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2015 Air Sampling and Vapor Intrusion Tier Response Evaluation Report

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, CA

July 2015

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Prepared for:

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, CA

July 2015

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Acronyms

µg/m^3	microgram(s) per cubic meter
µg/L	microgram(s) per liter
Ames	Ames Research Center
AOR	area of Responsibility
bgs	below Ground Surface
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
DCA	dichloroethane
DCE	dichloroethane
DoD ELAP	U.S. Department of Defense Environmental Laboratory Accreditation Program
DTSC	Department of Toxic Substances Control
EC	engineering control
EMD	Environmental Management Division
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FFA	Federal Facilities Agreement
FSM	Facility Site Manager
ft	foot
ft^2	square foot
GIS	Geographical Information System
HVAC	heating, ventilation, and air conditioning
IC	institutional controls
MEW	Middlefield-Ellis-Whisman
MEW Site	MEW Superfund Study Area
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NASA AOR	NASA vapor intrusion area of responsibility
Navy	U.S. Department of the Navy
Navy AOR	Navy vapor intrusion area of reponsibility
NELAP	National Environmental Laboratory Accreditation Program

PCBs	polychlorinated biphenyls
PCE	perchloroethene
ppb	parts per billion (ppb)
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RA	remedial action
RD	remedial design
ROD	Record of Decision
ROD Amendment	*Record of Decision Amendment of the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman (MEW) Superfund Study Area, Mountain View and Moffett Field, California (EPA 2010)*
SIM	selected ion monitoring
TCE	trichloroethene
VOC	volatile organic compound
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Executive Summary

Earth Resources Technology, Inc. (ERT) has prepared this *2015 Air Sampling and Vapor Intrusion Tier Response Evaluation Report for* the National Aeronautics and Space Administration (NASA) Ames Research Center (NASA Ames) Moffett Field, California. This Report documents air sampling activities and building tiering evaluation conducted by NASA Ames for buildings within NASA Ames' Area of Responsibility (Ames AOR) pursuant to United States Environmental Protection Agency (USEPA) 2010 Record of Decision Amendment of the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman (MEW) Superfund Study Area, Mountain View and Moffett Field, California (ROD Amendment).

Background

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NASA Ames is located at the southern end of the San Francisco Bay in Santa Clara County, California approximately 25 miles southeast of San Francisco, 10 miles northwest of San Jose and adjacent to the cities of Mountain View and Sunnyvale (Figure 1).

Groundwater contamination is present beneath NASA Ames primarily from upgradient sources. The groundwater contamination resulted from releases from the Middlefield-Ellis-Whisman (MEW) Superfund site and from operations at former Naval Air Station Moffett Field (NAS Moffett Field). The comingled groundwater contamination is referred to as the "Regional Plume." NASA Ames, the United States Department of Navy (Navy), and the MEW Superfund site potentially responsible parties are each conducting remediation of designated portions of the Regional plume (1989 MEW Site ROD).

In August 2010, the EPA amended the MEW Site 1989 Record of Decision (ROD) in accordance with CERCLA and the NCP to address health risks associated with long-term exposure to TCE and other MEW Site chemicals of potential concern through the vapor intrusion pathway in current and future buildings overlying the shallow subsurface contamination at the MEW Site. Subsequently, the EPA selected a remedy for the vapor intrusion pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings (EPA 2010 ROD Amendment).

The ROD Amendment for the Vapor Intrusion Pathway selected a remedy for the vapor intrusion pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings. The ROD Amendment defines the Vapor Intrusion Study Area as the area where TCE concentrations in shallow groundwater are greater than 5 micrograms per liter (µg/L) or parts per billion (ppb).

In September 2011, in coordination with the MEW Companies, NASA Ames, and the Navy, EPA developed the Statement of Work for the Vapor Intrusion Remedy Remedial Design and Remedial Action. Pursuant to an agreement among NASA Ames, Navy, and the MEW Companies, each entity is responsible for implementing the Vapor Intrusion Remedy in their designated Area of Responsibility, as depicted on Figure 2.

The ROD Amendment provides a tiering system to determine the appropriate response action for each building/property within the Vapor Intrusion Study Area based on indoor air sampling with or without an HVAC system in place and other lines of evidence. TCE is the primary chemical of concern (COC) for the vapor intrusion pathway, along with perchloroethene (PCE), cis- and trans-1,2-dichloroethene (DCE), vinyl chloride, 1,1 dichloroethane (DCA), and 1,1-DCE.

This Summary Report was prepared to document air sampling events conducted during the performance of this task and to evaluate the buildings using the tiering system pursuant to an agreement between NASA Ames, the EPA, and the Water Board for NASA Ames to implement the vapor intrusion remedy in its area of responsibility.

Figure 1: Site Location Map

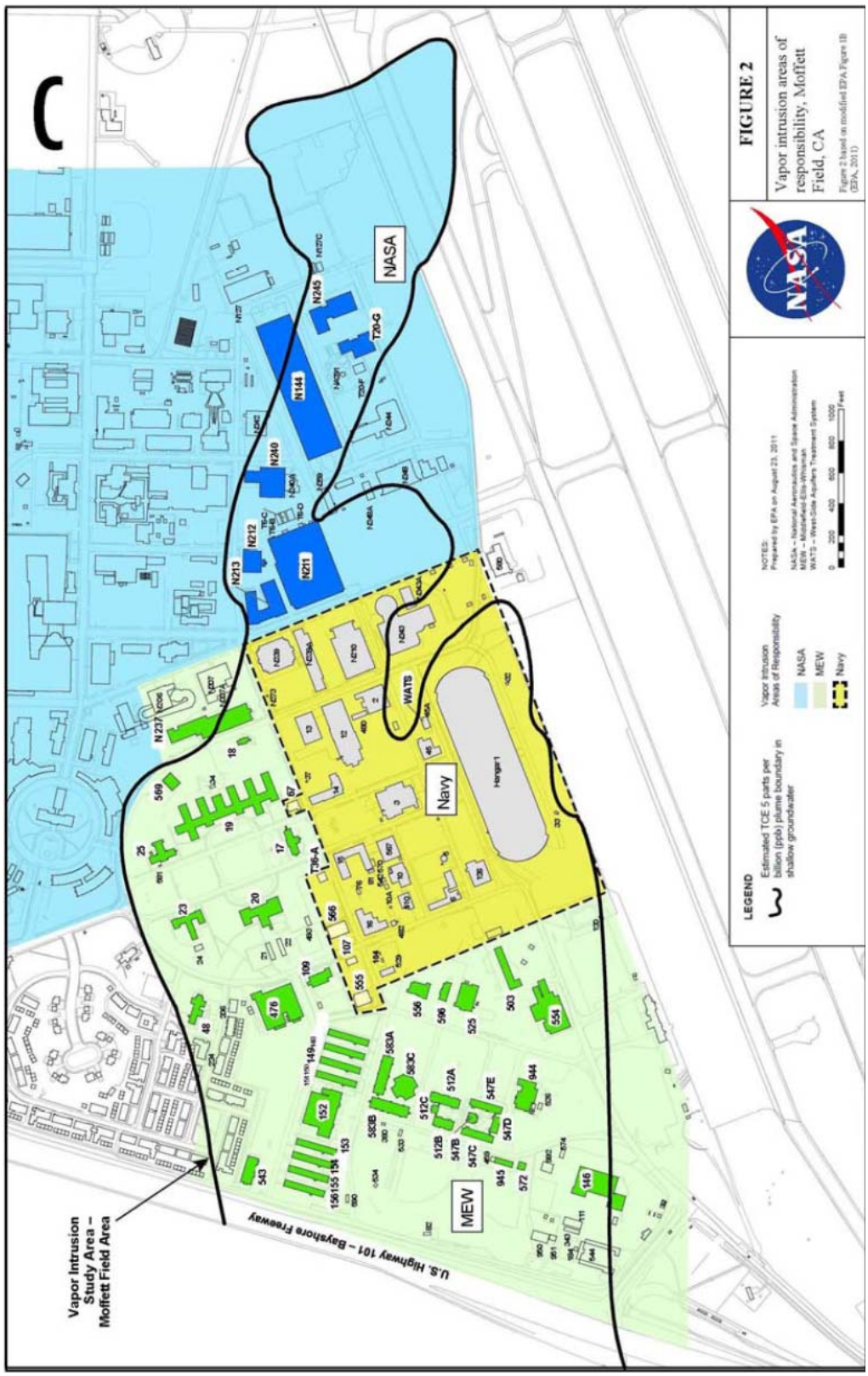

Figure 2: Vapor Intrusion Areas of Responsibility & Building Location Map

Round 1 (2012) Air Sampling Activities

To determine the appropriate tier and corresponding response action for the nonresidential buildings within the NASA Ames Area of Responsibility (AOR), an initial (Round 1) vapor intrusion investigation was conducted consisting of indoor and background air sampling and analysis of COCs by EPA Method TO-15 SIM. The initial indoor air investigation was conducted between February 19, 2012, and February 23, 2012. A total of 41 air samples, including indoor and outdoor air samples, were collected to evaluate the vapor intrusion pathways in the six (6) fully or partially occupied buildings in NASA's AOR. The six (6) buildings sampled in 2012 were Buildings N144, N212, N214, N240, N245, and T20G; Building N211 was not sampled during the 2012 sampling effort because it was previously believed that its primary use was hangar space instead of work space. A total of two (2) outdoor air samples were also collected to provide information on COC concentrations in background air (ISSi, 2012).

Round 2 (2015) Indoor Air Sampling Activities

A total of 60 air samples, including indoor and outdoor air samples, were collected on February 11, 2015 and February 22, 2015 confirm the Round 1 sampling results and to evaluate the occurrence of and pathways for vapor intrusion in seven (7) fully or partially occupied buildings at NASA's AOR. A total of 58 indoor air samples (including duplicates) were collected from 32 locations within the seven (7) buildings. Sample locations and numbers collected for each building were selected using the results of the building surveys and the 2012 indoor air sampling locations and results. Samples were collected from the breathing zone of basement and first floor work areas (office areas, meeting rooms, and high-traffic areas such as hallways), at potential vapor intrusion pathways (elevator vaults and basement sumps), and in background outdoor air. In buildings with operating HVAC systems, indoor air samples were collected during normal work hours with the HVAC system operating (HVAC-ON) and on a Sunday after the HVAC system had been shut down for 36 hours (HVAC-OFF). The HVAC-ON sampling duration was 24 hours and the HVAC-OFF sampling duration was 8 hours. Background air samples were collected concurrently with the indoor air samples for both the 24-hour and 8-hour sampling durations.

Indoor air and background outdoor air samples were collected using 6-liter canisters, each quipped with a fixed-rate flow controller. The number of samples per building varied from two (2) samples in Building N245 to 22 samples in Building N213. Outdoor air samples were collected south of Building N258 for comparison to indoor air in order to evaluate the potential contribution of VOCs from outdoor air to indoor air. Indoor and outdoor air samples were analyzed by a U.S. Department of Defense Environmental Laboratory Accreditation Program–and National Environmental Laboratory Accreditation Program–certified analytical laboratory using EPA Method TO-15 SIM for the COCs (PCE, TCE, cis-1,2- DCE, trans-1,2-DCE, 1,1-DCE, 1,1-DCA, and vinyl chloride).

2015 Building Surveys

Building surveys were conducted between January 29, 2015 and February 11, 2015 in order to identify each building's structural condition, observe the ventilation system layout and use by the building occupants, observe operational procedures in laboratory and maintenance areas, and gather information about building use schedules. Follow-up surveys were conducted between February 12, 2015 and February 20, 2015 to identify any changes since the original surveys. The building surveys and previous indoor air sampling results were used to select potential sampling locations within each building for the indoor air sampling work plan.

2015 Air Sampling Results

A total of 60 air samples, including indoor and outdoor air samples, were collected on February 11, 2015 and February 22, 2015.

Indoor and outdoor air samples were analyzed by a U.S. Department of Defense Environmental Laboratory Accreditation Program– and National Environmental Laboratory Accreditation Program–certified analytical laboratory using EPA Method TO-15 SIM for the COCs (TCE, PCE, vinyl chloride, 1,1-DCE, 1,1-DCA, cis-1,2-DCE, and trans-1,2-DCE) and results were reported in micrograms per cubic meter ($\mu g/m^3$).

No work area samples in the in the seven (7) buildings sampled had concentrations of COCs that exceeded the commercial use air cleanup levels in the ROD Amendment.

Building N144: TCE concentrations exceeded outdoor air concentrations (outdoor air consternation range for all COCS: <0.029 $\mu g/m^3$ to <0.036 $\mu g/m^3$) but were below the indoor air cleanup level. The concentration of TCE measured in Building N144 ranged from 1.2 $\mu g/m^3$ to 2.9 $\mu g/m^3$ in samples from Rooms 142 and 141, respectively. Building N144 has no operating HVAC system in the portion of the building where these samples were collected.

Building N211: The concentration of COCs detected in Building N211 were below the indoor air cleanup levels and within outdoor air concentration ranges.

