Annual Site Environmental Report

Department of Energy

Energy Technology Engineering Center – Area IV

Santa Susana Field Laboratory

Prepared for:
U.S. Department of Energy

Prepared by:
North Wind, Inc.
Santa Susana Field Laboratory

April 2019

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Annual Site Environmental Report

Department of Energy Operations at the Energy Technology Engineering Center – Area IV Santa Susana Field Laboratory

April 2019

Contract No. DE-EM0000837-DT0007583

Prepared for:
U.S. Department of Energy

Prepared by:
North Wind, Inc.
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Idaho Falls, ID 83402

CERTIFICATE OF ACCURACY

I certify that I have personally examined, and am familiar with, the information submitted herein and, based on inquiry of those individuals immediately responsible for preparing this report, believe that the submitted information is true, accurate, and complete.

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April 2019

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Energy Technology Engineering Center
4100 Guardian Street, Suite 160
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February 4, 2020

SUBJECT: DOE Certification for the 2019 Site Environmental Report for the Energy Technology Engineering Center (ETEC)

North Wind, Inc has prepared the subject report for the U.S. Department of Energy (DOE). It is a comprehensive summary of the Department's environmental protection activities at ETEC in Canoga Park, California for Calendar Year 2019. Site Environmental reports are prepared annually for all DOE sites with significant environmental activities.

To the best of my knowledge, this report accurately summarizes the results of the 2019 environmental monitoring and restoration program at ETEC for DOE. This statement is based on reviews conducted by DOE-ETEC staff and by the staff of North Wind, Inc.

John Jones,
Director
U.S. Department of Energy/ETEC

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ACKNOWLEDGEMENTS

Preparation of this report has been a collaborative effort of members of DOE EMCBC, North Wind, Inc., and our subcontractors.

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The staff of North Wind, Inc., CDM Federal Services (CDM), and the Department of Energy provided technical contributions to this report.

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Acronyms and Abbreviations

%D	percent difference or percent drift
%R	percent recovery
µg/L	microgram per liter
1,1,1- TCA	1,1,1-trichloroethane
AOC	Administrative Order on Consent
ASER	Annual Site Environmental Report
ASL	above sea level
ASME	American Society of Mechanical Engineers
BCG	biota concentration guide
bgs	below ground surface
CAA	Clean Air Act
CDM	Camp Dresser & McKee
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Co-60	cobalt-60
Cs-137	cesium-137
D&D	decontamination and decommissioning
DCS	derived concentration standard
DMR	discharge monitoring report
DOE	Department of Energy
DPH	Department of Public Health
DQI	data quality indicator
DQO	data quality objective
DRO	diesel-range organic
DTSC	Department of Toxic Substances Control
EA	environmental assessment
EIS	environmental impact statement
EMCBC	Environmental Management Consolidated Business Center
EPA	Environmental Protection Agency

ESH&Q	Environmental Safety, Health and Quality
ETEC	Energy Technology Engineering Center
Eu-152	europium-152
FESOP	Federally Enforceable State Operating Permit
FFCA	Federal Facilities Compliance Act
FONSI	Finding of No Significant Impact
FR	Federal Register
FSDF	Former Sodium Disposal Facility
GRO	gasoline-range organic
GWIM	groundwater interim measure
H-3	tritium
HMSA	Hazardous Material Storage Area
HWMF	Hazardous Waste Management Facility
ICP	inductively coupled plasma
ID	identification
IDW	investigation-derived waste
ISMS	Integrated Safety Management System
K-40	potassium-40
LARWQCB	Los Angeles Regional Water Quality Control Board
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LOX	Liquid Oxygen Plant
LUT	look-up table
MCL	maximum contaminant level
MDC	minimal detectable limit
MDL	method detection limit
MEI	maximally exposed individual
mR/y	milli-Roentgens per year
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
NAAQS	National Ambient Air Quality Standards

NASA	National Aeronautics and Space Administration
NBZ	Northern Buffer Zone
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
Ni-63	nickel-63
NIST	National Institute of Standards and Technology
NO_2	nitrogen dioxide
NOA	Notice of Availability
NOI	Notice of Intent
North Wind	North Wind, Inc.
NPDES	National Pollutant Discharge Elimination System
NQA-1	Nuclear Quality Assurance–1
NSPS	New Source Performance Standards
O_3	ozone
ORISE	Oak Ridge Institute for Science and Education
OSLD	optically stimulated luminescence detector
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
Pb	lead
PCE	tetrachloroethylene
pCi/g	picocuries per gram
PM_{10}	10-micron particulate matter
$PM_{2.5}$	2.5-micron particulate matter
Pu	plutonium
Q1	Quarter One
QA/QC	Quality Assurance/Quality Control
QAPjP	Field Quality Assurance Project Plan for Groundwater Monitoring
QAPP	Field Quality Assurance Project Plan
R&D	research and development
Ra-226	radium-226
Ra-228	radium-228
RAD	radiochemical
RCRA	Resource Conservation and Recovery Act

RFI	RCRA Facility Investigation
RHB	Radiological Health Branch
RL	reporting limit
RMHF	Radioactive Materials Handling Facility
Rn-222	radon-222
RPD	relative percent difference
SDG	sample delivery group
SDS	serial dilution sample
SIM	selective ion monitoring
SIP	state implementation plan
SNAP	Systems for Nuclear Auxiliary Power
SO_2	sulfur dioxide
SPCC	spill prevention, control and countermeasure
SPTF/CHCF	Sodium Pump Test Facility / Component Handling & Cleaning Facility
Sr-90	strontium-90
SRE	Sodium Reactor Experiment
SSFL	Santa Susana Field Laboratory
STP	Site Treatment Plan
Tc-99	technetium-99
TCE	trichloroethylene
TCP	trichloropropane
Th-230	thorium-230
TLD	thermoluminescent dosimeter
U	uranium
EPA	U.S. Environmental Protection Agency
VCAPCD	Ventura County Air Pollution Control District
VOC	volatile organic compound
WQSAP	Water Quality Sampling and Analysis Plan

1. EXECUTIVE SUMMARY

This Annual Site Environmental Report (ASER) for 2018 describes the environmental conditions related to work performed for the Department of Energy (DOE) at Area IV of the Santa Susana Field Laboratory (SSFL) as required by DOE O 231.1B Admin Chg. 1, "Environment, Safety and Health Reporting." This report is used to communicate internally to DOE, and externally to the public, the environmental monitoring results and the state of environmental conditions related to DOE activities at Area IV at SSFL. The report summarizes:

- Environmental management performance for DOE activities (e.g., environmental monitoring of effluents and estimated radiological doses to the public from releases of radioactive materials)
- Environmental occurrences and responses reported during the calendar year
- Compliance with environmental standards and requirements
- Significant programs and efforts related to environmental management.

