the results of these analyses are provided in the appropriate project-specific report.

11.0 Schedule

The VIAWP consists of three primary phases: 1) pre-assessment planning and preparation and update of the WSTF soil vapor RBCs; 2) execution of the field assessment activities; and 3) data evaluation and preparation of the AR detailing the findings of the assessment. The schedule for these activities is presented below relative to NMED approval of this VIAWP.

- Project 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. In conjunction with project planning and preparation activities, the WSTF RBCs (NASA, 2012c) must be updated with currently available exposure data.

Following NMED approval of the WSTF RBCs, NASA will utilize these in conjunction with NMED VISLs during the data review process and development of the final report. NASA expects planning, preparation, and RBC update activities to require approximately four months following NMED approval of the VIAWP.

- Field assessment includes preparation of the buildings to be assessed, sample planning and preparation activities, and sample collection and management. Field activities will commence following appropriate planning and preparation activities and NMED approval of updated WSTF RBCs. NASA anticipates that field assessment activities will require approximately six months in order to complete two semi-annual soil vapor sampling events that will be performed in consecutive summer and winter seasons.

- Chemical analytical results from the two soil vapor sampling events will be verified, validated, and used to develop the final AR. It is expected that chemical analytical data will be available for use approximately one month following completion of the second soil vapor sampling event. Evaluation of the data and preparation of the AR will require approximately two additional months. NASA anticipates submitting the AR to NMED approximately three months after field assessment activities have been completed.

12.0 References

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Figures

Figure 1.1 WSTF Location Map

(SEE NEXT PAGE)

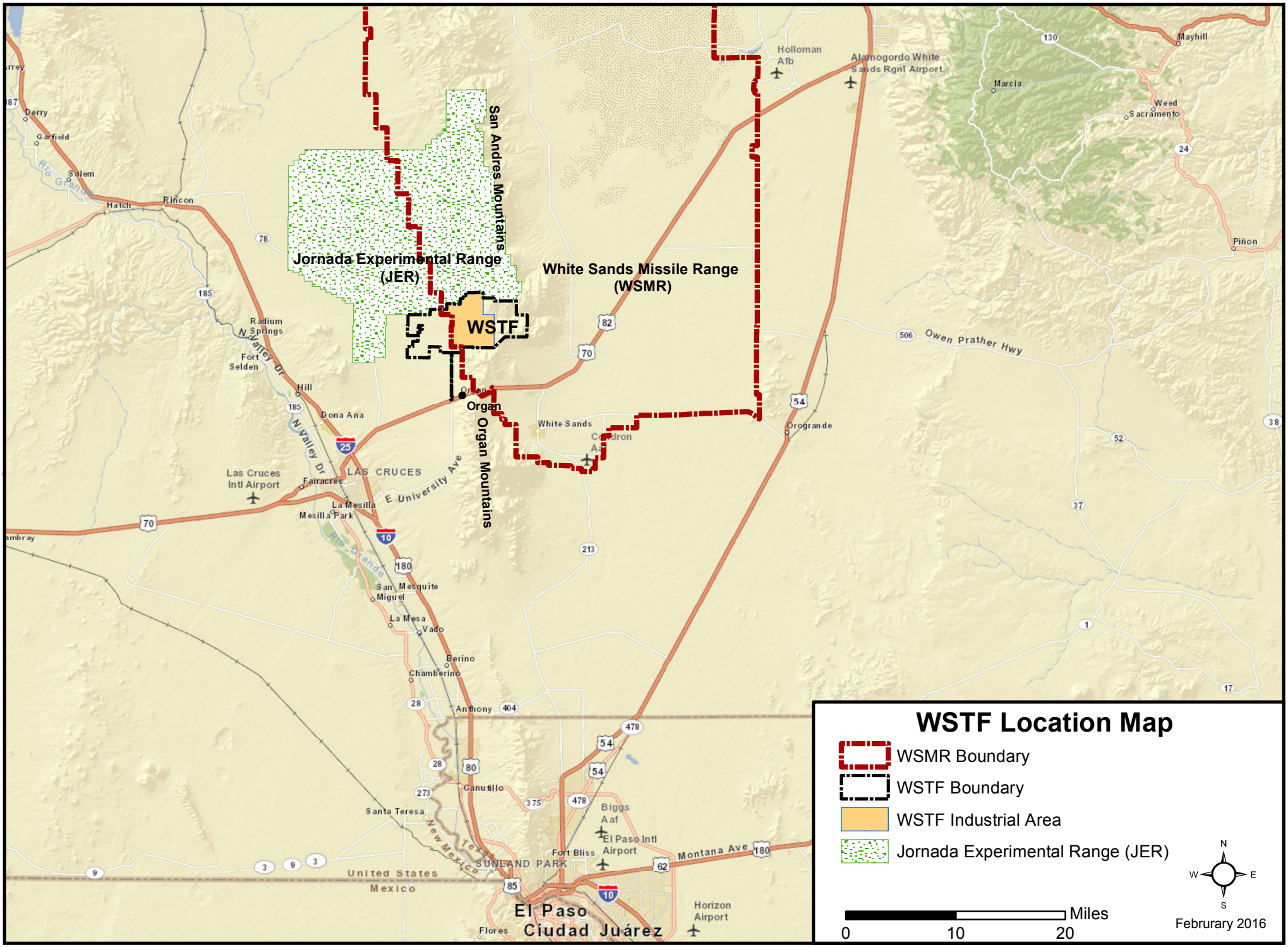
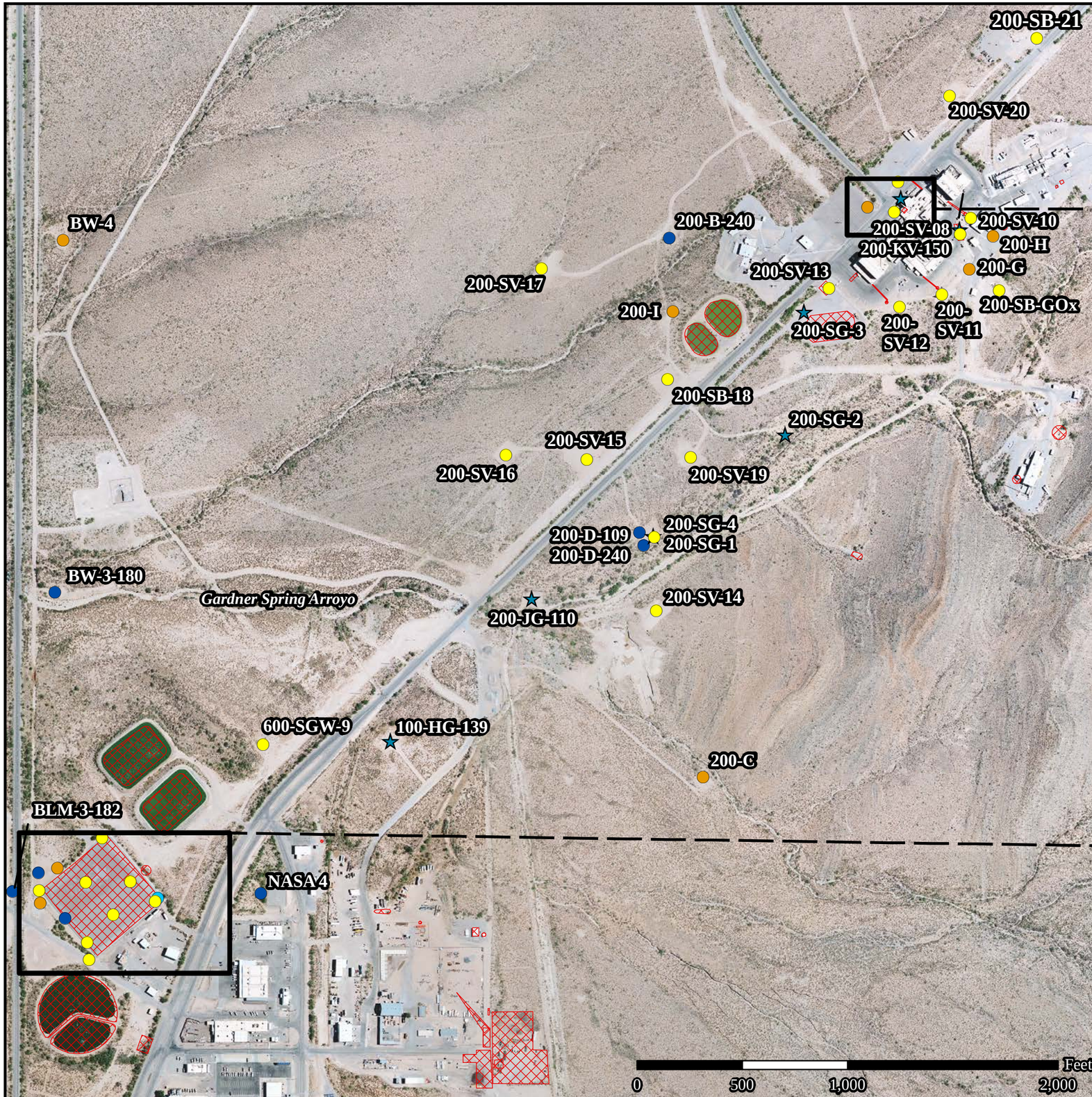
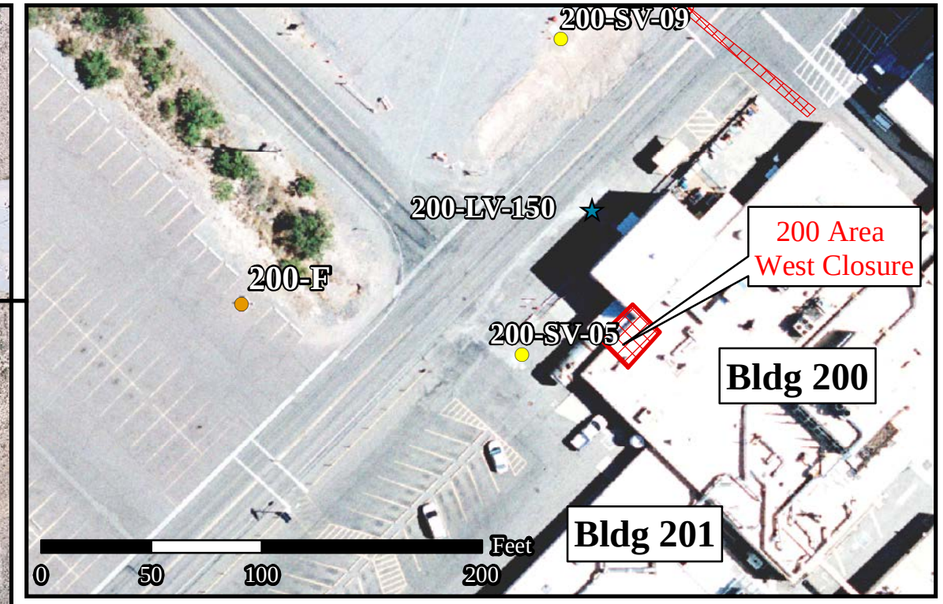
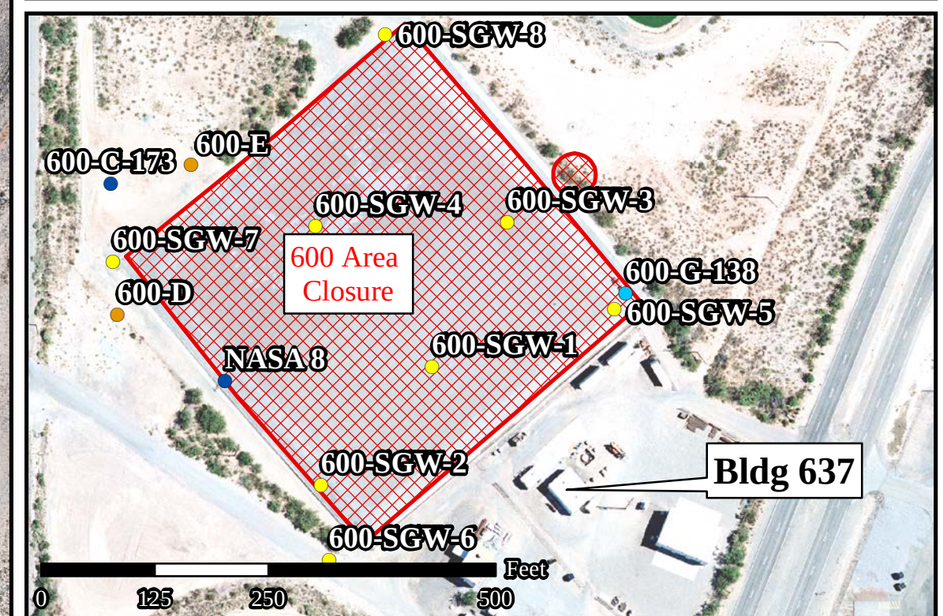