Building N212: The concentrations of COCs detected in Building N212 were below the indoor air cleanup levels and within outdoor air concentration ranges.

Building N213: In Building N213, concentrations of COCs in work area samples did not exceed the indoor air clean-up levels. However, concentrations of vinyl chloride, TCE, PCE, and cis-1,2-DCE were detected above the indoor air cleanup levels in non work-area grab-samples; These 5 minute grab samples were collected from utility room sumps in the basement of Building N213 with the HVAC system not operating.

Results for Building N213 basement sump samples exceeded cleanup levels with the following ranges:

- Vinyl chloride: 2.6 µg/m^3 (cleanup level – 2 µg/m^3), Room N002;
- TCE: 75 µg/m^3 (cleanup level – 5 µg/m^3), Room N002;
- PCE: 2.0 µg/m^3 (cleanup level – 2 µg/m^3) Room N042;
- cis-1,2-DCE: 290 µg/m^3 (cleanup level – 210 µg/m^3), Room N002.

The concentrations of COCs above the long-term cleanup level are likely the result of groundwater seepage into the sumps where the samples were collected.

Building N240: In Building N240, TCE was measured at a concentration above the background background air concentration range in the C101 Hallway with both the HVAC system on and off and in the 5-minute grab sample collected from the elevator shaft located in the western half of the building with the HVAC system off.

Building N245: Concentrations of COCs were detected below the long-term cleanup levels and within background air concentration ranges in Building N245.

Building T20G: In Building T20G, the concentration of COCs detected were below the long-term cleanup levels and within background air concentration ranges.

Response Action Tiering Evaluation System

Using the relevant historical data, 2012 and current (2015) indoor air sampling results, and Tables 6A and 6B of the ROD Amendment (EPA 2010), the buildings were tiered to determine the need for a response action in accordance with the Response Action Tiering System.

Indoor air quality results for COCs were compared to the ROD Amendment cleanup levels and to outdoor air concentration ranges with consideration of whether or not an air quality engineering control (EC) is in place. Of the seven (7) buildings sampled, four (4) buildings (Buildings N144, N212, N213 and N240) are classified as Tier 3A because the indoor air concentrations measured in samples from these buildings were below the indoor air cleanup levels but above the outdoor air concentration range. The remaining three (3) buildings (Buildings N211, N245, and T20G) are classified as Tier 3B because indoor air concentrations measured in samples from these buildings are below indoor air cleanup levels in work areas and at or within the outdoor air concentrations levels.

Recommendations

Based on the two rounds of indoor air sampling conducted between 2012 and 2015 and the above discussed results and recommended tier designations, additional indoor air sampling and analysis will be conducted for all Tier 3A buildings (N144, N212, N213 and N240). A sampling and analysis plan will be submitted to the USEPA for concurrence.

The Tier 3B buildings (N211, N245 and T20G) do not require long-term monitoring in accordance with the ROD Amendment because indoor air concentrations are at or within the outdoor air concentrations.

Institutional controls (ICs) will be implemented for both Tier 3A and 3B buildings.

Conclusions

All of the seven (7) buildings evaluated are classified as Tier 3A or Tier 3B because the indoor air concentrations measured during the sampling events meet indoor air cleanup level requirements in work areas without an EC in place or operating.

Of these buildings, only four (4) buildings—N212, N213, N144, and N240—are classified as Tier 3A because indoor air concentrations exceeded the outdoor air concentrations but were below the indoor air cleanup level for any of the seven COCs. The response action for buildings classified as Tier 3A is the development and implementation of a long-term monitoring plan as per the 2010 ROD Amendment for Vapor Intrusion.

The remaining three (3) buildings—N211, N245, and T20G—are classified as Tier 3B because indoor air concentrations are at or within range of the outdoor air concentrations. No engineered remedy or long-term monitoring is required for buildings classified as Tier 3B. ICs will be implemented for both Tier 3A and 3B buildings.

Additional lines of evidence, such as soil vapor samples from the perimeter of buildings, sub-slab samples, and shallow groundwater samples can be collected in the future to supplement existing data for buildings in Tier 3B to evaluate the feasibility of reclassification to Tier 4 (no further action) by demonstrating there is no potential for vapor intrusion to cause indoor air to exceed indoor air cleanup levels and background levels.

1 Introduction

Earth Resources Technology, Inc. (ERT) has prepared this *2015 Air Sampling and Vapor Intrusion Tier Response Evaluation Report for* the National Aeronautics and Space Administration (NASA) Ames Research Center (NASA Ames) Moffett Field, California. This Report documents air sampling activities and building tiering evaluation conducted by NASA Ames for buildings within NASA Ames' Area of Responsibility (Ames AOR) pursuant to United States Environmental Protection Agency (USEPA) 2010 Record of Decision Amendment of the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman (MEW) Superfund Study Area, Mountain View and Moffett Field, California (ROD Amendment).

NASA Ames is located at the southern end of the San Francisco Bay in Santa Clara County, California approximately 25 miles southeast of San Francisco, 10 miles northwest of San Jose and adjacent to the cities of Mountain View and Sunnyvale (Figure 1).

Groundwater contamination is present beneath NASA Ames primarily from upgradient sources. The groundwater contamination resulted from releases from the Middlefield-Ellis-Whisman (MEW) Superfund site and from operations at former Naval Air Station Moffett Field (NAS Moffett Field). The comingled groundwater contamination is referred to as the "Regional Plume." NASA Ames, the United States Department of Navy (Navy), and the MEW Superfund site potentially responsible parties are each conducting remediation of designated portions of the Regional plume (1989 MEW Site ROD).

In August 2010, the EPA amended the MEW Site 1989 Record of Decision (ROD) in accordance with CERCLA and the NCP to address health risks associated with long-term exposure to TCE and other MEW Site chemicals of potential concern through the vapor intrusion pathway in current and future buildings overlying the shallow subsurface contamination at the MEW Site. Subsequently, the EPA selected a remedy for the vapor intrusion pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings (EPA 2010 ROD Amendment).

The ROD Amendment for the Vapor Intrusion Pathway selected a remedy for the vapor intrusion pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings. The ROD Amendment defines the Vapor Intrusion Study Area as the area where TCE concentrations in shallow groundwater are greater than 5 micrograms per liter (µg/L) or parts per billion (ppb).

In September 2011, in coordination with the MEW Companies, NASA Ames, and the Navy, EPA developed the Statement of Work for the Vapor Intrusion Remedy Remedial Design and Remedial Action. Pursuant to an agreement among NASA Ames, Navy, and the MEW Companies, each entity is responsible for implementing the Vapor Intrusion Remedy in their designated Area of Responsibility, as depicted on Figure 2.

The ROD Amendment provides a tiering system to determine the appropriate response action for each building/property within the Vapor Intrusion Study Area based on indoor air sampling with or without an HVAC system in place and other lines of evidence. TCE is the primary chemical of concern (COC) for the vapor intrusion pathway, along with perchloroethene (PCE), cis- and trans-1,2-dichloroethene (DCE), vinyl chloride, 1,1 dichloroethane (DCA), and 1,1-DCE.

This Summary Report was prepared to document air sampling events conducted during the performance of this task and to evaluate the buildings using the tiering system pursuant to an agreement between NASA Ames, the EPA, and the Water Board for NASA Ames to implement the vapor intrusion remedy in its area of responsibility.

1.1 Purpose

The purpose of the February 2015 sampling event was to provide for collection of a second series of indoor and outdoor air samples of buildings in NASA's AOR in. This follow-up to the February 2012 air sampling event has allowed for comparison to outdoor air quality and indoor air cleanup levels (as provided in the 2010 ROD Amendment).

The combined air sample results from 2012 and 2015 are used to designate the *Response Action Tier Classification* for each building. The tier ranking/classification determines the response action required for each building, using Tables 6A and 6B in the ROD Amendment.

1.2 Scope of Work

The air sampling program was conducted in accordance with the "*Indoor Air Sampling and Analysis Work Plan (SAWP) for Existing, Unsampled Commercial Buildings for the MEW and Moffett Field Vapor Intrusion Study Area*" (Haley & Aldrich, 2011) and the "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2012), as amended in 2015. The 2015 work plan provided for collection of a second series of indoor air samples as follow-up to samples collected in February, 2012.

The air sample results are used to qualify and finalize the tier ranking of buildings in accordance with the ROD Amendment Vapor Intrusion Tier Response System (EPA 2010).

Indoor air samples were collected from all buildings sampled in February 2012 plus Building N211, which was not sampled during the 2012 sampling event. The indoor air samples were collected at most of the basement and first floor sample locations identified in February 2012 as per the "*Indoor Air Sampling and Analysis Work Plan (SAWP) for Existing, Unsampled Commercial Buildings for the MEW and Moffett Field Vapor Intrusion Study Area*" (Haley & Aldrich, 2011) and the "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2012), as amended in 2015. A list of the buildings that were sampled is provided in **Table 2** of **Appendix B** and the building locations are shown on Figure 2.

The scope of work consisted of the following activities:

- Coordinating with NASA Ames Facility Engineering to collect the basic heating, ventilation, and air conditioning (HVAC) system information for all buildings planned for sampling.

- Performing a walk-through survey of each building between January 29, 2015 and February 11, 2015, to identify each building's structural condition, discuss the ventilation system layout and use by the building occupants, observe operational procedures in laboratory and maintenance areas, and gather information about building use schedules.

- Developing building-specific sampling plans taking into consideration the sampling design and rationale of previous indoor air sample results, building construction and use, and additional information about the buildings, including potential operation and maintenance sources for VOCs, and identified potential vapor intrusion pathways.

- Performed follow-up surveys of the buildings between February 12, 2015 and February 20, 2015 to resolve building access issues, address concerns on operation of computer servers during the air sampling event, and confirmed building sample locations.

- Coordinated with Simi Valley, California, ALS Environmental Laboratory to ensure timely delivery of the sampling equipment at Moffett Field and for receipt and processing of the samples at the laboratory. ALS Environmental's Simi Valley laboratory is certified by both the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) and National Environmental Laboratory Accreditation Program (NELAP).

- Approximately one month before the sample events, plans for field activities were finalized and access was requested to the buildings and the site area at NASA Ames for collection of the air samples. The request and notification were made to building-specific Facility Site Manager (FSM). Formal notification of the upcoming sampling event was submitted to EPA.

- Storage boxes, sample canisters, and other equipment and supplies were mobilized to the Moffett Field office on February 9, 2015 and February 20-21, 2015.

- Air samples were collected using 6-liter canisters, each equipped with a fixed-rate flow controller. The sample canisters were placed 36 to 60 inches above the floor. A total of 58 indoor air samples (including duplicates) were collected from 32 locations within seven (7) buildings. A total of two (2) outdoor air samples were also collected to provide information on background air. For the second round of indoor air sampling, sampling was conducted between February 10- 11, 2015 and on February 22, 2015.

    - Buildings with an operating HVAC system that supplies outdoor air to a portion or all of a building were sampled twice: once during work hours with the HVAC system operating (HVAC-ON) and once after the building ventilation system had

been shut down for 36 hours (HVAC-OFF). The HVAC-ON sampling duration was 24 hours and the HVAC-OFF sampling duration was 8 hours.

- The northern open warehouse portion of Building N144, which does not have an operating HVAC system, was sampled over a period of 24 hours.

- Selected pathway, 5-minute air samples were collected as grab samples during HVAC-OFF sampling.

- Background 24-hour and 8-hour outdoor air samples were collected at the same outdoor location near N258.

- The air samples were analyzed by EPA Method TO-15 SIM (selected ion monitoring) for perchloroethene (PCE), TCE, cis- and trans-1,2-dichloroethene (cis- and trans-1,2-DCE),1,1-DCE, 1,1-dichloroethane (1,1-DCA), and vinyl chloride. These are the COCs that are identified in the ROD Amendment.

- The analytical results were compared to the indoor air cleanup levels that are presented in Table 3 of the ROD Amendment (EPA 2010) and to background outdoor air concentrations.

- The indoor air data was evaluated using Response Action Tiering System criteria as presented in Table 6A and 6B of the ROD Amendment (EPA 2010). The tiering descriptions, response actions, and selected remedies provided in Tables 6A and 6B of the ROD Amendment are compiled and presented in **Table 4** of **Appendix B**.

- Preparation of this Summary Report to document sampling activities, provide sampling results, conduct the tiering system evaluation, and make recommendations based on the results of the tiering system evaluation. This Summary Report includes the following additional information as listed in Administrative Order Docket Number 91-4A (EPA 2011).

  - Building conditions, occupancy and use conditions.

  - Descriptions and summaries of all lines of evidence and specific data collected to determine response action tier

  - Maps of building/property layouts and actual sampling locations

  - Photographs of the sampling locations

  - Sampling and data collection results and summary of data

  - Laboratory analytical data, including Quality assurance (QA)/quality control (QC) data and activities

- Response action tier designation
- Recommendations for subsequent air sampling and for collection of additional lines of evidence

2 Site Background

The NASA Ames Area of Responsibility (AOR) is within the Vapor Intrusion Study Area on Moffett Field (Figure 2). NAS Moffett Field is a National Priorities List site (EPA ID: CA2170090078). EPA is the lead regulatory agency responsible for directing the cleanup process under CERCLA and per a 2014 Federal Facility Agreement (FFA) between NASA Ames and EPA Region 9. The Water Board is the state lead agency.