No activities occurred in Area IV in 2018 that would have released effluents into the atmosphere. Therefore, the potential radiation dose to the general public through airborne release was zero. Similarly, the radiation dose to an off-site member of the public (maximally exposed individual) due to direct radiation from SSFL is indistinguishable from background.

Results of the radiological monitoring program continue to indicate that there are no significant releases of radioactive material from Area IV of SSFL. All potential exposure pathways are sampled and/or monitored, including air, soil, surface water, groundwater, direct radiation, transfer of property (land, structures, waste), and recycling.

No radioactive wastes were processed for disposal during 2018. No liquid radioactive wastes were released into the environment.

During 2018, four regulatory agency inspections and/or visits were conducted relating to DOE operations in Area IV. These inspections and visits were carried out by the California Department of Public Health (DPH). In addition, the EPA Department of Toxic Substances Control (DTSC) visited the site for meetings and to observe field activities.

The following sections in this report provide information related to ensuring protection of human health and the environment for DOE's operations at Area IV:

- Section 3, Compliance Summary, identifies and provides status of applicable permits and other regulatory requirements for DOE's closure mission.
- Section 4, Environmental Management System, summarizes the programs in place for characterization, monitoring, and response to known or potential releases to the environment that may pose a threat to human health and the environment.
- Section 5, Environmental Radiological Protection Program and Dose Assessment, summarizes the data collection activities and associated results for radiological contaminants.

- Section 6, Environmental Non-Radiological Program Information, summarizes the data collection activities and associated results for non-radiological contaminants.
- Section 7, Groundwater Protection and Monitoring Program, addresses collection, analysis of groundwater samples, and measurement of the water levels at SSFL.
- Section 8, Soil Investigation Program, summarizes soil investigations with the objectives of determining the nature and extent of chemicals in soil, and the potential threat to groundwater.
- Section 9, Quality Assurance Program, summarizes the Quality Assurance/Quality Control (QA/QC) elements incorporated into the data analysis program.

2. INTRODUCTION

This annual report describes the environmental monitoring programs related to the DOE activities at Area IV of the SSFL facility located in Ventura County, California, during 2018. Area IV has been used for DOE activities since the 1950s. A broad range of energy-related research and development (R&D) projects, including nuclear technology projects, were conducted at the site. All nuclear R&D operations in Area IV ceased in 1988 and efforts were directed toward environmental restoration and decontamination and decommissioning (D&D) activities. By 2007, D&D remained for two former nuclear facilities, two liquid metal facilities, and various support facilities. In May 2007, the D&D operations in Area IV were suspended until DOE's completion of the SSFL Area IV Environmental Impact Statement (EIS). The Draft EIS was released by DOE in January 2017 and the EIS was finalized in November 2018 (DOE 2018). Environmental monitoring and characterization programs were continued for the remainder of 2018. The Energy Technology Engineering Center (ETEC), a government-owned, company-operated test facility, was located in Area IV. The operations in Area IV included development, fabrication, operation and disassembly of nuclear reactors, reactor fuel, and other radioactive materials. Other activities in the area involved the operation of large-scale liquid metal facilities that were used for testing non-nuclear liquid metal fast breeder reactor components. All nuclear work was terminated in 1988, and all subsequent radiological work has been directed toward environmental restoration and D&D of the former nuclear facilities and their associated sites. Liquid metal R&D ended in 2002. Since May 2007, the D&D operations in Area IV have been suspended by the DOE, but the environmental monitoring and characterization programs have continued.

North Wind, Inc., (North Wind) officially assumed responsibilities for the ETEC Closure activities October 1, 2014, under contract DE-EM0000837-DT0007583. Boeing was previously responsible for the management of the site from 1996–2014.

2.1 Site Location and Setting

The SSFL site occupies 2,850 acres located in the Simi Hills of Ventura County, California, approximately 48 km (30 miles) northwest of downtown Los Angeles. The SSFL is situated on rugged terrain with elevations at the site varying from 500 to 700 m (1,640 to 2,250 ft) above sea level (ASL). The location of the SSFL site in relation to nearby communities is shown in Figure 2-1. No significant agricultural land use exists within 30 km (19 miles) of the SSFL site. Undeveloped land surrounds most of the SSFL site.

Boeing owns the majority of the site, which is divided into four administrative areas and undeveloped land. Figure 2-2 illustrates the arrangement of the site. Area IV consists of approximately 290 acres, of which DOE leases 90 acres. Boeing and DOE-operated facilities (Figures 2-3 and 2-4) share the Area IV portion of this site. While the land immediately surrounding Area IV is undeveloped, suburban residential areas are at greater distances. The community of Santa Susana Knolls lies 4.8 km (3.0 miles) to the northeast, the Bell Canyon area begins approximately 2.3 km (1.4 miles) to the southeast, and the American Jewish University is adjacent to the north. Except for the Pacific Ocean, which is approximately 20 km (12 miles) south, no recreational body of water of noteworthy size is located in the surrounding area. Four major reservoirs providing domestic water to the greater Los Angeles area are located within

50 km (30 miles) of SSFL; the closest to SSFL (Bard Reservoir, near the west end of Simi Valley), is more than 10 km (6 miles) from Area IV.