WSTF Location Map
WSMR Boundary
WSTF Boundary
WSTF Industrial Area
Jornada Experimental Range (JER)
Miles
0
10
20
N
S
E
W
Februrary 2016
Jornada Experimental Range (JER)
White Sands Missile Range (WSMR)
WSTF
San Andres Mountains
Organ Mountains
Organ
Holloman Afb
Alamogordo White Sands Rgnl Airport
Mayhill
Marcia
Weed
Sacramento
Piñon
Owen Prather Hwy
Orogrande
White Sands
Cloudcroft
Derry
Garfield
Salem
Hatch
Rincon
Radium Springs
Fort Selden
Hill
Dona Ana
N Valley Dr
Las Cruces Intl Airport
LAS CRUCES
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
Biggs Aaf
El Paso Intl Airport
Fort Bliss
SUNLAND PARK
Montana Ave
United States
Mexico
El Paso
Ciudad Juárez
Flores
Horizon Airport

Figure 1.2 Vapor Intrusion Assessment Building Locations

(SEE NEXT PAGE)







Vapor Intrusion Assessment Building Locations

- Conventional Groundwater Well
- Perched Groundwater Well
- Multiport Groundwater Well
- Multiport Soil Vapor Well
- Multiport Soil Vapor & Groundwater Well
- SWMU or HWMU

N
W E
S

February 2016

Figure 2.1 Freon 113 Soil Vapor and Groundwater Concentrations (October 2014)

(SEE NEXT PAGE)