2.1 History

NASA Ames consists of the NASA Ames Campus and a portion of former NASA Moffett Field, which includes the NASA Research Park (Figure 3). The former NAS Moffett Field site was originally commissioned as NAS Sunnyvale in 1933. In 1935, the facility was transferred to the U.S. Army Air Corps. In 1939, Ames Aeronautical Laboratory obtained a permit to use a portion of the property (NASA Ames Campus area). NAS Sunnyvale was transferred to the Navy in 1942 and was renamed NAS Moffett Field. In 1991, the Navy designated NAS Moffett Field for decommissioning and on July 1, 1994, NAS Moffett Field was transferred to NASA Ames with the exception of the Orion Park and Wescoat military housing areas. Occupied buildings at the NASA Ames Campus and NASA Research Park are primarily used for office, research, logistics or maintenance space. Several buildings are also unoccupied and planned for demolition.

Groundwater contamination is present beneath NASA Ames primarily from upgradient sources. The groundwater contamination resulted from releases from the Middlefield-Ellis-Whisman (MEW) Superfund site and from operations at former NAS Moffett Field. The comingled groundwater contamination is referred to as the "Regional Plume."

In June 1989, EPA Region 9 (1989) issued a Record of Decision (ROD) under CERCLA selecting the groundwater cleanup remedy for the MEW Site. NASA Ames, the United States Department of Navy (Navy), and the MEW Superfund site potentially responsible parties are each responsible for remediation of a portion of the plume (1989 MEW Site ROD).

In August 2010, EPA (2010) amended the 1989 ROD to select a remedy for the vapor intrusion pathway to prevent subsurface contaminants from migrating into indoor air or accumulating in enclosed building spaces at concentrations exceeding their indoor air cleanup criteria for long-term exposure (ROD Amendment). As specified in the ROD Amendment, the Vapor Intrusion Study Area is defined as the area where TCE concentrations in shallow groundwater are greater than 5 µg/L. The NASA Area of Responsibility (AOR) is shown on ***Figure 2.***

The ROD Amendment provides a tiering system to determine the appropriate response action for each building/property within the Vapor Intrusion Study Area. The tiering system for existing buildings is based on indoor air sampling with or without ECs in place and other lines of evidence. To determine the appropriate tier and corresponding response action for the occupied buildings within the NASA AOR (there are no residential buildings present), plans were developed to conduct a vapor intrusion investigation consisting of indoor air and background air

sampling with analysis for the COCs by EPA Method TO-15 SIM. The COCs are PCE, TCE, cis- and trans-1,2-DCE, 1,1-DCE, 1,1-DCA, and vinyl chloride.

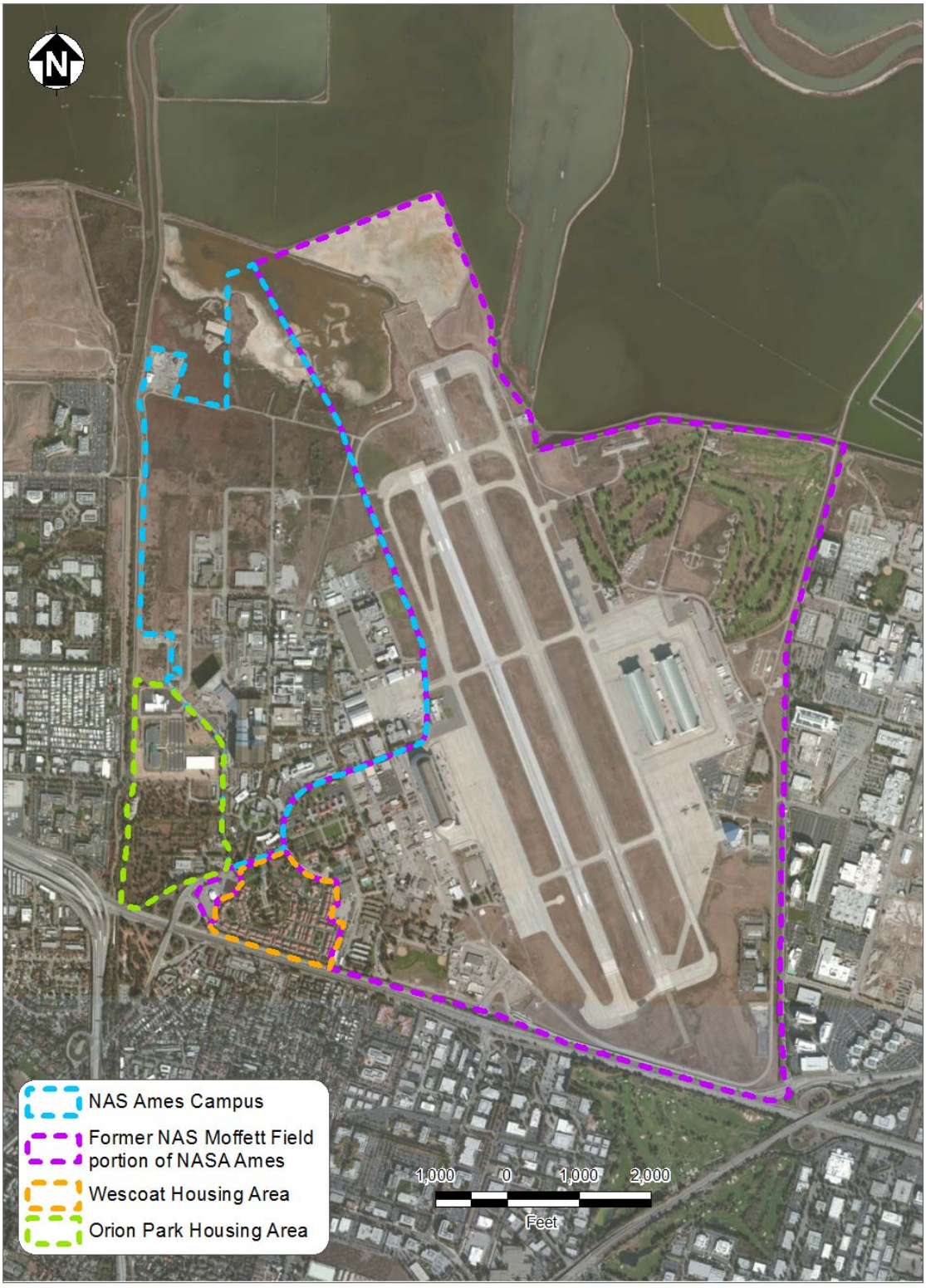

Figure 3: Composition of NASA Ames Research Center

The vapor intrusion activities for the NASA AOR are presented as follows, in their chronological order:

- The *Indoor Air Sampling and Analysis Work Plan for Existing, Unsampled Commercial Buildings, Middlefield-Ellis-Whisman (MEW) and Moffett Study Area, Mountain View, CA* (Haley & Aldrich, 2011) was issued by MEW Companies as a guideline for the vapor intrusion studies.

- The *NASA Building Specific Sampling Plan VI Workplan* (NASA, 2011) was issued in August 2011 to conduct a vapor intrusion investigation at NASA Ames.

- The *Statement of Work (SOW) for Vapor Intrusion Sampling at National Aeronautics and Space Administrations, Ames Research Center, Moffett Field, CA* (NASA, 2011) was issued in December 2011 to outline the work to be accomplished under the ISSi Environmental Services Contract NNA05AC42C.

- Building surveys were conducted prior to the sampling in order to identify each building's structural condition, ventilation system layout, and use; determine occupancy times, observe operational procedures in laboratory and maintenance areas, and gather information on the use and storage of solvents, chemicals, and cleaners.

- Six (6) nonresidential buildings in the NASA AOR were sampled on February 19-23, 2012 to identify indoor areas that have VOCs in air from vapor intrusion that exceed cleanup levels for COCs as listed in the ROD Amendment. The six (6) buildings that were sampled during the 2012 vapor intrusion study are listed in **Table 1** of **Appendix B** and identified on Figure 2.

- The Building Specific Vapor Intrusion Air Sampling Report (iSSI, 2012) was issued in September 2012 and presented the results of the February 2012 indoor air sampling. The report recommended additional vapor sampling and analysis for the two buildings (Building N144 and N212) that revealed the presence of COCs above the long-term cleanup levels.

- The *NASA Building Specific Sampling Plan VI Workplan* (NASA, 2011) was amended in 2015 to conduct another vapor intrusion investigation in February 2015. The results of the sampling are presented in this Summary Report.

2.2 Site Conditions

The NASA Ames AOR is within the Vapor Intrusion Study Area on Moffett Field. The Vapor Intrusion Study Area, as defined by the 2010 ROD Amendment, is generally defined as the area where TCE concentrations in shallow groundwater are greater than 5 µg/L, or parts per billion (ppb). The estimated extent of TCE in shallow groundwater and the Vapor Intrusion Study Area are shown on ***Figure 2***. Shallow groundwater beneath NASA Ames is approximately 5 to 10 feet below ground surface (bgs) and generally flows in a northerly direction (EPA 2010).

Based on the results of groundwater and air sampling results collected since 2002 for both commercial and residential areas (as provided in Table 1 and Table 2 of the ROD Amendment), TCE is the primary COC for the vapor intrusion pathway along with PCE, cis-1,2- DCE, trans-1,2-DCE, 1,1-DCE, 1,1- DCA, and vinyl chloride.

2.3 Conceptual Site Model for Vapor Intrusion

The vapor intrusion pathway refers to the migration of volatile chemicals (i.e., chemicals that easily evaporate) from the subsurface soils and groundwater upwards as vapors, through conduits and preferential pathways, and into overlying buildings. These vapors can then collect inside the buildings and affect indoor air quality (Figure 4). A conceptual model was developed to aid the evaluation of the vapor intrusion pathway by identifying the potential sources of VOCs in indoor air, site COCs, and potential pathways and receptors (EPA 2010). Indoor exposure to VOCs can result from one or more of the following potential sources:

- Volatilization from subsurface shallow soil or groundwater contamination into a building structure (vapor intrusion);
- Occupational, household, or consumer product use or storage inside or outside of the building/workplace;
- Contribution from outdoor air moving into a building through opened doors or windows or from air intakes of HVAC systems. This outdoor air can include contributions from off-site background concentrations, nearby industrial emissions, and volatilization from the subsurface to outdoor air near the building.

Pathways: Chemicals may volatilize from the groundwater and soil, migrate upward and enter buildings through voids and cracks in the floors, dry conduits, or subsurface structures (e.g., basements and other subsurface structures), and then enter buildings. For buildings with basements, VOCs may volatilize from groundwater directly through the basement floor and walls; receptors inside the buildings could inhale these vapors.

Potential Receptors: Potential receptors are persons in current and future buildings in the Vapor Intrusion Study Area. While there are no immediate or short-term health or ecological concerns, the response action in the ROD Amendment (EPA 2010) ensures building occupants are protected from potential long-term inhalation exposure to COCs.

Site Conceptual Model: Volatilization of VOC contamination in shallow groundwater is the primary source of vapors that may migrate into buildings in the NASA Ames AOR. Releases of chlorinated solvents from on- and off-site sources have impacted the shallow groundwater in the NASA Ames area, primarily with TCE and PCE. The COCs dissolved in shallow groundwater volatilize to the vapor phase in the unsaturated soil until they equilibrate with groundwater concentrations. Also, the COCs will attenuate through sorption onto soils resulting in a three-way partition – onto soil, dissolved in groundwater and in soil vapor. However, the partition across site media is complicated by variations in temperature and the percent moisture in soils, particularly at the capillary fringe, which is the partially saturated contact of the water table with the unsaturated soil.