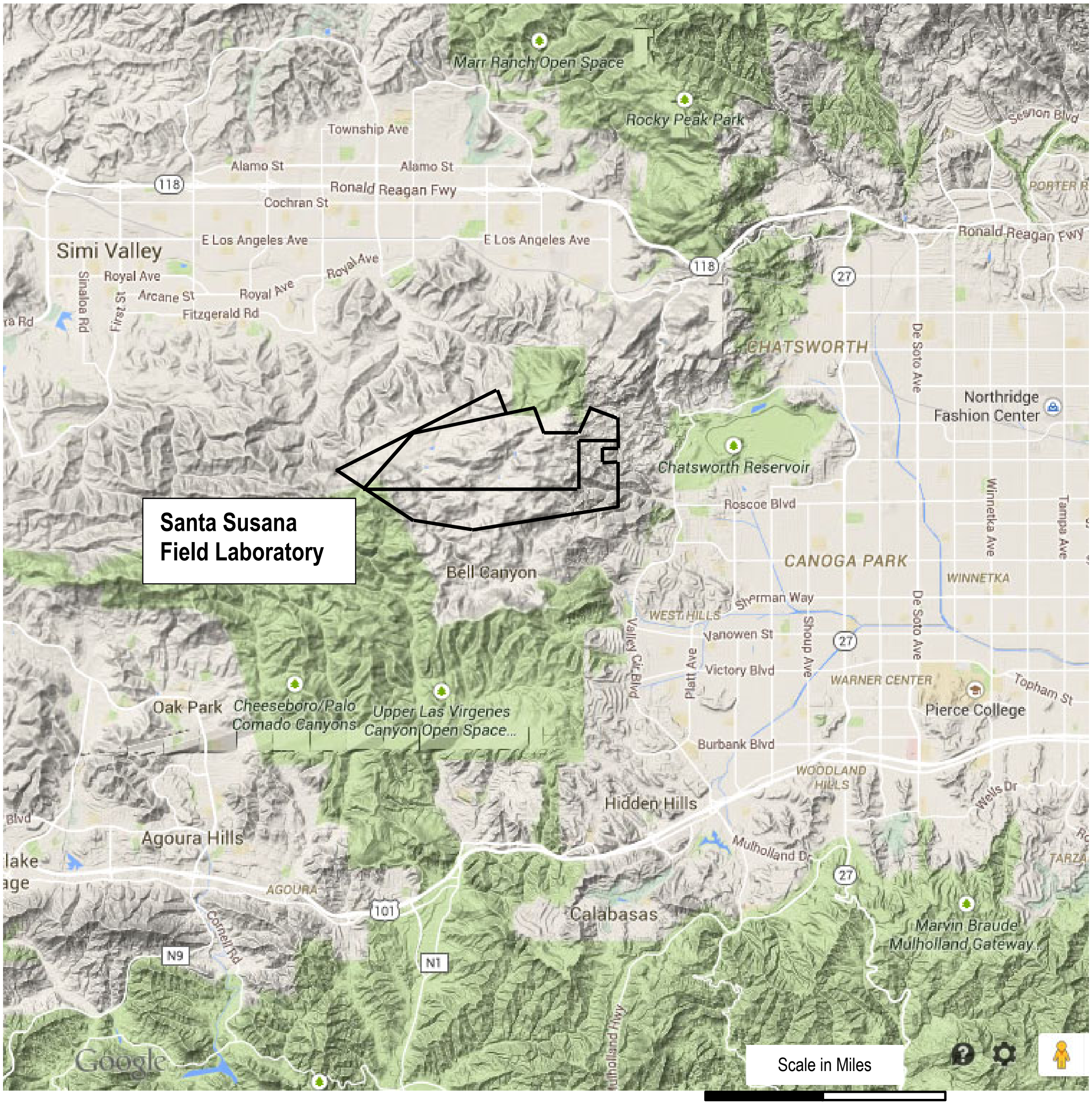

Figure 2-1. Map Showing Location of SSFL

Subdivisions			
Owner	**Jurisdiction**	**Acres**	**Subtotals**
Boeing	Boeing—Area IV Boeing—Areas I and III Boeing (Undeveloped land)	289.9 784.8 1,324.6	2,399.3
Government	NASA (former AFP 57) NASA (former AFP 64)	409.5 41.7	451.2
Total Acres			2,850.5