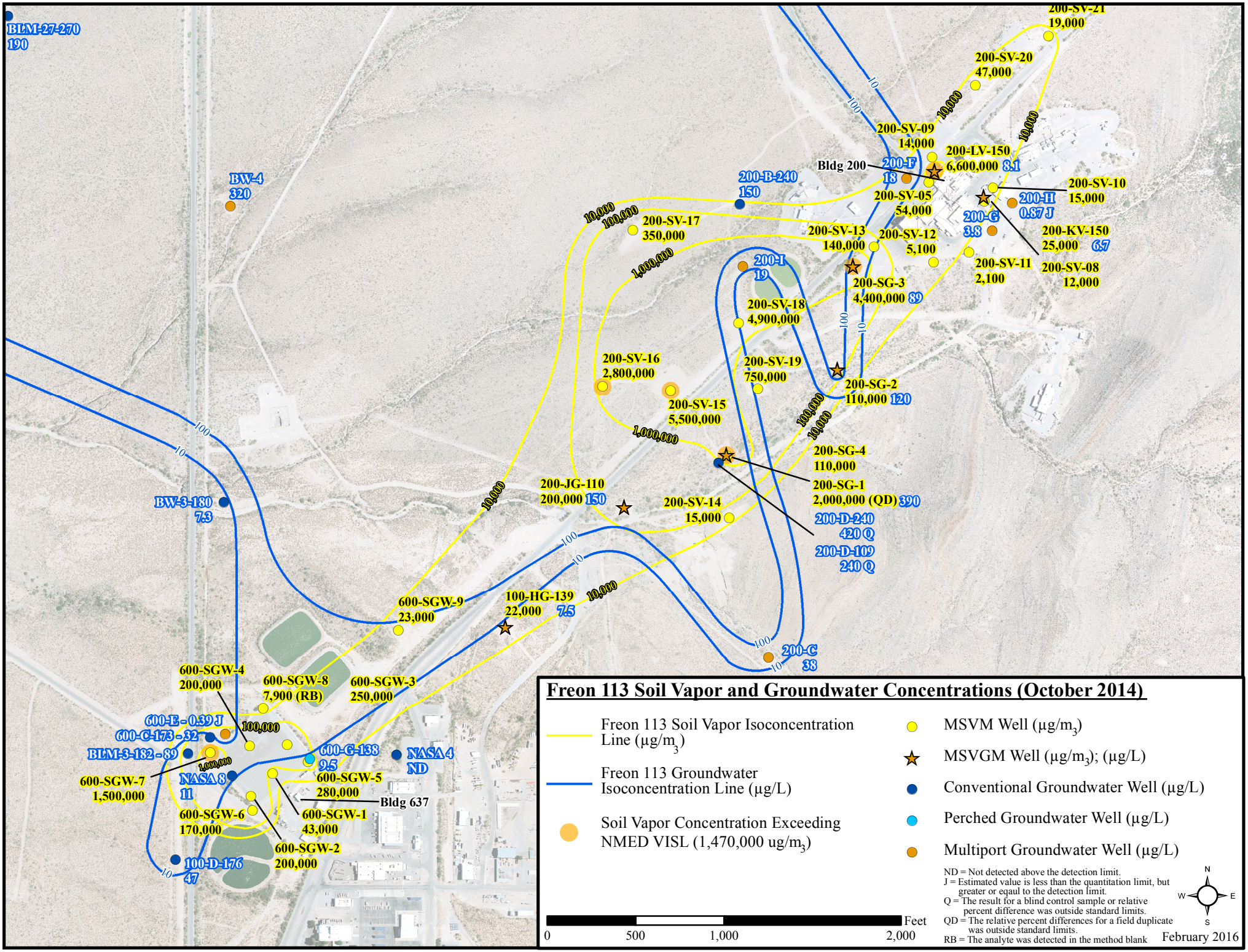

Freon 113 Soil Vapor and Groundwater Concentrations (October 2014)
Freon 113 Soil Vapor Isoconcentration Line (µg/m3)
Freon 113 Groundwater Isoconcentration Line (µg/L)
Soil Vapor Concentration Exceeding NMED VISL (1,470,000 ug/m3)
MSVM Well (µg/m3)
MSVGM Well (µg/m3); (µg/L)
Conventional Groundwater Well (µg/L)
Perched Groundwater Well (µg/L)
Multiport Groundwater Well (µg/L)
ND = Not detected above the detection limit.
J = Estimated value is less than the quantitation limit, but greater or eqaul to the detection limit.
Q = The result for a blind control sample or relative percent difference was outside standard limits.
QD = The relative percent differences for a field duplicate was outside standard limits.
RB = The analyte was detected in the method blank
Feet
0
500
1,000
2,000
N
S
E
W
February 2016
BLM-27-270
190
BW-4
320
200-SV-21
19,000
200-SV-20
47,000
200-SV-09
14,000
200-LV-150
6,600,000 8.1
Bldg 200
200-F
18
200-SV-05
54,000
200-B-240
150
200-SV-10
15,000
200-H
0.87 J
200-G
3.8
200-KV-150
25,000 6.7
200-SV-17
350,000
200-SV-13
140,000
200-SV-12
5,100
200-SV-11
2,100
200-SV-08
12,000
200-I
19
200-SG-3
4,400,000 89
200-SV-18
4,900,000
200-SV-16
2,800,000
200-SV-19
750,000
200-SG-2
110,000 120
200-SV-15
5,500,000
200-SG-4
110,000
200-SG-1
2,000,000 (QD) 390
200-JG-110
200,000 150
200-SV-14
15,000
200-D-240
420 Q
200-D-109
240 Q
BW-3-180
7.3
600-SGW-9
23,000
100-HG-139
22,000 7.5
200-C
38
600-SGW-4
200,000
600-SGW-8
7,900 (RB)
600-SGW-3
250,000
600-E - 0.39 J
600-C-173 - 32
BLM-3-182 - 89
600-G-138
9.5
NASA 4
ND
600-SGW-7
1,500,000
NASA 8
11
600-SGW-5
280,000
Bldg 637
600-SGW-6
170,000
600-SGW-1
43,000
600-SGW-2
200,000
100-D-176
47
10
100
10,000
100,000
1,000,000

Figure 2.2 TCE Soil Vapor and Groundwater Concentrations (October 2014)

(SEE NEXT PAGE)

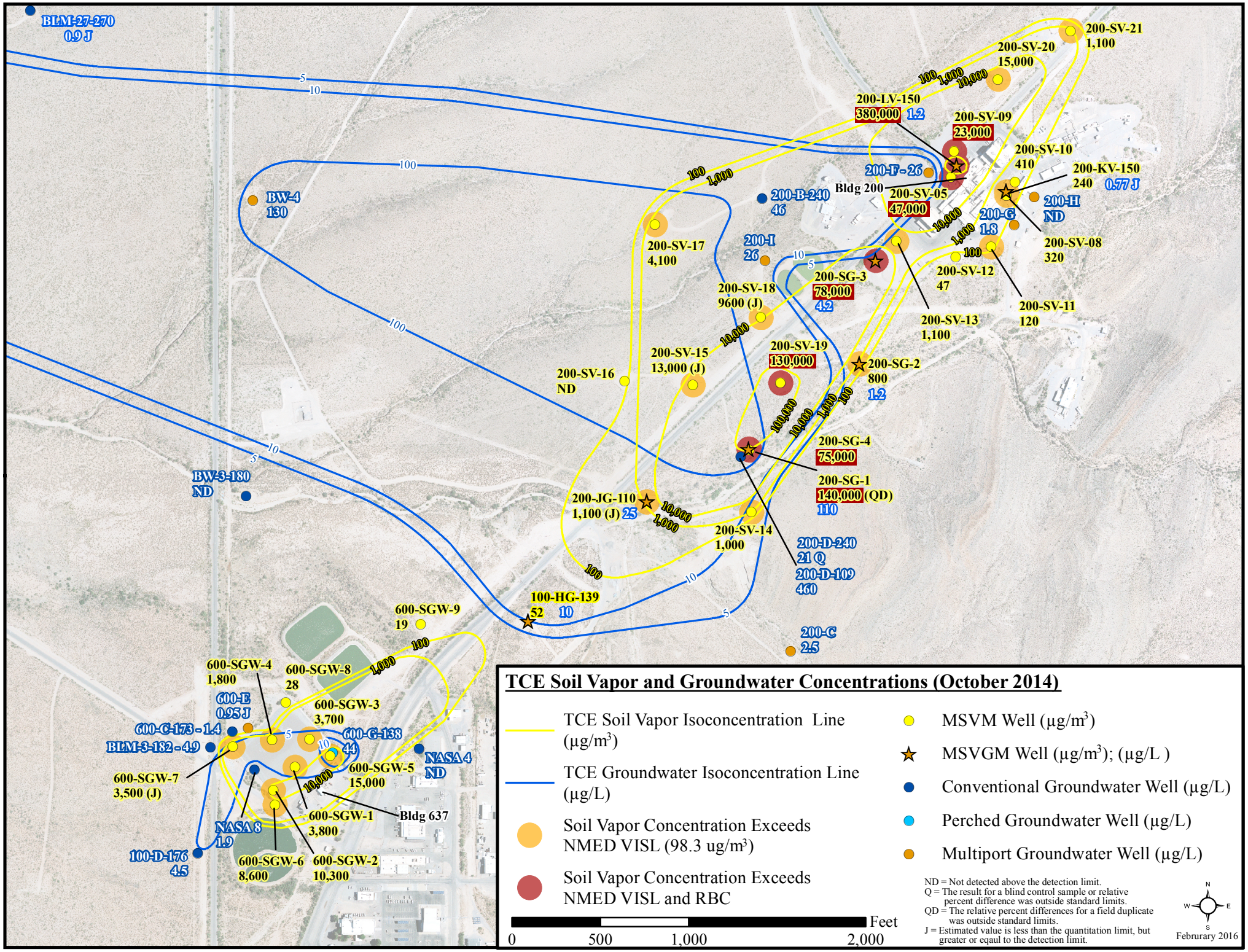

BLM-27-270
0.9 J
BW-4
130
BW-3-180
ND
200-SV-21
1,100
200-SV-20
15,000
200-LV-150
380,000
1.2
200-SV-09
23,000
200-SV-10
410
200-KV-150
240
0.77 J
200-F-26
Bldg 200
200-SV-05
47,000
200-H
ND
200-G
1.8
200-SV-08
320
200-B-240
46
200-SV-17
4,100
200-I
26
200-SG-3
78,000
4.2
200-SV-12
47
200-SV-18
9600 (J)
200-SV-13
1,100
200-SV-11
120
200-SV-15
13,000 (J)
200-SV-19
130,000
200-SG-2
800
1.2
200-SV-16
ND
200-SG-4
75,000
200-SG-1
140,000 (QD)
110
200-JG-110
1,100 (J)
25
200-SV-14
1,000
200-D-240
21 Q
200-D-109
460
100-HG-139
52
10
200-C
2.5
600-SGW-9
19
600-SGW-4
1,800
600-SGW-8
28
600-E
0.95 J
600-SGW-3
3,700
600-C-173 - 1.4
600-G-138
44
BLM-3-182 - 4.9
NASA 4
ND
600-SGW-7
3,500 (J)
600-SGW-5
15,000
600-SGW-1
3,800
Bldg 637
NASA 8
1.9
100-D-176
4.5
600-SGW-6
8,600
600-SGW-2
10,300
TCE Soil Vapor and Groundwater Concentrations (October 2014)
TCE Soil Vapor Isoconcentration Line (µg/m³)
TCE Groundwater Isoconcentration Line (µg/L)
Soil Vapor Concentration Exceeds NMED VISL (98.3 ug/m³)
Soil Vapor Concentration Exceeds NMED VISL and RBC
MSVM Well (µg/m³)
MSVGM Well (µg/m³); (µg/L)
Conventional Groundwater Well (µg/L)
Perched Groundwater Well (µg/L)
Multiport Groundwater Well (µg/L)
0
500
1,000
2,000
Feet
ND = Not detected above the detection limit.
Q = The result for a blind control sample or relative percent difference was outside standard limits.
QD = The relative percent differences for a field duplicate was outside standard limits.
J = Estimated value is less than the quantitation limit, but greater or equal to the detection limit.
N
W
E
S
Februrary 2016

Figure 2.3 PCE Soil Vapor and Groundwater Concentrations (October 2014)