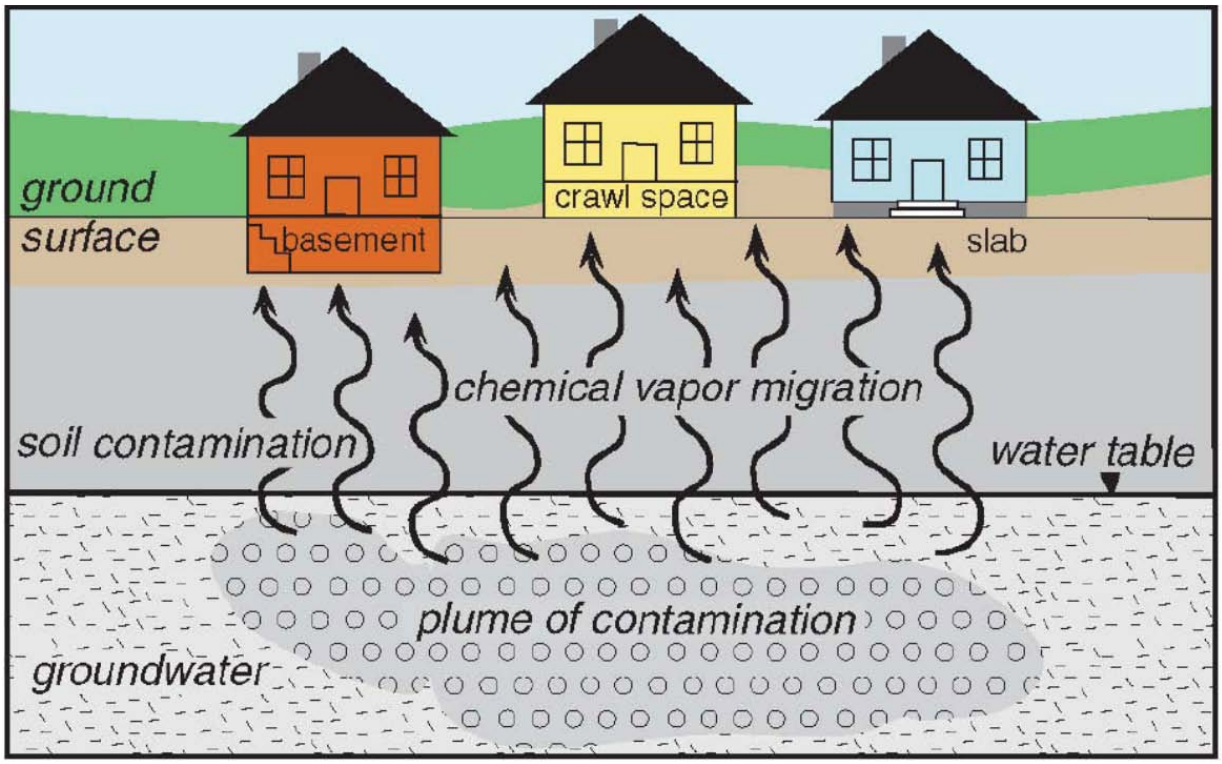

Figure 4: Vapor Intrusion Pathway - Conceptual Diagram (EPA, 2010)

TCE vapors in soil gas are more widely distributed than areas with elevated concentrations in groundwater, likely due to the dispersion/spreading of the soil vapors throughout the soil vadose zone, while contaminated groundwater migrates primarily through sandy stream deposits that are surrounded by finer-grained inter-channel sediments.

Factors affecting the vapor intrusion pathway into and within buildings include vapor pressure differences inside the building and below the foundation sub-slab, the presence of cracks and breaks in the foundation, utility conduits and drain lines that penetrate the foundation, existence of subfloor crawl spaces where vapors can accumulate, negative and positive pressure differences from operation of an HVAC system, fans and powered vents (such as in laboratories, kitchens, break rooms, and restrooms), temperature gradients within the building, and ventilation pathways from open windows, wall cracks, siding separation, and open vertical conduits such as stairwells, elevator and ventilation shafts, and multi-floor utility conduits.

2.4 Vapor Intrusion ROD Amendment

In August 2010, EPA (2010) amended the MEW Site 1989 ROD to select a remedy for the vapor intrusion pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings. The ROD Amendment provides a tiering system to determine the appropriate response action for each building/property within the Vapor Intrusion Study Area. The tiering system for existing

buildings is based on indoor air sampling with or without engineering controls (ECs) in place and other lines of evidence. The corresponding response action may include both engineering and ICs (EPA 2010).

A summary of the ROD Amendment tiering descriptions and response actions for existing commercial buildings is provided in **Table 4** of **Appendix B**.

2.5 Building Surveys

Building surveys were conducted between January 29, 2015 and February 11, 2015 in accordance with the approved "*Indoor Air Sampling and Analysis Work Plan (SAWP) for Existing, Unsampled Commercial Buildings for the MEW and Moffett Field Vapor Intrusion Study Area*" (Haley & Aldrich, 2011) and the amended "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2011) to identify each building's structural condition, observe the ventilation system layout and use by the building occupants, observe operational procedures in laboratory and maintenance areas, and gather information about building use schedules. Follow-up surveys were conducted between February 12, 2015 and February 20, 2015 (prior to each air sampling investigation) to identify any changes since the original surveys. Prior to conducting the surveys, information about HVAC systems and chemical use and storage was collected from NASA Ames Facility Engineering. The Building Survey Forms and a summary table are provided in **Appendix D.**

During the inspections, the survey team observed building construction and integrity, mechanical systems and operations, tenant use and activities, and use and storage of chemicals. In addition, interviews were conducted with building tenants/occupants to understand hours of use/occupancy, tenant activities, system operations, and historical building uses. Also, meetings were held with the building managers to resolve building access issues for the planned sampling events, address concerns on operation of computer servers while HVAC systems were shut down, and finalize sample locations. The survey team conducted the following activities during the building surveys:

- Examine ground floor and basement rooms to identify areas where COCs were used or are present.
- Locate plumbing or piping systems, power conduits, communication conduits, elevator shafts, sumps, or floor drains that penetrate the base slab.
- Collect information on chemical use and storage in the building, including operational procedures in laboratory and maintenance areas.
- Obtain information on ventilation operation, observe the ventilation system layout and use by the building occupants, and observe the configuration and operation of HVAC systems.
- Gather information about building use schedules.

- Identify potential sample locations inside the buildings.

- Confirm the outdoor location where background air samples would be collected during the planned vapor intrusion sampling events

The building survey results were used to select potential sampling locations and sample duration within each building for the indoor air sampling work plan.

2.6 2012 Indoor Air Sampling Plan

To determine the appropriate tier and corresponding response action for the nonresidential buildings within the NASA AOR, a vapor intrusion investigation was conducted consisting of indoor air sampling and background air sampling.

The initial indoor air investigation was conducted from February 19-23, 2012. The work involved the collection of indoor air samples from six (6) buildings, as identified in **Table 1** of **Appendix B**, and outdoor air samples at Moffett Field as per the "*Indoor Air Sampling and Analysis Work Plan (SAWP) for Existing, Unsampled Commercial Buildings for the MEW and Moffett Field Vapor Intrusion Study Area*" (Haley & Aldrich, 2011) and the "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2011). The six (6) buildings were included in the 2012 study based on occupancy and ventilation criteria for the building use and construction. A total of 41 samples, including 39 indoor and two (2) outdoor air samples, were collected to evaluate the vapor intrusion pathways in the six (6) fully or partially occupied buildings at NASA Ames, where partially occupied infers that only a part of a building was occupied or utilized. Indoor and outdoor air samples were analyzed by an analytical laboratory using EPA Method TO-15 SIM for the COCs (PCE, TCE, cis- and trans-1,2-DCE, 1,1-DCE, 1,1-DCA, and vinyl chloride). Results were reported in micrograms per cubic meter ($\mu g/m^3$).

Of the six (6) buildings evaluated in the 2012 study, two buildings (Buildings N144 and N212) revealed the presence of two (2) of the seven (7) COCs above the EPA long-term cleanup level but below the ATSDR's short-term action levels. Buildings N213, N240, and T20G had concentrations of COCs below the EPA long-term cleanup levels, but above background outdoor air concentration ranges. Concentrations of COCs measured in Building N245 were within background outdoor air concentration ranges.

Based on the 2012 indoor air sampling results, the buildings within the NASA AOR were recommended for collecting follow-up samples to evaluate the tier classification and vapor intrusion pathways.

3 Response Action Tiering System

The Response Action Tiering System in the ROD Amendment (EPA 2010) classifies buildings by the need for response action according to the detected concentrations of COCs in indoor air as specified in Tables 6A and 6B of the ROD Amendment. Table 6A is for existing commercial and residential buildings with passive or active ECs in place. Table 6B is for existing commercial and residential buildings with no EC in place. Table 8 of the ROD Amendment provides EPA's selected vapor intrusion remedy for existing and future buildings in the Vapor Intrusion Study Area. The tiering descriptions, response actions, and selected remedies provided in Tables 6A, 6B, and 8 of the ROD Amendment are compiled and presented in **Table 3** of **Appendix B.**

Using the indoor air sampling results and Tables 6A and 6B of the ROD Amendment (EPA 2010), the buildings were tiered in accordance with the Response Action Tiering System (see Section 7). Recommendations were prepared based on the ROD Amendment selected vapor intrusion remedy for existing and future buildings (**Table 3**).

3.1 Tier 1

Buildings are classified as Tier 1 if the indoor air concentrations for any of the seven COCs exceed the outdoor air concentrations and the indoor air cleanup levels. Tier 1 buildings need an appropriate EC implemented as a remedy to meet indoor air cleanup levels. Governmental, proprietary, and informational ICs will be implemented as needed.

3.2 Tier 2

Buildings are classified as Tier 2 if indoor air concentrations are below cleanup levels with an EC in place or in operation. For Tier 2, operation and maintenance of active ventilation systems will be continued or other selected engineered remedies will be implemented to meet remedial action objectives. Long-term monitoring and governmental, proprietary, and informational ICs will be implemented. If the remedy is achieved through operation of an active ventilation system, then agreement of the property owner must be contained in a recorded agreement.

3.3 Tiers 3A and B

For a building without an effective EC in place or in operation, if the indoor air concentrations exceed the outdoor air concentrations but are below the indoor air cleanup level for any of the seven COCs, then the building is classified as Tier 3A. If the indoor air concentrations are at or within the outdoor air concentrations, then the building is Tier 3B. Tier 3A and 3B buildings do not need an engineered remedy. Long-term monitoring is required for Tier 3A, but not for Tier 3B. Governmental ICs will be implemented for both Tier 3A and 3B.

3.4 Tier 4

Buildings are classified as Tier 4 when converging lines of evidence demonstrate there is no longer the potential for vapor intrusion to exceed the indoor air cleanup levels. For Tier 4 buildings, no action is required after EPA approves confirmation sampling results and

documentation that no action is necessary.

4 Indoor Air Sampling Methodology

Indoor air sampling was conducted at all buildings within the NASA Ames' AOR that are currently in use or will be used in the future. Buildings that are not in use and planned for demolition were not part of the sampling program. The list of buildings that were sampled are listed in **Table 2** of **Appendix B** and shown on Figure 2.

4.1 Sampling Program

To support selection of the appropriate tier and corresponding response action for the nonresidential buildings within the NASA AOR, a vapor intrusion investigation was conducted consisting of indoor and background air sampling and analysis of COCs by EPA Method TO-15 SIM. This sampling provides air quality results for the winter season of 2015, which will be used with the winter 2012 indoor air sampling results to conduct the tier response evaluation.

The six (6) nonresidential buildings (Building N144, N212, N213, N240, N245, and T20G) within the NASA AOR that were sampled during February 2012 (Figure 2) were resampled during this investigation. Building N211 was also added to the sampling plan, resulting in a total of seven (7) buildings sampled during the February 2015 investigation. Building N211 was not sampled during the first round of vapor intrusion sampling conducted in 2012 because it was previously believed that its primary use was hangar space instead of work space. As a result, the EPA requested that N211 be sampled in the second round.

Based on the 2012 results, indoor air samples were collected only in the basement and first floor of the seven (7) buildings. There were three types of samples: work areas, vapor pathways, and background. Samples were collected in the breathing zone of work areas (offices areas, meeting rooms, and high-traffic areas such as hallways), at vapor intrusion pathways (elevator vaults and basement sumps), and in background outdoor air. Grab samples were collected from elevator vaults and basement sumps.

In buildings with HVAC systems, indoor air samples were collected during normal work hours with the HVAC system operating (HVAC-ON) and at the end of a weekend after the HVAC system had been shut down for 36 hours (HVAC-OFF). The sampling duration was 24 hours for the samples collected during normal work hours with the HVAC system operating and 8 hours for the samples collected on the weekend with the HVAC system shut down. The warehouse portion of Building N144, which does not have an operating HVAC system in the northern portion of the building, was sampled for 24 hours. The number of samples collected per building is provided in **Table 5** of **Appendix B**. **Table 6** in **Appendix B** lists the sample names, locations, durations, types, rationales, and collection dates.

Outdoor air samples were also collected to establish background or background air concentrations at the time of sampling. An background outdoor air sample was collected during both the 8-hour and 24-hour sampling periods at one location south of Building 258.

All field activities, including sample collection, were conducted during February 10-11, 2015 and on February 22, 2015.

Indoor and outdoor air samples were analyzed by a DoD ELAP– and NELAP-certified analytical laboratory using EPA Method TO-15 SIM for the COCs and results were reported in $\mu g/m^3$. The samples were analyzed with a standard turnaround time of 10 business days for the initial e-mail report. The Level D report was provided within 21 days of receipt of the samples. Quality Assurance/Quality Control (QA/QC) activities complied with the requirements as specified in the Site-wide Work Plan (Haley & Aldrich, 2011a) and as per ASTM Standard Test Method D 5466-01 (ASTM, 2007).