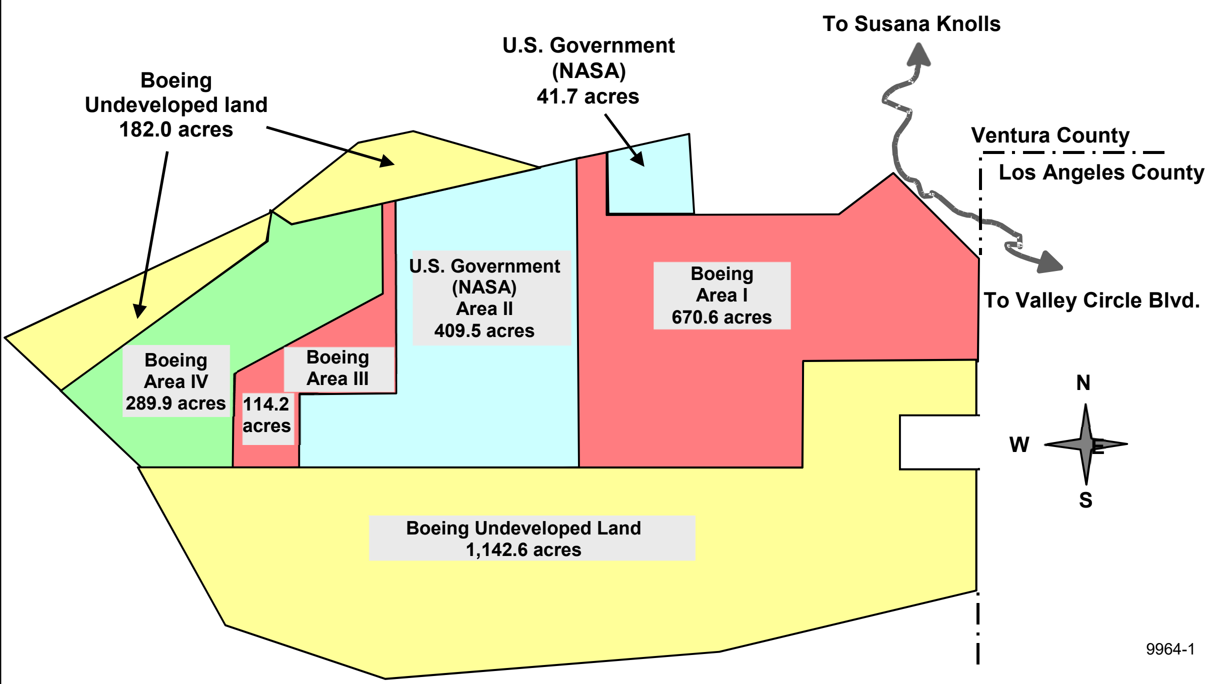

Figure 2-2. Santa Susana Field Laboratory Site Arrangement

2.2 Operational History

The SSFL has been used for various research, development, and test projects funded by several U.S. government agencies, including DOE, Department of Defense, and National Aeronautics and Space Administration (NASA). Since 1956, various R&D projects had been conducted in Area IV, including small tests and demonstrations of reactors and critical assemblies, fabrication of reactor fuel elements, and disassembly and de-cladding of irradiated fuel elements. These projects were completed and terminated during the subsequent 30 years. Details for projects can be found at the DOE website devoted to the ETEC closure: (http://www.etec.energy.gov).

All nuclear R&D operations in Area IV ceased in 1988. The only work related to the nuclear operations after 1988 has been the cleanup and decontamination of the remaining inactive radiological facilities and off-site disposal of radioactive waste. In 1998, DOE awarded Boeing a contract for the closure of all DOE facilities in Area IV. Environmental remediation and restoration activities at SSFL were conducted as directed by DOE. In May 2007, DOE suspended the D&D activities in Area IV, pending completion of an EIS. In October 2014 North Wind officially took over the responsibilities for the ETEC closure. DOE issued a draft EIS in January 2017 and the Final EIS was issued in November 2018 (DOE 2018).

2.3 Facility Descriptions

There were 27 radiological facilities that operated in Area IV (See Figure 2-4). As of the end of 2014, 20 have been released for unrestricted use and four have been declared suitable for unrestricted release by DOE. Demolition is pending for two facilities: Building 4024 and the Radioactive Materials Handling Facility (RMHF). Six former radiological facilities in Area IV have been declared free of contamination: 4009 (Boeing), 4011 (Boeing), 4019 (DOE), 4029 (DOE), 4055 (Boeing), and 4100 (Boeing).

In addition to radiological facilities, two inactive sodium and related liquid metal test facilities remain in Area IV, as well as various support facilities. They are the Sodium Pump Test Facility/Component Handling & Cleaning Facility (SPTF/CHCF) and the Hazardous Waste Management Facility (HWMF). These were constructed at SSFL to support development testing of components for liquid metal electrical power production systems. With the completion of the EIS, the facilities will undergo closure and demolition.

2.3.1 Radiological Facilities

Radioactive Materials Handling Facility (RMHF)

The RMHF complex consists of Buildings 4021, 4022, 4034, 4044, 4075, 4563, 4621, 4658, 4663, 4665, and 4688. Sump 4614 was a holdup pond located at the base of the drainage channel west of the RMHF complex. The use of the pond was discontinued, and the pond was excavated in 2006. The drainage channel and pond have been replaced with an above-ground storage tank that receives storm water runoff from the RMHF via a drainage pipe.

Operations at RMHF included processing, packaging, and temporary storage of radioactive waste materials for off-site disposal at DOE approved facilities. The radioactive waste included uranium (U), plutonium (Pu), mixed fission products such as cesium-137 (Cs-137) and strontium-90 (Sr-90), and activation products including cobalt-60 (Co-60), europium-152 (Eu-152), and tritium (H-3).

No effluents were released into the atmosphere through the stack at the RMHF and no radioactive liquid effluents were released from the facility. DOE has developed a draft closure plan for the RMHF, which is under review at the DTSC.

Figure 2-3. Santa Susana Field Laboratory Site, Area IV (2018)

Building 4024

Building 4024, Systems for Nuclear Auxiliary Power (SNAP) Environmental Test Facility, housed four experimental reactor systems in the 1960s. Following termination of the experimental projects, all equipment and fuel were removed from the facility. The shielding concrete in the vaults has low-level activation products, including Co-60 and Eu-152. Building remediation began in 2004 and portions of the building used to support the office space and the mechanical ventilation systems were demolished.

The ventilation stack was removed and a geophysical study supporting final building demolition was completed. In 2007, final demolition of the building was put on hold by the DOE pending completion of the EIS. The Final EIS was issued in November 2018 but no demolition work was performed in 2018.

Figure 2-4. Map of Prior and Current Radiological Facilities in Area IV

Building 4059

Building 4059 is the former SNAP reactor ground test facility. Demolition of the building was completed in 2004, and radioactively contaminated building debris was shipped to the Nevada Test Site. In October 2004, Oak Ridge Institute for Science and Education (ORISE) conducted an independent verification survey and found that only H-3 and nickel-63 (Ni-63) were present above background, with concentrations significantly below 2004 acceptable limits of 31,900 picocuries per gram (pCi/g) and 55,300 pCi/g, respectively. Two other verification surveys were completed; the first by the California Department of Health Services in October 2006, and the second by ORISE in February 2008. The ORISE survey encompassed the previous building footprint area and confirmed that 2008 release limits of 4.7 pCi/g for Cs-137 and 2.8 pCi/g for Eu-152 had been satisfied. As such, the site could be released for unrestricted use.

2.3.2 Former Sodium Facilities

Sodium Pump Test Facility / Component Handling & Cleaning Facility (SPTF/CHCF)

All utility connections to the SPTF/CHCF buildings were severed in 2007. Demolition of Building 4461 was completed in early 2007. In May 2007, DOE halted demolition, and the remaining buildings (4462 and 4463) were placed into a safe shutdown condition.

Hazardous Waste Management Facility (HWMF)

The HWMF, a DTSC Resource Conservation and Recovery Act (RCRA)-permitted facility consisting of buildings 4133 and 4029, was approved for closure and demolition by the DTSC in 2006. In May 2007, DOE halted plans for demolition pending completion of the EIS. This facility is maintained in a safe shutdown mode. No demolition work was performed in 2018.