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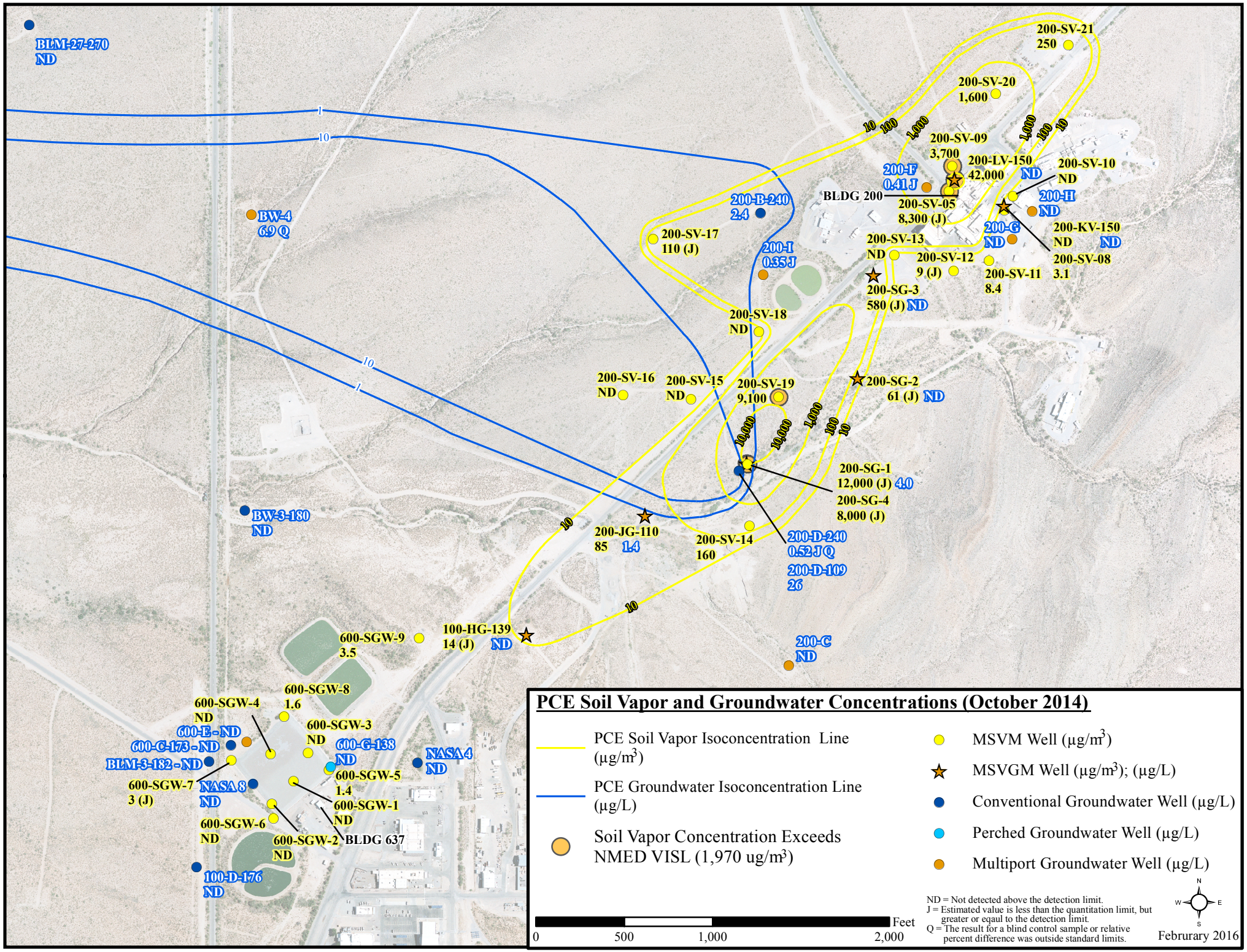

PCE Soil Vapor and Groundwater Concentrations (October 2014)
PCE Soil Vapor Isoconcentration Line (µg/m3)
PCE Groundwater Isoconcentration Line (µg/L)
Soil Vapor Concentration Exceeds NMED VISL (1,970 ug/m3)
MSVM Well (µg/m3)
MSVGM Well (µg/m3); (µg/L)
Conventional Groundwater Well (µg/L)
Perched Groundwater Well (µg/L)
Multiport Groundwater Well (µg/L)
ND = Not detected above the detection limit.
J = Estimated value is less than the quantitation limit, but greater or eqaul to the detection limit.
Q = The result for a blind control sample or relative percent difference was outside standard limits.
0
500
1,000
2,000
Feet
Februrary 2016
BLM-27-270 ND
BW-4 6.9 Q
BW-3-180 ND
200-SV-21 250
200-SV-20 1,600
200-SV-09 3,700
200-LV-150 42,000
200-SV-10 ND
200-F 0.41 J
BLDG 200
200-SV-05 8,300 (J)
200-H ND
200-G ND
200-KV-150 ND
200-SV-08 3.1
200-SV-13 ND
200-SV-12 9 (J)
200-SV-11 8.4
200-SG-3 580 (J) ND
200-B-240 2.4
200-SV-17 110 (J)
200-I 0.35 J
200-SV-18 ND
200-SV-16 ND
200-SV-15 ND
200-SV-19 9,100
200-SG-2 61 (J) ND
200-SG-1 12,000 (J) 4.0
200-SG-4 8,000 (J)
200-JG-110 85 1.4
200-SV-14 160
200-D-240 0.52 J Q
200-D-109 26
100-HG-139 14 (J) ND
200-C ND
600-SGW-9 3.5
600-SGW-8 1.6
600-SGW-4 ND
600-E - ND
600-C-173 - ND
BLM-3-182 - ND
600-SGW-3 ND
600-G-138 ND
NASA 4 ND
600-SGW-7 3 (J)
NASA 8 ND
600-SGW-5 1.4
600-SGW-1 ND
600-SGW-6 ND
600-SGW-2 ND
BLDG 637
100-D-176 ND
1
10
100
1,000
10,000
N
S
E
W

Figure 2.4 Site Conceptual Exposure Model

(SEE NEXT PAGE)

Site Conceptual Exposure Model

Source of Contamination

Soil vapor contamination at the former Clean Room USTs location in the 200 Area and at the 600 Area Surface Impoundments.

Release Mechanism

Infiltration of contaminants into groundwater and into vadose zone pore space as vapor-phase contamination in the vicinity of 200 Area Building 200 and 600 Area Building 637.

Potential Exposure Pathway

Inhalation of contaminated soil vapor migrating through building foundation or walls into indoor airspace.