Each sample collected was assigned a unique sample identification number used to record and report the results. A "P" following the sequential two-digit code was used to indicate a 5-minute grab sample. A "D" directly following the HVAC operational code was used to indicate a duplicate sample. A floor level of "B" indicates a basement sample. The HVAC operation code was identified for each building sample as follows:

- ON – EC (HVAC) is on (operating)
- OFF – EC (HVAC) is off (shut down)

An HVAC operation code was not included in the sample identification number for buildings without an operational HVAC system, such as building N144.

4.2 Indoor Air Samples

Sample locations and number of samples collected for each building were selected using the results of the building surveys and the 2012 indoor air sampling locations and results A total of 58 indoor air samples (including duplicates) were collected from 32 locations within the seven (7) buildings. The number of samples per building varies from two (2) in Building N245 to 22 in Building N213. The number of samples for individual buildings and sample locations are provided in **Tables 5** and **6** in **Appendix B**, respectively. The sampling location maps for each building are provided in **Appendix A**. Indoor air samples focused on the basement and ground floor of the building. The inlet of the indoor air sampling devices was placed within the breathing zone. Duplicate samples were collected at a rate of approximately 10% for a total of five (5) samples.

Indoor air samples were collected using 6-liter canisters, each equipped with a fixed-rate flow controller. Prior to use, the analytical laboratory cleaned and individually certified the canisters and flow controllers to be used for indoor air analysis. The indoor air vapor intrusion investigation included the following types of samples: indoor air (work area), outdoor background air, and pathway air. For work area samples, the sample canisters were placed in the breathing zone in occupied or potentially occupied areas. Pathway samples were collected in areas where potential conduits (vaults or sumps) in the building were observed that might provide a direct route for VOC vapor migration into the building. For vapor intrusion pathway grab samples, the tubing attached to the canisters was inserted into the building sump and elevator shaft air spaces. After collection of the air samples, the sample canisters were collected, packed, labeled in the field, and then submitted to the analytical laboratory under chain of custody in accordance with the "*Indoor Air Sampling and Analysis Work Plan (SAWP) for Existing, Unsampled Commercial Buildings for the MEW and Moffett Field Vapor Intrusion*

Study Area" (Haley, 2011) and the "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2011), as amended in 2015.

Buildings sampled in the Vapor Intrusion Study were tiered based on whether the building was sampled with or without an operating EC system:

1. Buildings sampled with an operating EC (e.g., HVAC system); and
2. Buildings sampled without an operating EC or with the EC turned off.

4.2.1 Group 1: Buildings Sampled with Engineering Control Systems (HVAC) Operating

Buildings with an EC (e.g., HVAC system) were sampled while the EC (HVAC System) was in operation during normal working hours and at the end of the weekend after the HVAC system was shut down for 36 hours.

Information regarding EC (HVAC) operations was verified with Facilities Engineering to provide a basis for proper shutdown and sample duration criteria. The available shutdown and subsequent sampling period was limited to weekend hours. The EC (HVAC) shutdown air samples were collected at the same locations as the EC (HVAC) operating samples. Air samples were collected using 6-liter canisters to provide consistent data collection methods during both sample events. Pathway samples from the elevator shafts and building sumps were collected as grab samples.

4.2.2 Group 2: Buildings Sampled without Engineering Control Systems (HVAC) Present or Operating

Air samples were collected during normal occupancy hours using 6-liter canisters, with the building windows shut to the extent possible. These samples were collected over 8 hours after the building HVAC system had been shut down for over 36 hours. The open warehouse portion of Building N144, which does not have an HVAC system, was not sampled during the HVAC-OFF sampling group.

Sampling was conducted between February 10-11, 2015 and on February 22, 2015. Initially, samples were collected from buildings with an operating EC (e.g., HVAC system). Buildings with an EC (HVAC system) were also sampled after the EC had been shut down for minimum of 36 hours. Duplicate samples were collected at a rate of approximately 10%.

4.3 Outdoor Air Samples

A total of two (2) outdoor air samples were collected to provide information on background air concentrations. Outdoor background air samples were collected south of Building N258. The outdoor air samples were collected concurrently with both the 24-hour HVAC-ON sampling and the 8-hour HVAC-OFF sampling.

Outdoor air samples were collected using the same sampling methodology used for the indoor air samples (e.g., 6-liter canister equipped with individually certified fixed-rate flow controller). Outdoor air samples were analyzed and reported in $\mu g/m^3$ by using EPA Method TO-15 SIM for the COCs.

4.4 Access Requirements

ERT personnel arranged for access to each of the seven (7) buildings through the FSMs of each building prior to finalizing the sampling schedule. Access was required for setting up the sample equipment, checking of samples following setup, and for final collection of sampling equipment. The FSMs of each building provided access to the buildings for collection of 24-hour HVAC-ON samples during standard work hours (buildings with HVAC on, or buildings without HVAC systems). NASA security personnel provided access to the buildings during the weekend, with the exception of Building N211, which required the presence of the FSM for security and access to locked portions of the building.

Availability of FSMs and access restrictions such as locked rooms or buildings required schedule changes and alternate placement of several samples and a startup of sample collections over a greater-than-one-hour period. Changes to the sampling schedule and/or sample placement were made due to the access restrictions. Some of the samples were moved within the originally planned room or to locations that better represent the conditions within the building. Sample location adjustments within a room were made because of the location of furniture or to avoid a busy work area. Section 4.5 discusses the deviations in sampling locations from the proposed locations.

4.5 Deviations from the Sampling Plan

This section describes the deviations from the sampling activities specified in the "*Indoor Air Sampling and Analysis Work Plan (SAWP) for Existing, Unsampled Commercial Buildings for the MEW and Moffett Field Vapor Intrusion Study Area*" (Haley & Aldrich, 2011) and the "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2011), as amended in 2015. **Table 7** of **Appendix B** presents the sampling location deviations. All deviations to the sampling plan were confirmed with EPA Region 9.

Five (5) proposed 8-hour HVAC-OFF samples from the northern portion of Building N144 were not sampled because the building investigation conducted prior to the sampling revealed that Building N144 did not have an HVAC system in the northern portion of the building; collecting the 8-hour samples in addition to the 24-hour samples in the northern portion of Building N144 would have been redundant because the sampling conditions would have been the same. An additional 8-hour sample was not collected from Building T20G due to sample container pressure failure.

Two (2) samples were moved from their proposed locations due to access restriction. The sample collected from Room 105 in Building N212 was originally proposed to be collected in Room 104, however access to Room 104 is limited and Room 105 is occupied more frequently than Room 104. The sample collected in Room 113 of Building N240 was originally proposed to be collected from Room 115A, but mission critical research prevented access to Room 115A. Room 113 was chosen instead because it is actively used during working hours as a clean laboratory and it is adjacent to Room 115A.

5 Air Sampling Results

Indoor and outdoor air samples were analyzed by DoD ELAP– and NELAP-certified analytical laboratory using EPA Method TO-15 SIM for the COCs (TCE, PCE, vinyl chloride, 1,1-DCE, 1,1-DCA, cis-1,2-DCE, and trans-1,2-DCE). This method provides detection limits below the cleanup levels and typical background outdoor air concentrations.

Quality Assurance/Quality Control (QA/QC) activities complied with the requirements as specified in the Site-wide Work Plan (Haley & Aldrich, 2011a) and as per ASTM Standard Test Method D 5466-01 (ASTM, 2007). There were no deviations or discrepancies identified in sampling protocols or field sampling techniques. Four duplicate samples were collected as part of this task. The laboratory followed media preparation procedures for the sample canisters and analyses. Project analytical and QA/QC data underwent a Tier IV evaluation for correctness, completeness, and accuracy; this information is included in **Appendix D**.

The sampled buildings and the sample results are listed in **Table 8** of **Appendix B**. The laboratory analytical reports are provided in **Appendix E**. The results from the 2012 sampling investigations are also provided in **Table 8** of **Appendix B**. The following subsections provide the building details and the air sampling results.

5.1 Background Air Samples

A total of two (2) outdoor air samples were collected on February 11, 2015 and February 22, 2015 to provide information on COC concentrations in background air at the time of indoor air sampling. Outdoor background air samples were collected south of Building N258. A map showing the outdoor air sample locations is provided in **Appendix A**.

Based on the results for background air samples collected on February 11, 2015 and February 22, 2015, outdoor concentrations of all COCs ranged from <0.029 µg/m^3 to 0.036 µg/m^3. **Table 9** of **Appendix B** provides the background air concentration ranges for all COCs.

5.2 Building N144 – FEMA Warehouse Office Area

A walk-through inspection of Building N144 was conducted on January 29, 2015. A Building Survey Form is included in **Appendix D.** Indoor air samples taken from the northern warehouse portion of the building were collected on February 11, 2015. Indoor air samples taken from the southern portion of Building N144 were collected on February 11, 2015 and February 22, 2015.

5.2.1 Building Condition

Building N144 is an approximately 160,000 square-foot single story building consisting of a raised concrete warehouse floor with wood siding and asphalt roofing. The internal floor to ceiling height in Building N144 is approximately 40 feet. The building was historically utilized as a supply depot by the Navy during the time when Moffett Federal Airfield was an active Navy base. Post departure of the Navy in 1994, the warehouse has been utilized primarily as a FEMA storage and transfer facility where goods and supplies are stored and processed for use in case of a declared emergency.

The interior consists of large storage open storage areas with racked storage shelves plus stacked palletized supplies. Forklifts are the only regular vehicle used within the building interior. There are interior office spaces located in the northern, central and southern portions of the building. The southern offices are unoccupied and are currently used for document storage, however the site janitorial service mobilizes and demobilizes on a daily basis from this portion of Building N144. The northern and central office space currently houses FEMA staff, normally Monday through Friday from 08:00 to 17:00.

There are no known floor drains nor openly stored paints, lacquers or thinners noted during the walkthroughs or sampling events.

5.2.2 HVAC System

The northern portion of Building N144 FEMA, which functions as a warehouse, does not have a central HVAC system. There is, however, an individual, wall mounted cooling/air conditioning unit plus separate ceiling mounted heater in Rooms 141 and 142 office areas. The air conditioner draws air from the open warehouse area while the heater pulls air from the interior of each office area. These heating and cooling systems are operational during normal office hours, each individually controlled by a local thermostat and none of them draw in air from the outside. It is noted here that neither unit was on during sample canister deployment nor retrieval events and weather during the sampling events was moderate.

The southern portion of Building N144, which is separated from the northern portion of the building, has an HVAC system that heats and cools that portion of the building. No air exchange occurs between the northern portion and southern portion of Building N144.

5.2.3 Existing Mitigation Measures

Currently, no mitigation measures are in place at Building N144.

5.2.4 Sample Locations and Results

5.2.4.1 Previous Sampling Results

Two indoor air samples (one HVAC-ON sample and one HVAC-OFF sample) were collected in February 2012 from Building N144 in Room 141. Four (4) of the seven (7) COCs were detected in the indoor air samples in Room 141. All four detections were well below the short-term action levels, with only TCE slightly above the long-term cleanup level; the HVAC-OFF sample for Room 141 revealed a TCE concentration at 7 µg/m^3, which is slightly above the long-term cleanup level of 5 µg/m^3 for TCE but well below the short-term action level of 540 µg/m^3 (ISSi, 2012).

5.2.4.2 Current (2015) Sampling Results

A total of Nine (9) indoor air samples were collected in building N144 between February 11, 2015 and February 22, 2015. Five (5) samples were collected from the warehouse portion of the FEMA N144 building which does not have an operating HVAC system; these samples were collected over a 24-hour period. One sample was collected from each of the following rooms: Room 171, Room 151 and Room 142. One sample plus one duplicate sample was collected from Room 141. All sample canisters were placed on a desk or table in the breathing zone.

The remaining four samples were collected from the southern portion of Building N144, which has an operating HVAC system; one 24-hour HVAC-ON sample and one 8-hour HVAC-OFF sample were collected in both Room 107 and C103 Hallway. The samples canisters in both locations were placed on the floor with sample tubing taped to the adjacent wall with the upper end near the breathing zone. The sampling location details are provided in **Table 6** of **Appendix B**.

All sample results for building N144 were significantly below EPA's indoor cleanup levels. Indoor air sample results were compared to the background outdoor air concentration range. TCE was measured above the background outdoor air concentration range at a concentration of 1.2 $\mu g/m^3$ in Room 142 and at 2.7 $\mu g/m^3$ in Room 141 (with one duplicate at 2.9 $\mu g/m^3$).

The ROD Amendment (EPA 2010) states that indoor air concentrations higher than outdoor air concentrations may be indicative of indoor sources of vapor intrusion. PCE (5 of 5 samples in northern portion of warehouse; 4 of 4 samples in southern portion of warehouse), trans-1,2-DCE (5 of 5 samples in northern portion of Building N144; 2 of 4 samples in southern portion of Building N144), cis-1,2-DCE (5 of 5 samples in northern portion of Building N144; of 4 samples in southern portion of Building N144), and 1,1-DCE (1 of 4 samples in southern portion of Building N144) were measured at concentrations within the outdoor background air concentration ranges. The chemicals trans-1,2-DCE and cis-1,2-DCE were detected in the southern portion of the warehouse with the HVAC system on. TCE (5 of 5 samples in northern portion of warehouse; 4 of 4 samples in southern portion of warehouse) was measured at concentrations at or exceeding the background outdoor air concentration ranges.