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3. COMPLIANCE SUMMARY

3.1 Compliance Status

During 2018, four regulatory agency inspections, audits, and visits were conducted in Area IV. These inspections and visits were carried out by the California DPH. In addition, DTSC was frequently on-site for meetings and to observe field activities.

A list of inspections, audits, and site visits in 2018 by the various agencies overseeing the SSFL sites is given in Table 3-1.

Table 3-1. 2018 Agency Inspections/Visits Related to DOE Operations

Date	Agency	Subject Area	Results
January 2, 2018	State of CA, DPH	Quarterly Environmental TLD Exchange	Compliant
March 28, 2018	State of CA, DPH	Quarterly Environmental TLD Exchange	Compliant
June 26, 2018	State of CA, DPH	Quarterly Environmental TLD Exchange	Compliant
October 3, 2018	State of CA, DPH	Quarterly Environmental TLD Exchange	Compliant

3.1.1 Radiological

The radiological monitoring programs at the SSFL comply with applicable federal, state, and local environmental regulations. The monitoring results indicate that the SSFL does not pose any significant radiological impact to the health and safety of the general public. All potential pathways, as illustrated in Figure 3-1, are monitored. These include air, soil, surface water, groundwater, direct radiation, transfer of property (land, structures, waste), and recycling.

3.1.1.1 Airborne Activity

For potential airborne releases from the RMHF exhaust stack, the maximum radiation exposure dose to an off-site individual is limited to 10 mrem/yr or less, as specified in 40 Code of Federal Regulations (CFR) 61, the National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H (DOE facilities). Due to the suspension of all DOE's D&D operations at SSFL, no effluents from the RMHF stack were released into the atmosphere in 2018. As a result, the potential radiation exposure dose from the airborne pathway was zero.

No soil excavation or building demolition with the potential to release airborne contaminants was conducted by DOE in Area IV in 2018. Annual NESHAP reports submitted by DOE to the EPA for 2018 and prior years are provided at:

https://www.etec.energy.gov/Environmental_and_Health/NESHAPs.php.

3.1.1.2 Groundwater

Annual Groundwater Sampling

In accordance with the Water Quality Sampling and Analysis Plan (WQSAP) (Haley and Aldrich 2010), which requires that annual groundwater sampling be performed, groundwater samples were collected from 47 monitoring wells and 11 seep wells located in the DOE portion of Area IV during the first quarter sampling event during February and March 2018.

A resampling event was conducted in August 2018 to verify one or more analytes at wells RD-33A, RD-33C, RD-59A, and RD-59C. Trespassers had tampered with wells RD-33A and RD-33C and thus the wells were resampled to assess whether the tampering had introduced contamination. Nothing anomalous was discovered, and this provides a line of evidence that tampering had not affected the groundwater or quality of Q1 samples collected from these wells. Sr-90 results from RD-59A and RD-59C from the Q1 sampling event were determined to be anomalous and false positives and, thus, the wells were resampled and the results were confirmed to be anomalous.

Data review and validation were completed for each sampling event. Q1 results were reported in the revised 2018 First Quarter Groundwater Sampling Report (North Wind 2019a) and the 2018 Report on Annual Groundwater Monitoring (North Wind 2019b).

The sampling of four clusters of groundwater seep probes was conducted in June 2018. One cluster is in the Northern Buffer Zone and the other three on Brandeis property north of SSFL Area IV. Tritium above background was observed in the Northern Buffer Zone cluster. No Area IV–related groundwater contamination was observed in the Brandeis clusters. The results are summarized in a technical memorandum (CDM Smith 2018b).

Analyses were specific for each well based on contamination history and included a variety of chemical and radiological constituents. Groundwater reports are provided online under the RCRA Facility Investigation – Groundwater tab in the SSFL Document Library at the following link:

https://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/ssfl_document_library.cfm

Former Sodium Disposal Facility (FSDF) Groundwater Interim Measure (GWIM)

In November 2017, DOE initiated a GWIM at the FSDF, which involved the periodic pumping of near-surface well RS-54, to remove contaminant mass for trichloroethylene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA) associated with near-surface bedrock fractures (about 30 feet bgs). The pumping and sampling of RS-54 continued into 2018 primarily on a monthly basis since water recovery in the well was slow. After pumping well RS-54 in June 2018, the well did not recover sufficient water for subsequent pumping. However, a corehole (C-21) drilled in June 2018 exhibited TCE concentrations greater than 1,000 micrograms per liter (µg/L), which is a requirement threshold for GWIM. Corehole C-21 was used for the subsequent groundwater extraction activity and was pumped in June, July, August, September, October, and December 2018. No pumping occurred in November due to the Woolsey Canyon wildfire.

A technical memorandum (CDM Smith 2018e) provides a summary of the history of the GWIM, groundwater contaminants treated, and volume of water extracted.

Hazardous Material Storage Area (HMSA) Well Installations

Two piezometers (PZ-162 and PZ-163) were installed into alluvium and weathered bedrock (nominally 40 feet below ground surface [bgs]), a deeper well was installed in the center of the HMSA (DD-146), and the depth of a shallow bedrock well (RD-89) was deepened (and renamed DD-147) as part of the groundwater investigation activities at the HMSA. Wells were sampled per the WQSAP following installation and development. A technical memorandum (CDM Smith 2018f) describes the installation activities.

HMSA Near-Surface Groundwater Aquifer Test

As part of the corrective measures study evaluation of the near-surface impacted groundwater at the HMSA, a short-term aquifer test was performed to provide data on the volume of impacted groundwater. Piezometer PZ-62 was used as the pumping well, and adjacent wells PZ-108, PZ-109, PZ-120, PZ-122, PZ-162, and DD-144 were used as observation wells. All wells with sufficient water were also sampled during the period of the aquifer test. A summary of the aquifer test findings is presented in a technical memorandum (CDM Smith 2018c).