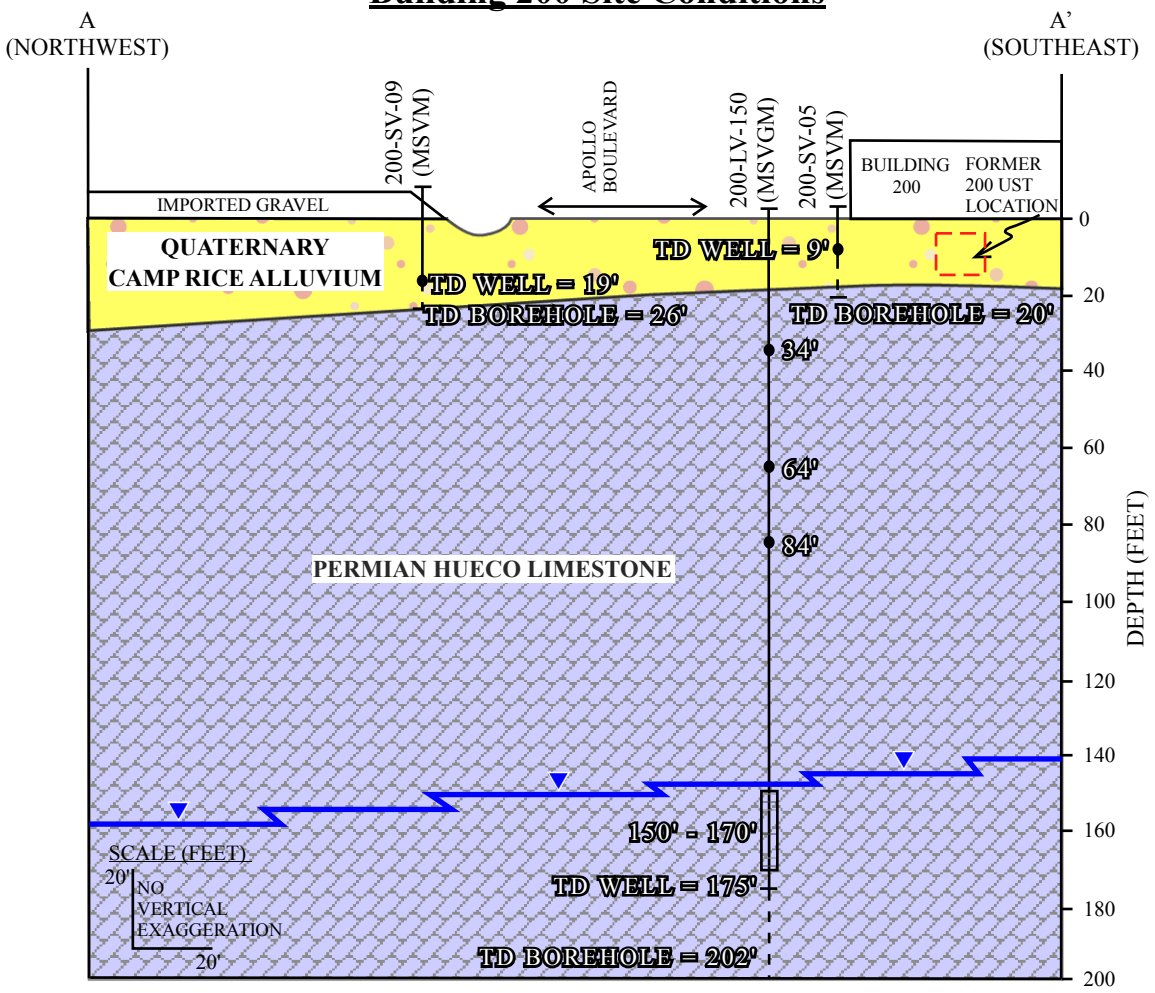
Industrial Potential Receptors

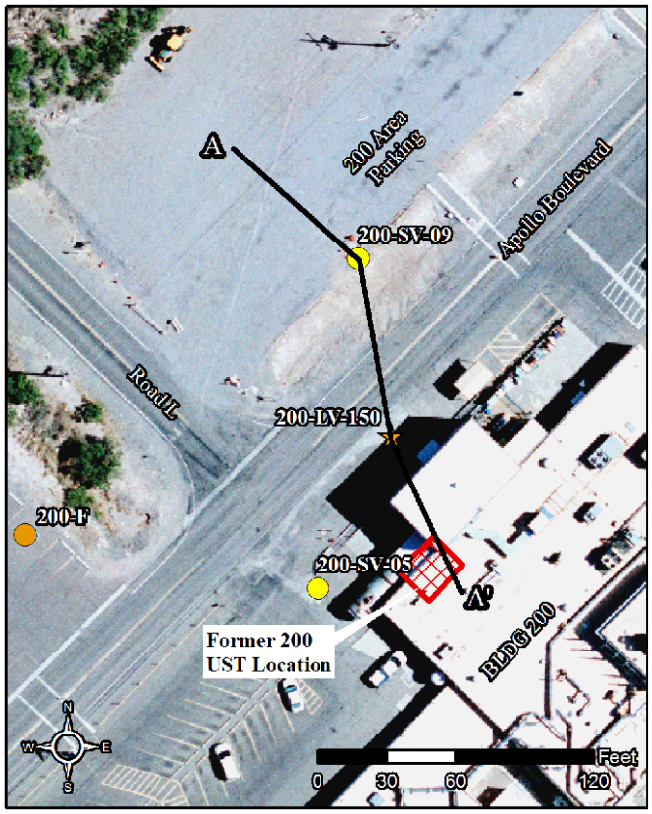
Industrial / occupational workers who utilize buildings in the adjacent areas in order to perform their daily duties.

Figure 3.1 Building 200 Site Conditions

(SEE NEXT PAGE)

Building 200 Site Conditions





TD WELL =9'
TD BOREHOLE =20'
MSVM WELL WITH VAPOR PORTS (DEPTH IN FEET)

84'
150' - 170'
TD WELL =9'
TD BOREHOLE =20'
MSVGM WELL WITH VAPOR PORTS AND GROUNDWATER MONITORING ZONES (DEPTH IN FEET)

QUATERNARY CAMP RICE ALLUVIUM

PERMIAN HUECO LIMESTONE

WATER TABLE (INFERRED FROM MONITORING WELL DATA)

CROSS-SECTION EXTENT (A-A')

HWMU

MULTIPORT GROUNDWATER WELL

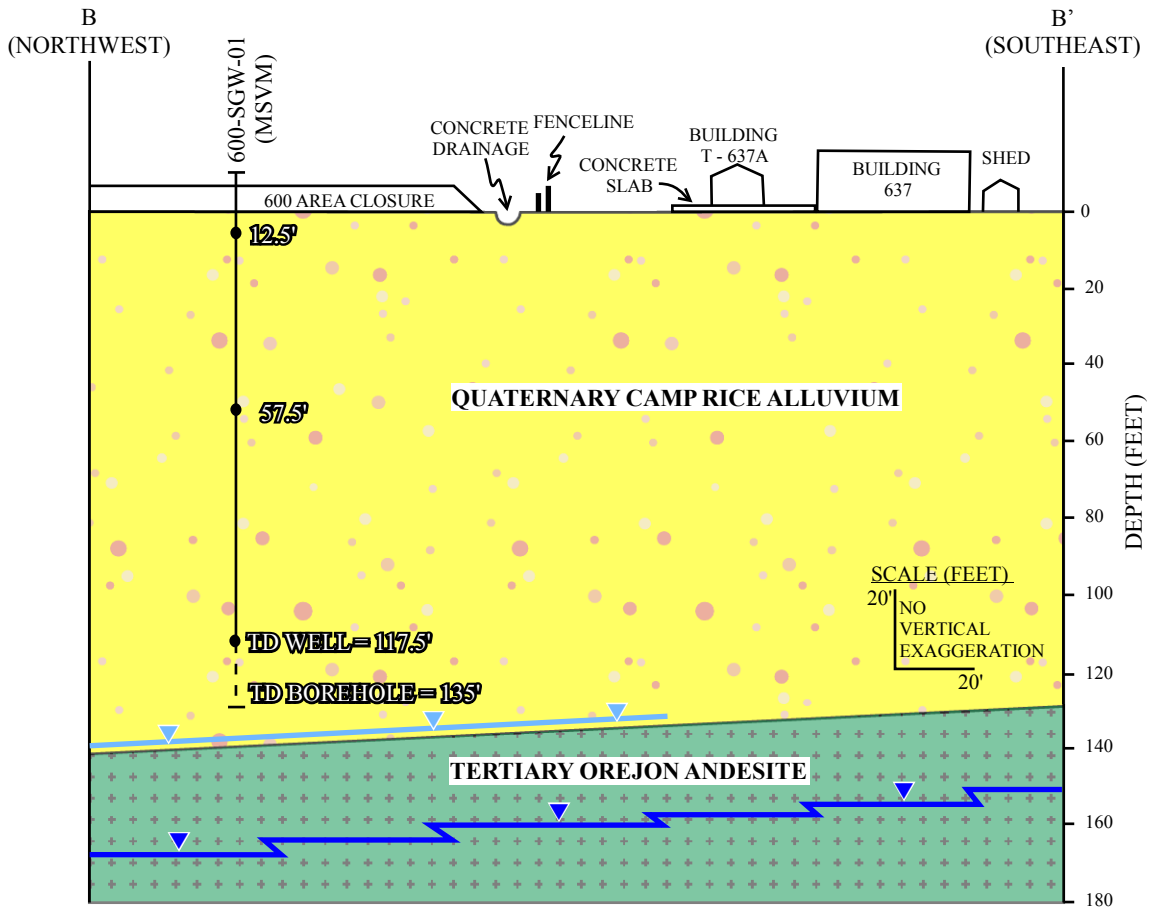
MSVGM WELL

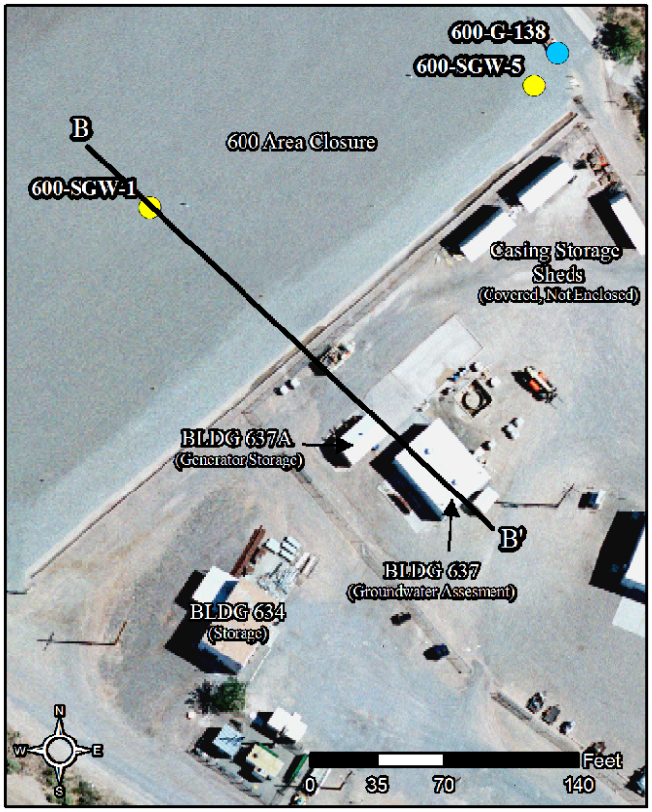
MSVM WELL

Figure 3.2 Building 637 Site Conditions

(SEE NEXT PAGE)