5.2.5 Response Action Tier Designation

Although TCE was detected above the long-term cleanup level in the 2012 sampling event, the concentrations of TCE measured in the 2015 sampling event were below the long-term cleanup level in all samples. However, TCE concentrations were measured above the background outdoor air concentrations in Rooms 141 and 142. Therefore, based on the 2012 and 2015 sample results, Building N144 is classified as Tier 3A.

5.3 Building N211 – Flight Support Facility

A walk-through inspection of Building N211 was conducted on January 29, 2015 and on February 5, 2015 for the northern and southern areas of the building, respectively. A Building Survey Form is included in **Appendix D.** The indoor air samples from Building N211 were collected on February 11, 2015 and on February 22, 2015.

5.3.1 Building Condition

Building N211 is an approximately 130,000 square-foot building that houses two open hanger spaces, open shop space, and enclosed office spaces. Various aircraft maintenance vehicles, and forklifts are regularly used and/or parked within the open hangar areas as are towed/parked aircraft. The office spaces within building N211 are normally used Monday through Friday, 06:00 to 17:00 by custodial and flight support staff.

5.3.2 HVAC System

Building N211 has one or more HVAC system(s) that heat and cool the interior of the building.

5.3.3 Existing Mitigation Measures

Currently, no mitigation measures are in place at Building N211.

5.3.4 Sample Location and Results

5.3.4.1 Previous Sampling Results

Building N211 was not sampled in the 2012 sampling event because it was previously believed that its primary use was hangar space instead of work space. As a result, the EPA requested that N211 be sampled in the 2015 sampling event.

5.3.4.2 Current (2015) Sampling Results

A total of Nine (9) indoor air were collected from Building N211 with both the HVAC system operating and with the HVAC system off. Four (4) Indoor air samples were collected on February 11, 2015 with the HVAC system operating and four (4) indoor air samples were collected on February 22, 2015 with the HVAC system shut down. One (1) 5-minute grab sample was collected from building N211 during the HVAC-OFF sampling.

The sampling location details are provided in **Table 6** of **Appendix B**. Indoor and outdoor air sample location maps are provided in **Appendix A**. Photographs taken during sampling activities are provided in **Appendix C**.

The HVAC-ON and HVAC-OFF samples were collected from Room 179, Room 136, Room 119, and Room 103, for a total of four (4) HVAC-ON samples and four (4) HVAC-OFF samples. Room 179, located between the smaller hanger portion and the larger hangar portion, functions primarily as office space. Room 166, which is located on the southwestern edge of the larger open hangar space, is a flight kitchen. Room 211 is additional office space for researchers and is located on the southeastern edge of the larger open hanger space. Room 105, located at the eastern corner of the open hangar space, functions as a flight control room and office space. One 5-minute grab sample was collected from the elevator shaft located near the southwest corner of building N211.

All COC detections for indoor air samples collected at Building N211 were significantly lower than EPA's indoor air cleanup levels. TCE (9 of 9 samples), PCE (9 of 9 samples), trans-1,2-DCE (6 of 9 samples), and cis-1,2-DCE (4 of 9 samples) were detected at levels within outdoor background air concentration ranges. TCE was measured in indoor air at concentrations ranging from 0.044 $\mu g/m^3$ to 0.38 9 $\mu g/m^3$; PCE measured in indoor air at concentrations ranging from 0.038 $\mu g/m^3$ to 0.086 $\mu g/m^3$; trans-1,2-DCE was measured in indoor air at concentrations ranging from 0.046 $\mu g/m^3$ to 0.08 $\mu g/m^3$; and cis-1,2-DCE was measured in indoor air at concentrations ranging from 0.041 $\mu g/m^3$ to 0.22 $\mu g/m^3$. All other COCs (vinyl chloride, 1,1-DCE, and 1,1-DCA) detections were within the outdoor background air concentration ranges. **Table 8** of **Appendix B** provides the indoor air and background air sample results.

5.3.5 Response Action Tier Designation

All sample results were below indoor air cleanup levels and background air concentration ranges for all COCs. Therefore, Building N211 is classified as Tier 3B.

5.4 Building N212 – Model Development Building

A walk-through inspection of Building N212 was conducted on January 29, 2015. A Building Survey Form for Building N212 is included in **Appendix D.** The 24-hour HVAC-ON indoor air samples were collected on February 11, 2015 and the 8-hour HVAC-OFF samples were collected on February 22, 2015.

5.4.1 Building Condition

Building N212 is a 12,000 square foot (ft^2), concrete building with a large open workshop with offices, a small workshop and storage located along the east side of the building. The building is used exclusively for the fabrication of metal and other components used for aerodynamic research.

5.4.2 HVAC System

Building N212 has one HVAC system for cooling of the building interior. The building also has an in-floor, hot water/steam radiant heat system.

5.4.3 Existing Mitigation Measures

Currently, no mitigation measures are in place at Building N212.

5.4.4 Sample Locations and Results

5.4.4.1 Previous Sampling Results

A total of two (2) samples were collected from Room 101A in Building N212 during the February 2012 sampling effort. Only one (1) of the seven (7) COCs was detected in the indoor air samples in Room 101A above the long-term cleanup level. This sample, N212-1-01-OFF, indicated the presence of PCE of 3 $\mu g/m^3$, which is slightly above the long-term action level of 2 $\mu g/m^3$. All remaining COCs were non-detect (ISSi, 2012).

5.4.4.2 Current (2015) Sampling Results

A total of six (6) indoor air samples were collected in Building N212 on February 11, 2015 and February 22, 2015. Two samples, including one 24-hour HVAC-ON sample and one 8-hour HVAC-OFF sample, were collected from the western portion of Room 101A; Room 101A is an enclosed workshop space located east of the main open workshop. Four samples, including two 24-hour HVAC-ON samples (original sample and duplicate sample) and two 8-hour HVAC-OFF samples (original sample and duplicate sample), were collected in Room 105. Room 105 is an office space located directly off of Room 101A.

The sampling location details are provided in **Table 6** of **Appendix B**. Indoor and outdoor air sample location maps are provided in **Appendix A**. Photographs taken during sampling activities are provided in **Appendix E**.

All sample results were below indoor air cleanup levels for all COCs. TCE (3 of 6 samples), PCE (6 of 6 samples), trans-1,2-DCE (3 of 6 samples), and cis-1,2-DCE (1 of 6 samples) were detected within the background air concentration ranges. TCE was measured in indoor air concentrations between 0.033 µg/m^3 and 0.092 µg/m^3 only in the 24-hour HVAC-ON samples. PCE was measured at concentrations ranging from 0.043 µg/m^3 to 0.067 µg/m^3 in both HVAC-ON and HVAC-OFF samples. Trans-1,2-DCE was measured at indoor air concentrations from 0.041 µg/m^3 to 0.053 µg/m^3 in both HVAC-ON and HVAC-OFF samples. The chemical cis-1,2-DCE was measured at a concentration of 0.046 µg/m^3 in the duplicate sample collected from Room 105 during the 24-hour HVAC-ON sampling. **Table 8** of **Appendix B** provides the indoor air and background air sample results.

5.4.5 Response Action Tier Designation

All COC results from the 2015 sampling event were significantly lower than indoor air cleanup levels. TCE (with HVAC system on), PCE (with both HVAC system on and off), trans-1,2-DCE (with both HVAC system on and off), and cis-1,2-DCE (with HVAC system on) were detected below and within the background air concentration ranges. However, because one (1) of the seven (7) COCs was detected in the indoor air samples in Room 101A above the EPA long-term cleanup level during the 2012 indoor air sampling event (sample, N212-1-01-OFF, indicated the presence of PCE of 3 µg/m^3), Building N212 is classified as Tier 3A.

5.5 Building N213 – Facilities Engineering

A walk-through inspection of Building N213 was conducted on February 2, 2015. A Building Survey Form for Building N213 is included in **Appendix D.** The 24-hour HVAC-OH indoor air samples were collected on February 11, 2015 and the 8-hour HVAC-OFF samples were collected on February 22, 2015.

5.5.1 Building Condition

Building N213 is approximately 12,000 square feet of floor space and consists of a two story concrete building plus a full basement. The building is occupied by the Ames Engineering and Facilities Divisions, and consists of general office and conference room space, the facility GIS division, the Ames engineering document control center and general storage space. There are also two (2) mechanical equipment rooms located in the basement which primarily contain compressors and boilers.

5.5.2 HVAC System

Building N213 has one or more HVAC system(s) that heat and cool the interior of the building.

5.5.3 Existing Mitigation Measures

Currently, no mitigation measures are in place at Building N213.

5.5.4 Sample Location and Results

5.5.4.1 Previous Sampling Results

A total of 15 indoor air samples (including one (1) duplicate) were collected in Building N213 between February 19, 2012 and February 23, 2012. Nine (9) air samples were collected from the basement and 1st floor portions of the building during the HVAC-OFF sampling when the HVAC

system was shut down. Five (5) samples plus one (1) duplicate air sample were collected from the basement and 1st floor portions during the HVAC-ON samples when the HVAC system operating. Additionally, four (4) 5-minute grab samples were collected from potential pathways in the basement portion of the building. All sample results were below indoor air clean up levels and within range of the background outdoor air concentration ranges (ISSi, 2012).

5.5.4.2 Current (2015) Sampling Results

A total of 22 samples were collected from Building N213 during the February 2015 sampling events. Eight (8) plus one (1) duplicate sample were collected during the 24-hour HVAC-ON sampling from the basement and first floor. Of the 13 8-hour HVAC-OFF samples collected from the basement and first floor, one (1) sample was a duplicate sample and four (4) samples were collected as 5-minute grab samples.

The three (3) 8-hour HVAC-OFF samples collected in the basement were taken from Room 004, Room 025, and from the C004 Hallway area. The four (4) 5-minute grab samples collected during the HVAC-OFF sampling event were taken from sumps in the mechanical Rooms N002 and N042, and from the elevator under vault areas V001 and V002. Room N002 experiences air exchange with the outdoors; there is an open-air passageway in Room N002 that leads outside to the courtyard area of Building N213. The five (5) HVAC-OFF air samples plus one (1) duplicate sample collected from the 1st floor areas were collected from all proposed areas (Rooms 103, 104, 104F, and hallways outside Rooms 132 and 146). The sample canisters collected in the hallways were placed on the floor and included sample tubing taped to the adjacent wall with the upper end near the breathing zone.

Of the nine (9) air samples collected with the HVAC system operating, three (3) samples plus one (1) duplicate were collected in the basement and five (5) samples were collected from the 1st floor. The five (5) HVAC-ON air samples collected on the 1st floor were collected in the same areas as the HVAC-OFF air samples. The three (3) HVAC-ON air samples collected in the basement were collected in the same areas as the HVAC-OFF air samples (Rooms 004, 025 and C004), including one (1) duplicate in Room 025. The sampling location details are provided in **Table 6** of **Appendix B**. Indoor and outdoor air sample location maps are provided in **Appendix A**. Photographs taken during sampling activities are provided in **Appendix C**.

All sample results were below indoor air cleanup levels in samples collected from work areas, with both the HVAC system operating and shut down.

TCE was detected at a concentration of 75 µg/m^3 in a 5-minute grab sample collected from a sump in the basement mechanical Room N002. PCE was detected at a concentration of 2.0 µg/m^3 in a 5-minute grab sample collected from a sump in the basement mechanical Room N042; vinyl chloride was measured at a concentration of 2.6 µg/m^3 (cleanup level – 2 µg/m^3) in Room N002 sump in the basement; cis-1,2-DCE was measured at a concentration of 290 µg/m^3 (cleanup level – 210 µg/m^3) in Room N002 sump.

Results for samples from the basement mechanical rooms that exceeded long-term cleanup levels had the following ranges:

- Vinyl chloride: 2.6 µg/m^3 (cleanup level – 2 µg/m^3), Room N002;
- TCE: 75 µg/m^3 (cleanup level – 5 µg/m^3), Room N002;
- PCE: 2.0 µg/m^3 (cleanup level – 2 µg/m^3) Room N042;
- cis-1,2-DCE: 290 µg/m^3 (cleanup level – 210 µg/m^3), Room N002.

Vinyl chloride (3 of 22 samples), PCE (21 of 22 samples), cis-1,2-DCE (19 of 22 samples), 1,1-DCE (3 of 22 samples), and 1,1-DCA (4 of 22 samples) were detected at concentrations meeting or exceeding the background outdoor air concentration ranges in Building N213. The chemicals trans-1,2-DCE (8 of 22 samples) and 1,1-DCE (3 of 22 samples) were detected at concentrations within range of the background outdoor air concentration ranges. Only TCE, PCE, trans-1,2-DCE, and cis-1,2-DCE were detected within background outdoor air concentration ranges on the 1st floor of Building N213. **Table 8** in **Appendix B** provides the indoor air and background air sample results.