FSDF Near-Surface Bedrock Fracture Source Investigation

As part of the evaluation of near-surface bedrock fractures harboring impacted groundwater (as is observed at well RS-54), eight 53- to 63-foot-deep borings were drilled into bedrock. During drilling, bedrock core samples were extracted for observations of fractures and chemical testing for volatile organic compounds (VOCs). Following drilling, the coreholes were converted to monitoring wells. All eight coreholes (C-20, C-21, C-22, C-23, C-24, C-25, C-26, C-27) produced sufficient water for sampling. Corehole C-21 exhibited the highest VOC concentrations and thus was used for the continuation of the FSDF GWIM. A technical memorandum (CDM Smith 2018d) provides the rock core VOC results.

3.1.1.3 Surface Water

Surface water is regulated under the Los Angeles Regional Water Quality Control Board (LARWQCB) National Pollutant Discharge Elimination System (NPDES). The existing NPDES Permit (CA0001309) for SSFL is held by Boeing and requires monitoring of storm water runoff, treated groundwater and fire suppression water into Bell Creek, a tributary to the Los Angeles River. The permit also regulates the discharge of storm water runoff from Area IV northwest slope locations into the Arroyo Simi, a tributary of Calleguas Creek. Storm water is collected at the five northwest outfalls (RMHF: Outfall 003; Sodium Reactor Experiment (SRE): Outfall 004; FSDF #1: Outfall 005; FSDF #2: Outfall 006; and Bldg. 4100: Outfall 007), pumped to a centralized storage and treatment center at Silvernale Pond in Area III, and subsequently discharges into Bell Creek. The permit applies the numerical limits for radioactivity established for drinking water suppliers to these discharges. The permit requires radiological measurements of gross alpha, gross beta, H-3, Sr-90, total combined radium-226 (Ra-226) and radium-228 (Ra-228), potassium-40 (K-40), C-137, and uranium isotopes. Detailed monitoring results are provided in the quarterly and annual NPDES discharge monitoring reports (DMR), which may be viewed under the LARWQCB tab in the SSFL Document library at the following link:

https://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/ssfl_document_library.cfm

3.1.1.4 Direct Radiation

The northern property boundary, the closest property boundary to the RMHF, is approximately 300 meters from the RMHF and separated by a sandstone ridge, effectively shielding the boundary from any direct radiation from the RMHF. Dosimeters placed on the RMHF side of this sandstone ridge, approximately 150 meters from the RMHF, were no different than natural background.

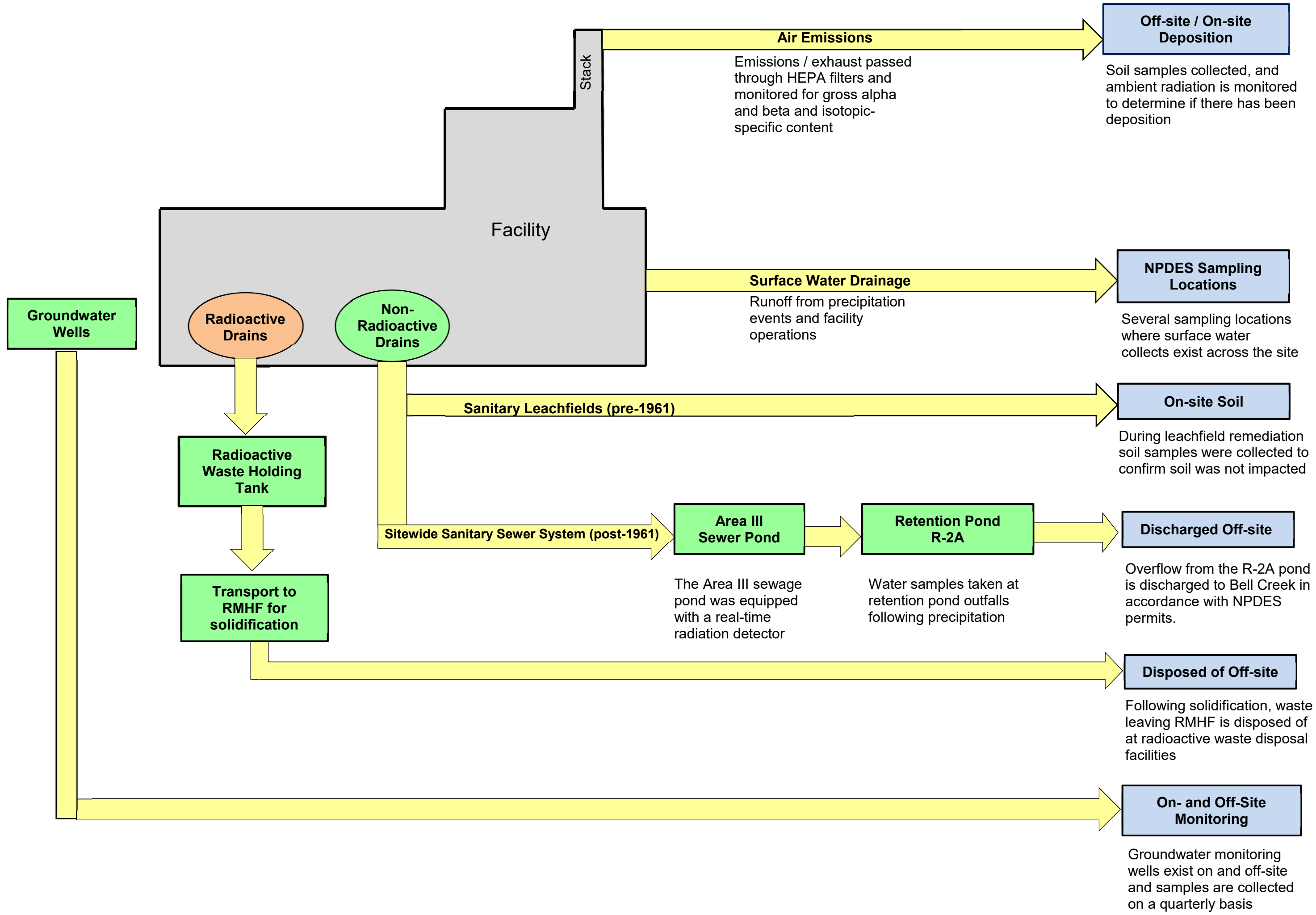

Figure 3-1. Conceptual Model of Potential Pathways

3.1.1.5 Protection of Biota

There is no aquatic system in Area IV of SSFL. Storm water discharge from the site is monitored in accordance with the Boeing NPDES permit (see Section 3.1.1.3).