Building 637 Site Conditions





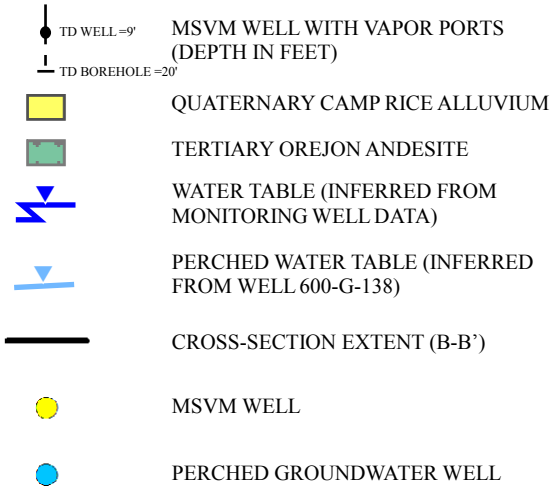
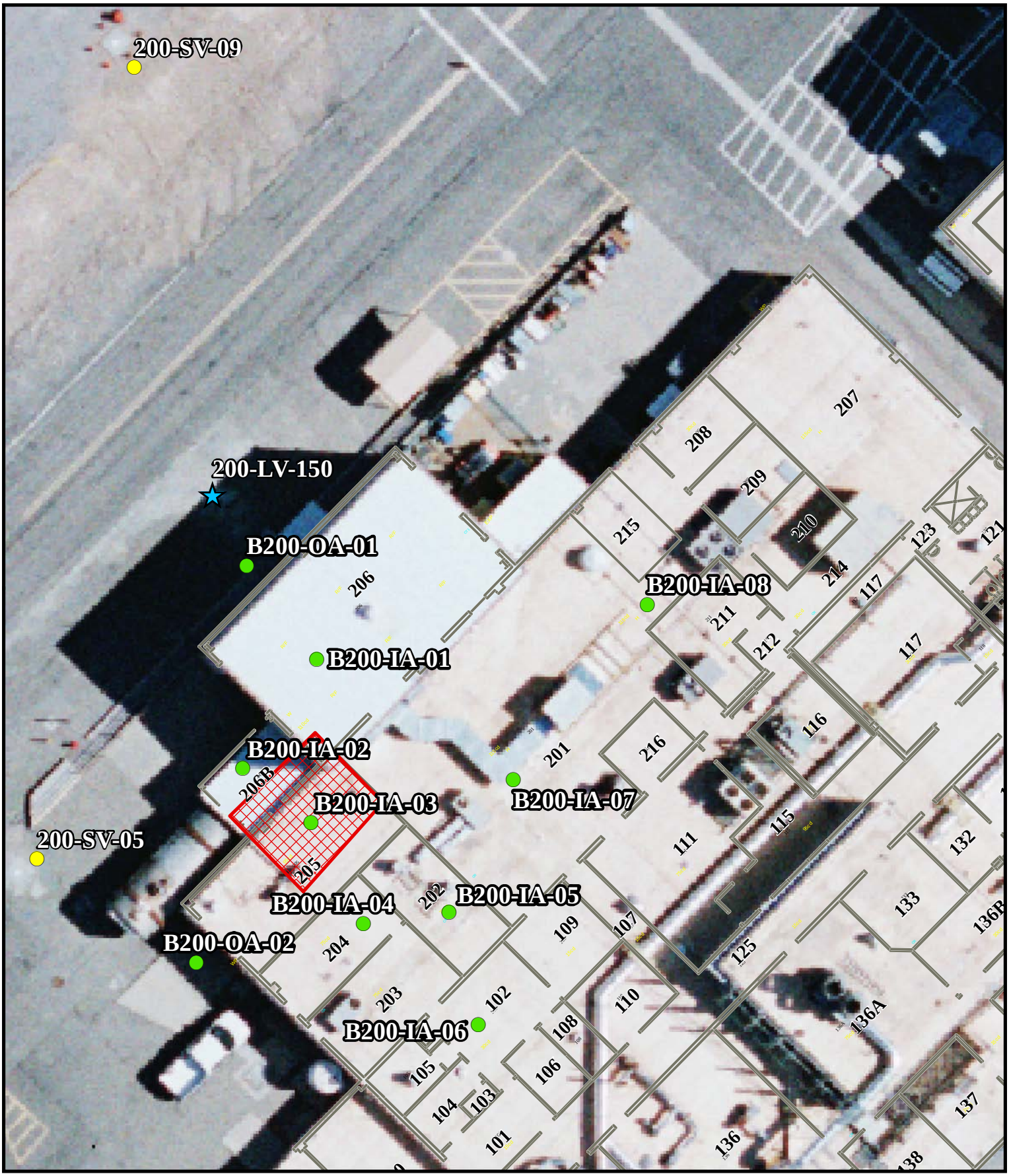


Figure 4.1 West Building 200 Soil Vapor and Air Sampling Locations

(SEE NEXT PAGE)



West Building 200 Soil Vapor and Air Sampling Locations

Air Sample Location

MSVGM Well Sample

HWMU

MSVM Sample

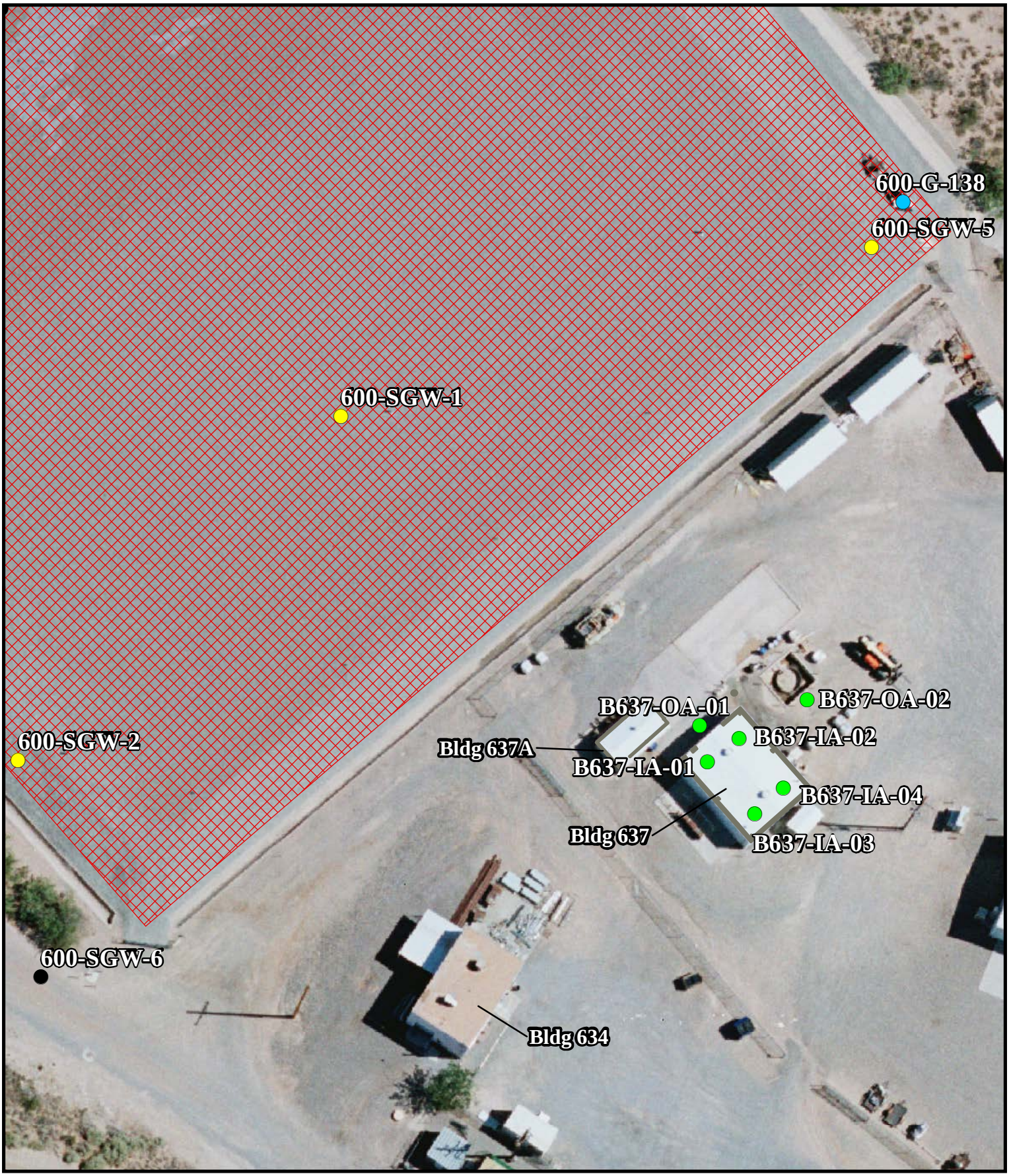
0 10 20 40 Feet

N W E S

February 2016

Figure 4.2 Building 637 Soil Vapor and Air Sampling Locations

(SEE NEXT PAGE)



Building 637 Soil Vapor and Air Sampling Locations

Air Sample Location

MGMV Well

SWMU

MGMV Well Sample

Perched GW Monitoring Well

0 15 30 60 Feet

N W E S

February 2016

Tables

Table 1.1 Comparison of Vapor Concentration Guidance Levels

Chemical	NMED VISLs[1]		WSTF RBCs[2]		OSHA STANDARDS	
	Industrial/ Occupational Indoor Air ($\mu g/m^3$)	Industrial/ Occupational Soil Vapor ($\mu g/m^3$)	Industrial/ Occupational Worker @ 5' bgs ($\mu g/m^3$)	Industrial/ Occupational Worker @ 10' bgs ($\mu g/m^3$)	Limits for Air Contaminants PEL TWA* (ppm)	Limits for Air Contaminants PEL TWA* ($\mu g/m^3$)
Freon 11	3,440	34,400	260,000	390,000	1,000	5,600,000
Freon 113	147,000	1,470,000	120,000,000	190,000,000	1,000	7,600,000
TCE	9.83	98.3	2,800	4,200	100	537,000
PCE	197	1,970	46,000	71,000	100	678,000

Notes:
[1] = NMED, 2015
[2] = NASA, 2012
*= OSHA (2016) Personal Exposure Limit (PEL) 8-Hour time weighted Average (TWA).