5.5.5 Response Action Tier Designation

Building N213 is classified as Tier 3A because the sample results in work areas were significantly below indoor air cleanup levels with both the HVAC system operating and shut down. Vinyl chloride, TCE, PCE, and cis-1,2-DCE were measured above the long-term cleanup levels in two pathway samples collected in Rooms N002 and N042 in the basement with the HVAC system not operating. The rooms in which these elevated concentrations were measured are not high-traffic or work areas; both rooms are mechanical rooms in the basement that are entered only for repair and upkeep by pertinent personnel. All seven COCs—Vinyl chloride, TCE, PCE, trans-1,2-DCE, cis-1,2-DCE, 1,1-DCE, and 1,1-DCA—were detected above the background outdoor air concentration ranges in Room N002 and N042 sumps during the 2015 sampling event.

5.6 Building N240 – Airborne Missions & Applied Life Sciences Experiments

Walk-through inspections of Building N240 were conducted on February 3, 2015 and February 19, 2015. A Building Survey Form for Building N240 is included in **Appendix D.** The 24-hour HVAC-ON indoor air samples were collected on February 11, 2015 and the 8-hour HVAC-OFF samples were collected on February 22, 2015

5.6.1 Building Condition

Building N240 is a 22,000 ft^2, concrete building that contains office space, cubical space, and several areas with NASA mission critical research. The building is used primarily for airspace and spacecraft research, development, and life science research experiments. The building has a central section where the facility research is conducted, with both western and eastern portions that contain the office spaces.

5.6.2 HVAC System

Building N240 has one or more HVAC system(s) that heat and cool the interior of the building.

5.6.3 Existing Mitigation Measures

Currently, no mitigation measures are in place at Building N213.

5.6.4 Sample Locations and Results

5.6.4.1 Previous Sampling Results

A total of five (5) samples were collected from Building N240 between February 19, 2012 and February 23, 2012. The COCs detected during both HVAC-OFF and HVAC-ON sampling durations were below the long-term cleanup levels. TCE was detected above background air concentration ranges in a 5-minute grab sample collected from the elevator vault, a non-work area (ISSi, 2012).

5.6.4.2 Current (2015) Sampling Results

A total of seven (7) indoor samples were collected from Building N240 during the February 2015 sampling event with both the HVAC system operating and off. Two (2) air samples, including one 8-hour HVAC-OFF sample and one 24-hour HVAC-ON sample, were collected from each of the following locations: Room 144 area, C101 Hallway area, and Room 113. The sample collected in Room 113 was originally proposed to be collected from Room 115A; however, mission critical research prevented access to Room 115A. Room 113 was chosen instead because it is actively used during working hours as a clean laboratory and it is adjacent to Room 115A. One (1) 5-minute grab air sample was also collected as proposed from the 1st floor elevator vault at E102.

An HVAC-ON and HVAC-OFF sample was collected from the central portion of the Room 144 in a cubicle. The sample canisters were placed on a desk. The HVAC-ON sample collected from the C101 Hallway area was placed on the floor with sample tubing taped to the adjacent wall with the upper end near the breathing zone. The HVAC-ON and HVAC-OFF samples collected from Room 113 were placed on a desk at breathing level.

The sampling location details are provided in **Table 6** of **Appendix B**. Indoor and outside air sample location maps are provided in **Appendix A**. Photographs taken during sampling activities are provided in **Appendix C**.

All sample results were below indoor air cleanup levels with both the HVAC system operating and shut down. TCE was detected above the background air concentrations in three (3) of the seven (7) samples. TCE was detected at a concentration of 1.2 µg/m^3 in the HVAC-ON and HVAC-OFF samples in the C101 Hallway area. TCE was also detected at a concentration of 1.7 µg/m^3 in the 5-minute grab sample collected in the elevator vault. PCE (6 of 7 samples), trans-1,2-DCE (3 of 7 samples), cis-1,2-DCE (3 of 7 samples) were detected at concentrations within the background air concentration ranges. Trans-1,2-DCE and cis-1,2-DCE were only detected in the samples collected with the HVAC system on.

5.6.5 Response Action Tier Designation

Building N240 is classified as Tier 3A due to indoor air concentrations of TCE slightly exceeding the background air concentration ranges. The concentrations of the COCs in each sample were well below the long-term cleanup goals for each respective contaminant. However,

TCE was detected above background outdoor air concentration ranges in three samples collected from two locations in Building N240 during the 2015 sampling event and in one sample from one location during the 2012 sampling event.

5.7 Building N245 – Space Science Research Laboratory

A walk-through inspection of Building N245 was conducted on January 29, 2015. A Building Survey Form for Building N245 is included in **Appendix D.** A 24-hour HVAC-ON indoor air sample was collected on February 11, 2015 and an 8-hour HVAC-OFF sample was collected on February 22, 2015.

5.7.1 Building Condition

Building N245 is a two story concrete building with a basement. The building is approximately 70,000 square feet in size. Building N245 contains a mixture of office, research, fabrication shop, and theatre space. The building is used primarily for research related to existence of life in "foreign" or non-earth atmospheres. Earth science research is also conducted in this building.

5.7.2 HVAC System

Building N245 has one or more HVAC system(s) that heat and cool the interior of the building.

5.7.3 Existing Mitigation Measures

No mitigation measures currently exist in Building N245.

5.7.4 Sample Locations and Results

5.7.4.1 Previous Sampling Results

A total of two (2) indoor air samples, one HVAC-ON and one HVAC-OFF, were collected in Building N245 between February 19, 2012 and February 23, 2012. Both samples were collected from Room 147 in Building N245. All COCs detected during the 2012 sampling event were below long-term cleanup levels and within background outdoor air concentration ranges (ISSi, 2012).

5.7.4.2 Current (2015) Sampling Results

A total of two (2) indoor air samples were collected in Building N245 during the 2015 sampling effort. One sample was collected with the HVAC system operating and the other sample was collected with the HVAC system shut down. Both samples were collected in Room 147, a 1,200ft^2 room in the east-central portion of Building N245. The sample canister was placed on a desktop for the collection of both HVAC-ON and HVAC-OFF samples. The sampling location details are provided in **Table 6** of **Appendix B**. Indoor and outside air sample location maps are provided in **Appendix A**. Photographs taken during sampling activities are provided in **Appendix C**.

All sample results were below the indoor air cleanup levels with both the HVAC system operating and shut down. TCE (2 of 2 samples), PCE (2 of 2 samples), trans-1,2-DCE (1 of 2 samples), and cis-1,2-DCE were measured at concentrations within the outdoor background air

concentrations ranges. Trans-1,2-DCE was only detected in the sample with the HVAC system on. The chemical cis-1,2-DCE was only detected in the sample with the HVAC system off.

5.7.5 Response Action Tier Designation

Building N245 is classified as Tier 3B as all sample results for all COCs were significantly lower than the indoor air cleanup levels and within the background outdoor air concentration ranges.

5.8 Building T20G – Modular Office Units

A walk-through inspection of Building N245 was conducted on February 4, 2015. A Building Survey Form for Building N245 is included in **Appendix D.** The 24-hour HVAC-ON indoor air samples were collected on February 11, 2015 and the 8-hour HVAC-OFF sample was collected on February 22, 2015.

5.8.1 Building Condition

Building T20G is a 15,000 ft^2, one-story modular office building with offices, conference rooms, and a small "wet lab" space used exclusively for environmental sample and equipment storage. The building is utilized to house primarily environmental and mission support staff.

5.8.2 HVAC System

Building T20G has one or more HVAC system(s) that heat and cool the interior of the building.

5.8.3 Existing Mitigation Measures

Currently, no mitigation measures have been taken in Building T20G.

5.8.4 Sample Locations and Results

5.8.4.1 Previous Sampling Results

Building T20G was sampled in February 2012. All COCs detected during both HVAC-OFF and HVAC-ON sampling events in Building T20G were below the long-term cleanup. PCE was detected above background outdoor air concentration ranges in one sample; the concentration of PCE detected in T20G (1.7 $\mu g/m^3$) was similar to the PCE concentration detected in the background sample collected during the same sampling period (1.3 $\mu g/m^3$). All remaining COCs were either non-detect or within background air concentration ranges (ISSi, 2012).

5.8.4.2 Current (2015) Sampling Event

A total of three (3) indoor air samples were collected from Building T20G with both the HVAC system operating and shut down. Indoor air samples were collected from the hallway areas adjacent to the Room 102 and Room 189 areas, which are office areas located on the western and south central portions of the building. Hallway area air sample containers were placed on the floor with sample tubing taped to the adjacent wall with the upper end near the breathing zone. One (1) 24-hour HVAC-ON and one (1) 8-hour HVAC-OFF sample was collected from the location near Room 189. One (1) 24-hour HVAC-ON sample was collected from the location near Room 102. It was originally proposed that one HVAC-ON and one HVAC-OFF sample be collected at each sample location, however the HVAC-OFF sample was not collected at the location adjacent to Room 102 due to sample container pressure failure.

The sampling location details are provided in **Table 6** of **Appendix B**. Indoor and outside air sample location maps are provided in **Appendix A**. Photographs taken during sampling activities are provided in **Appendix C**.

All sample results were below the indoor air cleanup levels, both during the HVAC-ON and HVAC-OFF sampling events. Concentrations of TCE (2 of 3 samples) and PCE (3 of 3 samples) were detected within the background outdoor background air concentration ranges. None of the other COCs were detected exceeding their background air concentration ranges at T20G.

5.8.5 Response Action Tier Designation

Building T20G is classified as Tier 3B as all sample results for all COCs were significantly below indoor air cleanup levels and within the background air concentration ranges.

6 QA/QC and Data Validation

Quality Assurance/Quality Control (QA/QC) activities completed during this investigation complied with the requirements as specified in the Site-wide Work Plan (Haley, 2011) and as per the "*NASA Building Specific Sampling Plan VI Workplan*" (NASA, 2011), as amended in 2015. There were no deviations or discrepancies identified in sampling protocols or field sampling techniques. A total of 58 indoor air samples, including five (5) duplicate samples plus two background samples were collected on February 10-11, 2015 and February 22, 2015 to evaluate the vapor intrusion pathway in seven (7) occupied buildings a NASA Ames. The laboratory followed required media preparation procedures for the sample canisters and analyses. Project analytical and QA/QC data underwent a Tier IV evaluation for correctness, completeness and accuracy, and are included in ***Appendix D***. The following sections describe the QA/QC procedures applied to this investigation for data evaluation and usability.

6.1 Laboratory Quality Control

Laboratory QC is designed to detect, reduce, and correct deficiencies in a laboratory's internal analytical process prior to the release of results and to improve the quality of the results reported. A discussion regarding the precision and accuracy of the laboratory's analytical systems is included in *Section 6.2*. Analytical services for air samples were provided by ALS Environmental Laboratory of Simi Valley, California. A total of 60 air samples, including the associated QC samples (duplicates), were submitted to this DoD ELAP– and NELAP-accredited laboratory for analysis of VOCs by EPA Method TO-15 SIM.

Upon sample arrival, the laboratory verified each sample's physical condition and ensured that all pertinent documentation associated with each sample was complete. Each analyst reviewed the quality of their work based on established protocols specified in the laboratory's standard operating procedures, analytical method protocols, project-specific requirements, and data quality objectives. All air samples were received by the laboratory in good condition. In general, QC sample results that were outside the laboratory acceptance criteria for data accuracy and precision were flagged by the laboratory and further qualified during data validation. Results for laboratory QC samples and reporting limits are discussed in *Section 6.2*.

6.2 Data Validation

Data validation was performed by ALS Laboratory Data Consultants, Inc., of Carlsbad, California, under EPA Level IV guidelines (***Appendix D***). The Level IV validation included review of laboratory QC summaries (blank, calibrations, spike recoveries, duplicates, etc.). The Level IV process incorporates a review of raw data including chromatograms and quantitation reports. This additional information is utilized in the Level IV data validation process for checking calculations of quantified analytical data. Analytical data was qualified based on data validation reviews. Qualifiers were consistent with the applicable EPA functional guidelines and were used to provide data users with an estimate of the level of uncertainty associated with the qualified results. The data usability was determined based on data validation results with respect to the following qualifiers:

- D – The reported result is from a dilution
- L – Laboratory control sample recovery outside the specified limits; results may be biased high
- R – non-usable data because duplicate precision not met
- ND – not detected at or above laboratory reporting limit

Once the data are reviewed and qualified according to the above mentioned documents, the data set is then evaluated using the precision, accuracy, representativeness, completeness, and comparability (PARCC) criteria. PARCC criteria provide an evaluation of overall data usability. The following is a discussion about PARCC criteria as it relates to the project data quality objectives. All VOC results were assessed to be valid since none of the results were rejected based on QC exceedances.

6.2.1 Holding Time

The sample analysis dates and sample collection dates were compared to ensure samples were analyzed within specified holding times. All samples were received by the subcontract laboratory in good condition, and all samples met the validation criteria.