Terrestrial biota, i.e., vegetation and small wild animals, are abundant at SSFL. They are subject to potential exposure to the radioactivity in soil. Screening analysis indicates that the potential radiation exposure is less than the dose limit recommended by the DOE. Section 5.4 provides detailed information on biota protection.

3.1.2 Chemical

3.1.2.1 Resource Conservation and Recovery Act

RCRA allows the EPA broad authority to regulate the handling, treatment, storage, and disposal of hazardous wastes. This authority has been delegated to the California EPA and DTSC. DOE owns and co-operated two RCRA-permitted treatment and storage facilities within ETEC: the RMHF and the HWMF. There are no active operations ongoing at either facility. Permit numbers are listed in Section 3.1.4.

Radioactive Materials Handling Facility (RMHF) – In 2018, the RMHF continued to be permitted as an Interim Status (Part A) facility. This facility was previously used primarily for the handling and packaging of low-level radioactive and mixed wastes. Interim status is required for the storage and treatment of the small quantities of mixed waste (waste containing both hazardous and radioactive constituents) resulting from D&D activities at ETEC. The final disposition of mixed waste is addressed under the DOE and DTSC approved Site Treatment Plan (STP), which is authorized by the Federal Facilities Compliance Act (FFCA). Currently there is no mixed waste at RMHF. The RMHF has been in a safe shutdown mode since May 2007 and is inactive, pending closure plan approval.

Hazardous Waste Management Facility (HWMF) – The HWMF includes an inactive storage facility (4029) and an inactive treatment facility (4133) that was utilized for reactive metal waste such as sodium. The HWMF is no longer in operation and is awaiting final closure.

RCRA Facility Investigation (RFI) – Under the Hazardous and Solid Waste Amendments of 1984, RCRA facilities can be brought into the corrective action process when an agency is considering any RCRA permit action for the facility. The SSFL was initially made subject to the corrective action process in 1989 by EPA, Region IX. The EPA has completed the Preliminary Assessment Report and the Visual Site Inspection portions of the RCRA Facility Assessment process. ETEC is now within the RCRA Facility Investigation (RFI) stage of the RCRA corrective action process under DTSC oversight for investigation of groundwater.

Administrative Order on Consent (AOC) – In December 2010, DOE and DTSC signed an Administrative Order on Consent (AOC), which outlines a specific soil investigation and remediation program for all of Area IV. Groundwater investigation and remediation is still being conducted under RCRA corrective action requirements specified in the 2007 Consent Order among DTSC, DOE, NASA, and Boeing. Samples collected and analyses performed to date at DOE locations are summarized in Section 7.

Groundwater – Characterization of the groundwater at the site continues (CDM Smith 2018a). The Groundwater RFI Report identified five distinct areas of TCE impacted groundwater in Area IV. From the groundwater samples collected in 2018, concentrations of TCE exceeding maximum contaminant levels (MCLs) were present in all five areas. Detailed analytical results are discussed in Section 7, and the Time Series Plots of Analytical Data are included in Appendix A.

3.1.2.2 Federal Facilities Compliance Act

In 2018, there were no mixed wastes in the inventory; and as such, there were no additions or removals. Historically, any mixed wastes were managed in accordance with the FFCA-mandated STP, approved in October 1995. All mixed wastes that required extended on-site storage were managed within the framework of the STP. Characterization, treatment, and disposal plans for each different waste stream are defined in the STP with enforceable milestones. Previous management of the mixed waste has been in full compliance with the STP.

3.1.3 National Environmental Policy Act

The National Environmental Policy Act (NEPA) establishes a national policy to ensure that consideration is given to environmental factors in federal planning and decision-making. For those projects or actions with a potential to affect human health or the environment, DOE requires that appropriate NEPA actions (e.g., Categorical Exclusion, Environmental Assessment [EA], Finding of No Significant Impact [FONSI], or Notice of Intent [NOI], draft EIS, final EIS, and/or Record of Decision), have been incorporated into project planning documents.

The DOE issued a FONSI and the final EA report on March 31, 2003. Subsequently, the Natural Resources Defense Council, City of Los Angeles, and the Committee to Bridge the Gap filed a lawsuit in federal court, claiming DOE had violated NEPA, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Endangered Species Act. Pursuant to a court order, the DOE released the *Draft EIS for Remediation of Area IV and the Northern Buffer Zone (NBZ) of the SSFL* on January 6, 2017, with EPA publishing a Notice of Availability (NOA) in the Federal Register (FR) on January 13, 2017, opening the 60-day public comment period. A subsequent notice was issued on March 17, 2017, extending the comment period for an additional 30 days. The DOE considered all comments received in the preparation of the final EIS document, with the NOA for the *Final EIS for the Remediation of Area IV and the Northern Buffer Zone of the SSFL* published in the FR on December 28, 2018:

http://www.ssflareaiveis.com/

The Final EIS analyzes the potential environmental and community impacts of remediation alternatives for soil, buildings, and groundwater associated with Area IV and the Northern Buffer Zone and presents the preferred remediation alternatives which are consistent with the site's end use as open space and are protective of human health and the environment. Based on the analysis presented in this Final EIS, the DOE will prepare one or more Records of Decision detailing the path forward for achieving remediation objectives established for environmental media and building structures in these areas.