Table 4.1 Proposed Soil Vapor Monitoring Well Sampling Locations

Well ID	Location Description	Well Type	Soil Vapor Sample Port Locations (Ft Bgs)	Groundwater Sample Location (Feet Bgs)	Horizontal Distance to Building (Feet)	Concentrations for Primary Contaminants from October 2014 (µg/m^3)
200 Area in the vicinity of the Clean Room Tank HWMU Located Below the East Side of Building 200						
200-SV-05	West side of B. 200 southwest of the former Clean Room Tank location	MSVM	9	---	28	Freon 11 = 160 (J) Freon 113 = 54,000 TCE = 47,000 PCE = 8,300 (J)
200-LV-150	Immediately west and adjacent to B. 200 at the former Clean Room Tank location	MSVGM	34, 64, 84	150 - 170	18	Freon 11 = ND Freon 113 = 6,600,000 TCE = 380,000 PCE = 42,000
200-SV-09	Across Apollo Boulevard to the west of B. 200 at location for former Clean Room Discharge pipe	MSVM	19	---	84	Freon 11 = ND Freon 113 = 14,000 TCE = 23.000 PCE = 3,700
600 Area in the Vicinity of the Southeast Side of the 600 Area Surface Impoundments Closure Near B. 637						
600-SGW-1	Northwest of B. 637 within southeast cell of former 600 Area Surface Impoundments	MSVM	12.5, 57.5, 117.5	---	184	Freon 11 = ND Freon 113 = 43,000 TCE = 3,800 PCE = ND
600-SGW-2	West of B. 637 along southwest side of southeast cell of former 600 Area Surface Impoundments	MSVM	12.5, 47.5, 107.5, 150	---	260	Freon 11 = ND Freon 113 = 200,000 TCE = 10,300 PCE = ND
600-SGW-5	North of B. 637 at east corner of southeast cell of former 600 Area Surface Impoundments	MSVM	7.5, 52.5, 102.5, 137.5	---	181	Freon 11 = 1,200 (J) Freon 113 = 280,000 TCE = 15,000 PCE = 1.4

Notes:
(J) = Estimated value is less than the quantitation limit, but greater than or equal to the detection limit
MSVM = Multiport Soil Vapor Monitoring, MSVGM = Multiport Soil Vapor and Groundwater Monitoring
- Two semi-annual sampling rounds are proposed to provide seasonal samples. Indoor and outdoor air pressure will be monitored during sampling.
- Approximately 7 vadose zone samples (one duplicate) per semi-annual sampling event and 14 samples total.

Table 4.2 Proposed Indoor and Outdoor Air Sampling Locations

Indoor Air (IA)/ Outdoor Air (OA) Sample ID	Horizontal Distance from Primary Vadose Zone Vapor Source* (Ft)	Sample Type and Frequency	Indoor/ Outdoor Air Sample Collection Location	Sample Collection Strategies	Sample Container and Analysis	Sample Notes
Building 200 (West Side 200 Area) in the Vicinity of the Clean Room Tank HWMU						
B200-IA-01	13	Indoor/ outdoor air grab sample. Two semi-annual sampling events in the summer and winter seasons.	3 to 5 feet above ground surface in typical breathing zone	Indoor samples will be collected with outer wall windows and doors closed to minimize any contribution from outside air and will be distributed through rooms as applicable. Outdoor air samples from a representative upwind location away from any wind obstructions.	3-Liter Summa canister, analysis by TO-15	Flow controller over 8-hour period
B200-IA-02	4					
B200-IA-03	0					
B200-IA-04	12					
B200-IA-05	22					
B200-IA-06	40					
B200-IA-07	24					
B200-IA-08	60					
B200-OA-01	33					
B200-OA-02	23					
Building 637 in the Vicinity of the Southeast Side of the 600 Area Surface Impoundments						
B637-IA-01	92	Indoor/ outdoor air grab sample. Two semi-annual sampling events in the summer and winter seasons.	3 to 5 feet above ground surface in typical breathing zone	Indoor samples will be collected with outer wall windows and doors closed to minimize any contribution from outside air and will be distributed through rooms as applicable. Outdoor air samples from a representative upwind location away from any wind obstructions.	3-Liter Summa canister, analysis by TO-15	Flow controller over 8-hour period
B637-IA-02	93					
B637-IA-03	118					
B637-IA-04	118					
B637-OA-01	100					
B637-OA-02	100					

Notes:

* = Primary elevated vapor source in the 200 Area is the footprint of the former Clean Room Tank excavation (HWMU). Primary elevated vapor source in the 600 Area is MSVM well 600-SGW-05.

- Two semi-annual sampling rounds are proposed to provide seasonal samples. Indoor and outdoor air pressure will be monitored during sampling.
- Approximately 18 indoor and outdoor air samples (two duplicates) per semi-annual sampling event and 36 samples total.

Appendix A
Investigation-Derived Waste Management Plan

National Aeronautics and
Space Administration

200 and 600 Area

Vapor Intrusion Assessment

Investigation-Derived Waste Management Plan

February 2016

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

Table of Contents

Table of Contents ii

List of Acronyms iii

1.0 Waste / Activity Description 1

2.0 Waste Characterization (Acceptable Knowledge) 1

3.0 Waste Management 1

4.0 Waste Characterization (Sampling and Analysis) 2

5.0 Waste Disposal 2

6.0 Reusable Materials 2

7.0 References 2

List of Acronyms

CFR	Code of Federal Regulations
DOT	Department of Transportation
HWMU	Hazardous Waste Management Unit
IDW	Investigation-derived waste
IWP	Investigation Work Plan
MSVGM	Multiport Soil Vapor and Groundwater Monitoring
MSVM	Multiport Soil Vapor Monitoring
NASA	National Aeronautics and Space Administration
NMED	New Mexico Environment Department
PCE	Tetrachloroethene
PPE	Personal protective equipment
RCRA	Resource Conservation and Recovery Act
TCE	Trichloroethene
UST	Underground Storage Tank
VIAWP	Vapor Intrusion Assessment Work Plan
VOC	Volatile Organic Compound
WSTF	White Sands Test Facility

1.0 Waste / Activity Description

The National Aeronautics and Space Administration (NASA) will conduct a vapor intrusion assessment of multiport soil vapor monitoring (MSVM) wells and multiport soil vapor and groundwater monitoring (MSVGM) wells, indoor air, and outdoor air in the vicinity of Building 200 in the 200 Area, and Building 637 in the 600 Area. The purpose of the assessment is to evaluate the potential vapor intrusion pathway between the vadose zone and the interior of the buildings. NASA will collect soil vapor samples from MSVM and MSVGM wells adjacent to Building 200 and Building 637, and indoor and outdoor air samples from the same buildings. Specific soil vapor ports in the MSVM and MSVGM wells will be sampled at surface for each of the wells, and at a height of 3 to 5 feet above ground level within and around the buildings, or as approved by the New Mexico Environment Department (NMED). This Investigation-Derived Waste (IDW) Plan will address the management of IDW that will be generated from the investigation activities.

A limited amount of IDW is expected to be generated from the vapor intrusion assessment. For the purpose of this IDW Plan, the types of IDW anticipated are identified as:

- Contact waste, including:
  - Non-dedicated soil vapor sampling equipment.
  - Personal protective equipment (PPE).
  - Alcohol-free moist wipes from the equipment decontamination process.

2.0 Waste Characterization (Acceptable Knowledge)

No wastes are anticipated to be directly contacted other than the potential inhalation of low concentrations of volatile organic compounds (VOCs) in soil vapor. VOCs known to have been historically managed in the 200 Area Clean Room Underground Storage Tanks (USTs; also classified as a Hazardous Waste Management Unit [HWMU]; NASA, 2012) and potentially discharged to the vadose zone during historical operations include: trichloroethene (TCE); tetrachloroethene (PCE); Freon®[1] 11; Freon 113; 2-butanone (methyl ethyl ketone); 1,1,1-trichloroethane; chloroform; benzene; ethylbenzene; toluene; xylenes; acetone; and 2-propanol (isopropyl alcohol). Waste management practices at White Sands Test Facility (WSTF) have been continually modified and improved through time to effectively minimize, document, store, and dispose of wastes. Wastes generated in the 200 Area were transported to the 600 Area impoundments (also classified as a HWMU). The VOCs placed in the 600 Area impoundments were identical to those stored in 200 Area USTs.