6.2.2 Precision and Accuracy

Field duplicates were used to assess the overall precision of the sampling effort contaminant variability in the sample matrix. Field duplicates were collected at the same time and from the same location as their corresponding primary samples. Field duplicates were collected at least 10 percent of all field samples. Precision is evaluated by collecting and analyzing field and laboratory duplicates and then calculating the variance between the samples, typically as a relative percent difference (RPD). Most samples were within the calibration range. Overall, the results from the sampling events indicate very good precision in the analytical method.

6.2.3 Representativeness

Representativeness is the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that depends on proper design of the sampling program.

The representativeness of data was maintained by the use of established field and laboratory procedures and their consistent application. Field personnel were responsible for collecting and handling samples according to the procedures in approved Haley 2011 and NASA 2011 work plans so that samples were representative of field conditions.

6.2.4 Completeness

Completeness is the ratio of usable results to unusable results in terms of percentage. Unusable results are defined as results rejected because of serious QC deficiencies. The value obtained for project completeness represents the attainment of specific project goals for data used for decision making. All requested parameters were analyzed by the laboratory. No results were rejected due to serious QC deficiencies. The data set met the completeness goal.

6.2.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another, including whether it was generated by a single or multiple

laboratories. The use of standardized field and analytical procedures ensures comparability of analytical data.

Sample collection and handling procedures adhered to EPA-approved protocols. Laboratory procedures followed standard analytical protocols, used standard units and standardized report formats, followed the calculations as referenced in approved analytical methods, and used a standard statistical approach for QC measurements.

6.2.6 Sensitivity

Sensitivity is a measure of method performance in terms of the ability to detect chemicals of concern at concentrations low enough to eliminate potential false negatives and to ensure the project goals in terms of meeting actionable concentrations. The project target detection limits are based on available, standard methods applicable to air and are below most applicable regulatory criteria.

6.2.7 Data Usability Summary

Based on the evaluation of the available QA/QC data and data validations, the completeness goal was achieved for all analyses based on the ratio of the number of usable data (data not rejected due to serious deficiencies) and the total number of planned samples. The overall findings of the data review and validation indicate that the data are of sufficient quality to support the findings of the Evaluation Report. There were no other issues associated with sample collection or the results of the analysis of field QC samples that would negatively impact data usability. The data is sufficient and acceptable to support the conclusions of this Evaluation Report.

7 Findings and Conclusion

A total of 60 air samples, including indoor and outdoor air samples, were collected during the 2015 air sampling event in order to evaluate the occurrence of and pathways for vapor intrusion in 7 fully or partially occupied buildings at NASA's AOR, where partially occupied infers that only a part of a building is occupied or utilized.
All of the seven (7) buildings evaluated are classified as Tier 3A or Tier 3B because the indoor air concentrations measured during the sampling events meet indoor air cleanup level requirements in work areas without an EC in place or operating.

Of these buildings, only four (4) buildings—N212, N213, N144, and N240—are classified as Tier 3A because indoor air concentrations exceeded the outdoor air concentrations but were below the indoor air cleanup level for any of the seven COCs. The response action for buildings classified as Tier 3A is the development and implementation of a long-term monitoring plan as per the 2010 ROD Amendment for Vapor Intrusion.

The remaining three (3) buildings—N211, N245, and T20G—are classified as Tier 3B because indoor air concentrations are at or within range of the outdoor air concentrations. No engineered remedy or long-term monitoring is required for buildings classified as Tier 3B. ICs will be implemented for both Tier 3A and 3B buildings.

This section summarizes the 2015 results and conclusions.

7.1 Summary of Findings

Of the seven (7) buildings sampled, none exhibited samples in work areas with concentrations exceeding the air cleanup levels in the ROD Amendment (EPA 2010).

Only one building—Building N213—demonstrated TCE concentrations above the long term clean up level in a non-work area; TCE was detected exceeding the indoor air cleanup level with a concentration of 75 µg/m^3 in one pathway sample collected from Room N002 sump, a mechanical room located in the basement of Building N213.

Building N144: TCE concentrations exceeded outdoor air concentrations (outdoor air consternation range for all COCS: <0.029 µg/m^3 to <0.036 µg/m^3) but were below the indoor air cleanup level. The concentration of TCE measured in Building N144 ranged from 1.2 µg/m^3 to 2.9 µg/m^3 in samples from Rooms 142 and 141, respectively. Building N144 has no operating HVAC system in the portion of the building where these samples were collected.

Building N211: The concentration of COCs detected in Building N211 were below the indoor air cleanup levels and within outdoor air concentration ranges.

Building N212: The concentrations of COCs detected in Building N212 were below the indoor air cleanup levels and within outdoor air concentration ranges.

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Building N213: In Building N213, concentrations of COCs in work area samples did not exceed the indoor air clean-up levels. However, concentrations of vinyl chloride, TCE, PCE, and cis-1,2-DCE were detected above the indoor air cleanup levels in grab/pathway samples collected in low-traffic, non-work areas in mechanical rooms located in the basement of Building N213. These samples were collected from wastewater sumps on the floor of rooms N002 and N042. Room N002 sample, which yielded concentrations of vinyl chloride, TCE, and cis-1,2-DCE, is exposed to outdoor air via an open ventilation passageway. These 5 minute grab samples were collected from utility room sumps in the basement of Building N213 with the HVAC system not operating

Results for Building N213 basement sump samples exceeded cleanup levels with the following ranges:

- Vinyl chloride: 2.6 µg/m^3 (cleanup level – 2 µg/m^3), Room N002;
- TCE: 75 µg/m^3 (cleanup level – 5 µg/m^3), Room N002;
- PCE: 2.0 µg/m^3 (cleanup level – 2 µg/m^3) Room N042;
- cis-1,2-DCE: 290 µg/m^3 (cleanup level – 210 µg/m^3), Room N002.

The concentrations of COCs above the long-term cleanup level are likely the result of groundwater seepage into the sumps where the samples were collected

Building N240: In Building N240, TCE was measured at a concentration above the background background air concentration range in the C101 Hallway with both the HVAC system on and off and in the 5-minute grab sample collected from the elevator shaft located in the western half of the building with the HVAC system off.

Building N245: Concentrations of COCs were detected below the long-term cleanup levels and within background air concentration ranges in Building N245.

Building T20G: In Building T20G, the concentration of COCs detected were below the long-term cleanup levels and within background air concentration ranges.

7.2 2012 vs. 2015 Data

At the request of EPA following the primary sampling event in February 2012, a second series of air analyses was performed in 2015 for the tiering evaluation and information on potential differences on the occurrence of vapor intrusion. The following section summarizes the differences in indoor air concentrations between the 2012 and 2015 indoor air sampling results.

Building N144: In the 2012 sampling, TCE was measured above the long-term cleanup goal at a concentration of 7.0 µg/m^3 in Room 141 of Building N144. PCE was also detected above the background outdoor air concentration range during the 2012 sampling.

During the 2015 sampling, Building N144 was identified as having TCE concentrations exceeding the background outdoor air concentrations but below the indoor air cleanup levels in Room 141. Building N144 has no operating HVAC system in the portion of the building where these samples were collected. Building N144 is classified as Tier 3A because the TCE concentrations remain above the background air concentration range even though the concentrations were reduced below the long-term cleanup goal from 2012 to 2015.

Building N211: Building N211 was not sampled during the February 2012 sampling event. In 2015, the concentration of COCs detected were below the long term cleanup levels and within background air concentration ranges in Building N211. Building N211 is classified as Tier 3B.

Building N212: In the 2012 sampling event, PCE was detected above the long-term cleanup goal at a concentration of 3.0 $\mu g/m^3$. All other COCs were within background air concentration ranges during the 2012 sampling event.

During the 2015 sampling event, concentrations of COCs were detected below the long term cleanup levels and within background air concentration ranges for all samples collected in Building N212. Building N212 is ranked as Tier 3A because PCE was detected above the long-term cleanup levels in 2012 but not in 2015.

Building N213: During the 2012 sampling event, none of the seven (7) COCs were detected in Building N213 above current action levels, during either the HVAC-OFF or HVAC-ON sampling events. Only one of the 5-minute grab air samples collected from the sample location V001 elevator under-vault area revealed the presence of TCE above the background outdoor air concentration range.

In 2015, Building N213 demonstrated concentrations of VOCs, including vinyl chloride, TCE, PCE, and cis-1,2-DCE, in grab-samples that exceeded the indoor commercial clean up levels. These samples were from non-work area samples and included 5-minute grab samples collected from utility room sumps in the basement of Building N213 with the HVAC system not operating. Because the samples containing concentrations of VOCs above the long-term cleanup levels were collected in non-work areas, Building N213 currently requires long term monitoring and is, therefore, classified as Tier 3A.

Building N240: During the 2012 sampling, all sample results were below the indoor air cleanup levels and within background air concentration ranges. During the 2015 sampling, TCE was detected above the background air concentration range in the samples collected from the C101 Hallway location and from the 5-minute grab sample collected from the elevator vault (with the HVAC system off). Building N240 is therefore classified as Tier 3A.

Building N245: During both the 2012 and 2015 sampling events, the concentrations of COCs in Building 245 were detected below the long term cleanup levels and within background air concentration ranges. Building N245 is classified as Tier 3B.

Building T20G: During the 2012 sampling, PCE was detected in Building T20G at a concentration slightly above the background air concentration range. During the 2015 sampling,

all sample results were below the long term cleanup levels and within background air concentration ranges. Because PCE was not measured above the background outdoor air concentration range during 2015, Building T20G is classified as Tier 3B.

7.3 Response Action Tiering System Evaluation

Using the relevant historical data, the 2012 and current (2015) indoor air sampling results as well as Tables 6A and 6B of the ROD Amendment (EPA 2010), the buildings were tiered to determine the need for a response action in accordance with the Response Action Tiering System. Indoor air quality results for COCs were compared to the ROD Amendment cleanup levels and to background outdoor air concentration ranges with consideration of whether or not an air quality EC is in place.

All of the seven (7) buildings evaluated are classified as Tier 3A or Tier 3B because the indoor air concentrations measured during the sampling events meet indoor air cleanup level requirements in work areas without an EC in place or operating.

Of these buildings, only four (4) buildings—N212, N213, N144, and N240—are classified as Tier 3A because indoor air concentrations exceeded the outdoor air concentrations but were below the indoor air cleanup level for any of the seven COCs. The response action for buildings classified as Tier 3A is the development and implementation of a long-term monitoring plan as per the 2010 ROD Amendment for Vapor Intrusion.

The remaining three (3) buildings—N211, N245, and T20G—are classified as Tier 3B because indoor air concentrations are at or within range of the outdoor air concentrations. No engineered remedy or long-term monitoring is required for buildings classified as Tier 3B. ICs will be implemented for both Tier 3A and 3B buildings

The tier classification for each building, based on the most recent and relevant historical data, is presented in **Table 11** of **Appendix B**.

Additional lines of evidence, such as soil vapor samples from the perimeter of buildings, sub-slab samples, and shallow groundwater samples can be collected in the future to supplement existing data for buildings in Tier 3B to evaluate the feasibility of reclassification to Tier 4 (no further action) by demonstrating there is no potential for vapor intrusion to cause indoor air to exceed indoor air cleanup levels and background levels.

8 Recommendations

Recommendations presented in this section were prepared based on 2012 and 2015 indoor air sampling results and as per the ROD Amendment (EPA, 2010)

8.1 Potential Mitigation Measures

Since none of the buildings sampled have a Tier 1 or Tier 2 designation, interim mitigation measures and final remedial approaches are not needed. However, in buildings where vapor intrusion has been detected above background levels, or above clean up levels in pathway samples, long term monitoring is required. If and where possible and feasible, interim mitigation measures may be considered to reduce the potential for vapor intrusion from contaminated sources. Such interim mitigation measures may include sealing cracks and conduits that penetrate foundations and floors.

8.1.1 Buildings N144, N212, N213 & N240:

Buildings N144, N212, N213 and N240 are classified as Tier 3A because indoor air concentrations exceeded the outdoor air concentrations but were below the indoor air cleanup level for any of the seven COCs. The response action for buildings classified as Tier 3A is the development and implementation of a long-term monitoring plan as per the 2010 ROD Amendment for Vapor Intrusion.

8.1.2 Buildings N211, N245 & T20G:

Buildings N211, N245 and T20G are classified as Tier 3B because indoor air concentrations are at or within range of the outdoor air concentrations. No engineered remedy or long-term monitoring is required for buildings classified as Tier 3B. ICs will be implemented for both Tier 3A and 3B buildings.

Additional lines of evidence, such as soil vapor samples from the perimeter of buildings, sub-slab samples, and shallow groundwater samples can be collected in the future to supplement existing data for buildings in Tier 3B to evaluate the feasibility of reclassification to Tier 4 (no further action) by demonstrating there is no potential for vapor intrusion to cause indoor air to exceed indoor air cleanup levels and background levels.

9 References

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