3.0 Waste Management

In order to be protective of human health and the environment, NASA will manage and accumulate the following IDW in accordance with WSI 22-SW-0005, *Waste Management*, (NASA, 2015) incorporating 40 Code of Federal Regulations (CFR) Part 262.34 (1982):

- Used non-dedicated soil vapor sampling equipment, personal protective equipment, and alcohol-free moist wipes will be containerized in Department of transport (DOT) compliant drums or bulk containers.

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

4.0 Waste Characterization (Sampling and Analysis)

Final waste characterization for any IDW will be completed in accordance with Attachment 12: *Waste Analysis Plan* of the NASA WSTF Hazardous Waste Permit (NMED, 2009). The VOCs that may be identified in soil vapor samples are listed in Section 2.2 of the 200 and 600 Area Vapor Intrusion Assessment Work Plan (VIAWP).

5.0 Waste Disposal

For IDW characterized as hazardous waste (40 CFR Part 261, 1980) Land Disposal notifications (40 CFR Part 268, 2003), disposal facility profiles, and hazardous waste manifests (40 CFR Part 262, 1982) will be completed as required. Waste will be transported for treatment and disposal at a permitted Resource Conservation and Recovery Act (RCRA) TSCA Treatment, Storage, and Disposal Facility (49 CFR, 2012).

6.0 Reusable Materials

Any materials, equipment, and structures associated with the vapor intrusion assessment (e.g., non-contaminated sampling equipment) will be evaluated for potential recycling or reuse.

7.0 References

Accumulation Time, 40 CFR § 262.34 (1982).

Identification and Listing of Hazardous Waste, 40 CFR § 261 (1980).

NASA Johnson Space Center White Sands Test Facility, (2012, March 28). *200 Area Investigation Work Plan and 200 Area Historical Information Summary*. Las Cruces, NM.

NASA Johnson Space Center White Sands Test Facility. (2015, February 17). *22-SW-0005, White Sands Test Facility Standard Instruction-Waste Management.* Las Cruces, NM.

NMED. Hazardous Waste Bureau. (2009, November). *Hazardous Waste Permit EPA ID No. NM8800019434 to United States National Aeronautics and Space Administration for the White Sands Test Facility Location in Doña Ana County, New Mexico. Permit Attachment 12.* Santa Fe, NM.

Pre-Transport Requirements, 40 CFR §262 Subpart C (1982).

Protection of the Environment, 40 CFR (2015).

Transportation, 49 CFR (2012).

Treatment Standards, 40 CFR §268 Subpart D (2003).

Appendix B
Building Inspection Form

Complete This Form For Each Building Involved In Indoor Air Testing/Sampling

Preparer's Name: _____ Date/Time Prepared: _____

Preparer's Affiliation: _____ Work Phone: _____

Purpose of Investigation: _____

1. **OCCUPANT:**
   Interviewed: Yes or No

   Last Name: _____ First Name: _____

   Address: _____

   County: _____

   Work Phone: _____ Alternate Phone: _____

   Number of occupants at location: _____

   Age of occupants: _____

2. **OWNER OR LANDLORD:** (Check if same as occupant)
   Interviewed: Y/N

   Last Name: _____ First Name: _____

   Address: _____

   County: _____

   Work Phone: _____ Alternate Phone: _____

3. **BUILDING CHARACTERISTICS:**

   Type of Building: (Circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _____

   If the property is residential, type? (Circle appropriate response)

Ranch	2-Family	3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouse/Condos
Modular	Log Home	Other: _____

If multiple units, how many? _____

If the property is commercial, type?

Business Type(s) _____

Does it include residences (i.e., multi-use)? Yes or No If yes, how many? _____

Other characteristics:

Number of floors: _____ Building Age: _____

Is the building insulated? Yes or No How air tight? Tight / Average / Not Tight

4. AIRFLOW

Use air current tubes or tracer smoke to evaluate airflow patterns & qualitatively describe:

Airflow between floors:

_____

Airflow near source:

_____

Outdoor air infiltration:

_____

Infiltration into air ducts:

_____

5. BASEMENT & CONSTRUCTION CHARACTERISTICS (Circle all that apply)

Above grade construction: wood frame concrete stone brick

Basement type: full crawlspace slab other: _____

Basement floor: concrete dirt stone other: _____

Basement floor: unsealed sealed

Covered with: _____

Concrete floor: unsealed sealed

Sealed with: _____

Foundation walls: poured block stone other: _____

Foundation walls: unsealed sealed

Sealed with: _____

The basement is: wet damp dry moldy

The basement is: finished unfinished partially finished

Sump present? Yes or No

Basement/Lowest level depth below grade: _____ feet

Water in sump? Yes No Not Applicable

Identify potential soil vapor entry points & approximate size (e.g., cracks, utility ports, drains).

_____

6. HEATING, VENTING & AIR CONDITIONING (Circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard
Space heaters	Steam radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler

Other: _____

The primary type of fuel used is:

Natural gas	Fuel oil	Kerosene
Electric	Propane	Solar
Wood	Coal	

Domestic hot water tank fueled by: _____

Boiler/furnace located in: Basement Outdoors Main Floor

Other: _____

Air conditioning: Central air Window units Open windows

Are there air distribution ducts present? Yes or No

Heat Pump None

Describe the supply & cold air return ductwork & its condition where visible, including whether there is a cold air return & tightness of duct joints. Indicate the locations on the floor plan diagram.

_____

7. OCCUPANCY

Is basement/lowest lever occupied?

Full-time Occasionally Seldom Almost never

Level General use of each floor (e.g., family room, bedroom, laundry, workshop, storage)

Basement: _____

1st Floor: _____

2nd Floor: _____

3rd Floor: _____

4th Floor: _____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

Is there an attached garage? Yes or No

Does the garage have a separate heating unit? Yes , No or Not Applicable

Are petroleum-powered machines or vehicles stored in the garage? (e.g., lawnmower, ATV, car)

Yes or No. Please specify: _____

Has the building ever had a fire? Yes or No. When? _____

Is a kerosene or unvented gas space heater present? Yes or No

Where & Type? _____

Is there a workshop or hobby/craft area? Yes or No

Where & Type? _____

Is there smoking in the building? Yes or No? Frequency? _____

Have cleaning products been used recently? Yes or No

When and What Type? _____

Have cosmetic products been used recently? Yes or No

When and What Type? _____

Has painting/staining been done in the last 6 months? Yes or No

Where and When? _____

Is there new carpet, drapes or other textiles? Yes or No

Where and When? _____

Have air fresheners been used recently? Yes or No

When and What Type? _____

Is there a kitchen exhaust fan? Yes or No

If yes, where vented? _____

Is there a bathroom exhaust fan? Yes or No

If yes, where vented? _____

Is there a clothes dryer? Yes or No If yes, is it vented outside? Yes or No

Has there been a pesticide application? Yes or No

When and Type? _____

Are there odors in the building? Yes or No

If yes, please describe: _____

Do any of the building occupants use solvents or volatile chemicals at work? Yes or No (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide applicator, cosmetologist, carpet installer)

If yes, what type of solvents are used? _____

If yes, are their clothes washed at work? Yes or No

Do any of the building occupants regularly use or work at a dry-cleaning service? (Circle one)
Yes, use dry-cleaning regularly (weekly) Yes, use dry-cleaning infrequently (monthly or less)

Yes, work at a dry-cleaning service No

Unknown

Is there a radon mitigation system for the building/structure? Yes or No

Date of Installation: _____

Is the system active or passive? Active or Passive

9. WATER & SEWAGE

Water Supply: Public water Drilled well Driven well Dug well

Other: _____

Sewage Disposal: Public sewer Septic tank Leach field Dry well

Other: _____

10. RELOCATION INFORMATION (for oil spill residential emergency)

a. Provide reasons why relocation is recommended:

_____

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Yes or No

d. Relocation package provided & explained to residents? Yes or No

11. FLOOR PLANS

Draw a plan view sketch of the basement & first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

First Floor:

Second Floor:

12. OUTDOOR PLOT

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc), outdoor air sampling location(s) & PID meter readings.

Also indicate compass direction, wind direction & speed during sampling, the locations of the well & septic system, if applicable, & a qualifying statement to help locate the site on a topographic map.

13. PRODUCT INVENTORY FORM

Make & Model of field instrument used: _____

List specific products found in the residence that have the potential to affect indoor air quality.

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo** Y / N

***Describe the condition of the product containers as Unopened (UO), Used (U), or Deteriorated (D)**
****Photographs of the front & back of the product containers can replace the hand written list of chemical ingredients. However, the photographs must be of good quality & ingredient labels must be legible.**