3.1.3.1 Clean Air Act

The 1970 Clean Air Act (CAA, amended 1977 and 1990) authorized the U.S. EPA to establish National Ambient Air Quality Standards (NAAQS) to limit the concentrations of pollutants in ambient (i.e., outdoor) air. The EPA has promulgated NAAQS for six "criteria" pollutants: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), 10-micron and 2.5-micron particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb). All areas of the United States must maintain ambient levels of these pollutants below the ceilings established by the NAAQS; any area that does not meet the standards is considered a NAAQS "nonattainment" area. Under the CAA, states are required to develop State Implementation Plans (SIPs) that define how each state will carry out its responsibilities under the CAA, mainly through promulgation and enforcement of air pollution control rules and regulations. However, the EPA must approve each SIP, and it can enforce the CAA itself under a Federal Implementation Plan if it deems a state's SIP unacceptable and the state or region is unwilling or unable to develop an acceptable SIP. Other requirements, including NESHAP, New Source Performance Standards (NSPS), and ambient air monitoring programs, were established to ensure that ambient air quality is acceptable for public health and environmental protection.

Area IV is regulated by the Ventura County Air Pollution District (VCAPCD) and must comply with all applicable rules, regulations, and permit conditions. DOE previously operated under Permit to Operate No. 00271. In 2008, this permit was consolidated with the existing Federally Enforceable State Operating Permit (FESOP) No. 00232 for SSFL, which presently covers Areas I, III, and IV. The NASA property – Area II and the former Liquid Oxygen Plant (LOX) Plant site located in Area I – was removed from the permit in January 2014. On December 15, 2014, VCAPCD issued administrative changes to the permit, relieving Boeing from responsibility for Area IV, except for activities and contractor's under Boeing's direct control. DOE activities currently being performed in Area IV are not subject to air permitting.

3.1.3.2 Clean Water Act

The Clean Water Act is the primary authority for water pollution control programs, including the NPDES permit program. The NPDES program regulates point source discharges of surface water and the discharge of storm water runoff associated with industrial activities.

Surface water discharges from SSFL are regulated under the California Water Code (Division 7) as administered by the LARWQCB. The existing Boeing NPDES Permit (CA0001309) for SSFL, which was renewed and became effective April 1, 2015, includes the requirements for a site-wide Storm Water Pollution Prevention Plan. The Storm Water Pollution Prevention Plan is revised as needed and includes by reference many existing pollution prevention plans, policies, and procedures implemented at the SSFL site.

The Spill Prevention, Control and Countermeasure (SPCC) plan serves to identify specific procedures for handling oil and hazardous substances to prevent uncontrolled discharge into or upon the navigable waters of the State of California or the United States. The U.S. EPA requires the preparation of an SPCC plan by those facilities that, because of their locations, could reasonably be expected to discharge oil in harmful quantities into or upon navigable waters. The SSFL Facility Spill Prevention and Response Plan, which serves as the site SPCC plan, was submitted by Boeing in January 2015 as a part of the 2014 Hazardous Materials Release Response Business Plan to the County of Ventura Environmental Health Division.

3.1.4 Permits and Licenses (Area IV)

Table 3-2 lists the permits applicable to activities in Area IV.

Table 3-2. SSFL Permits

Permit/License	Facility	Valid
Air (VCAPCD/FESOP)		
Permit 00232	Combined permit renewed	Current
Treatment Storage (EPA)		
CAD000629972 (93-3-TS-002)	HWMF (Bldg. 4133 and Bldg. 4029)	Inactive. The closure plan was approved on 12/22/06, but demolition has been suspended by DOE pending completion of the EIS (Draft EIS was released by DOE in January 2017 [DOE 2017]). The Final EIS was released in November 2018, no demolition work was performed in 2018 (DOE 2018). A permit Modification was approved by DTSC on January 22, 2015 to change the owner/operator from Boeing to DOE/North Wind, Inc.
CA3890090001	RMHF	Draft closure plan submitted in 2007. A permit Modification was approved by DTSC on January 22, 2015, to change the owner/operator from Boeing to DOE/North Wind, Inc.
NPDES (LARWQCB)		
CA0001309	SSFL	Current
State of California		
SWPPP 56C312650	Area IV	Current

3.2 Current Issues and Actions

3.2.1 Area IV Environmental Impact Statement

Pursuant to a federal court order issued in May 2007, the DOE submitted a Draft EIS for Area IV, and the Final EIS was approved in November 2018:

http://www.ssflareaiveis.com/

Activities conducted in support of this EIS are described below.

- DOE, in partnership with the state of California, completed the remaining “go-back” phase, including stepping down and any remaining data gap sampling as identified as Phase 3 in the 2010 AOC.
- DOE conducted extensive analysis of previous groundwater sampling conducted and developed groundwater sampling plans to complete groundwater characterization to understand the nature and extent of groundwater contamination.
- As both the groundwater and soil characterizations were nearing an end, DOE began to focus more completely on the EIS. In February 2014, DOE issued an Amended NOI to prepare the EIS.
- DOE conducted monthly community site visits and bi-monthly community meetings in conjunction with DTSC. The tours included inspection of ongoing field activities and areas of interest to stakeholders involved in the site investigation. Stakeholders also provided input to planning for collocated soil sampling described above.

3.2.2 Radiological D&D

Since May 24, 2007, the D&D of the remaining DOE facilities in Area IV is on hold following the federal court order to conduct an EIS.

3.2.2.1 Radioactive Materials Handling Facility

During 2018, the RMHF remained in a safe shutdown mode with operations limited to routine inspections and surveys.

The status of the D&D at the RMHF may be found at:

http://www.etec.energy.gov/Operations/Support_Ops/RMHF.php

http://www.etec.energy.gov/Library/RMHFDocRecord.php

3.2.2.2 SNAP Environmental Test Facility

During 2018, the SNAP Environmental Test Facility (Building 4024) remained in a safe shutdown mode with operations limited to routine inspections and surveys.

The status of the D&D of the Building 4024 may be found at:

http://www.etec.energy.gov/Operations/Major_Operations/SNAP.php

http://www.etec.energy.gov/Library/Building24DocRecord.php

Groundwater that infiltrates into the cells and french drain of Building 4024 has historically been pumped into Baker tanks and sampled for radionuclides, and periodically for chemicals, prior to being shipped off-site as non-hazardous waste water. During 2018, approximately 14,800 gallons of water were pumped out of the Building 4024 sump into Baker tanks and shipped to the Cosby and Overton, Inc., waste water treatment facility in Long Beach, CA.

3.2.3 Disposal of Non-Radiological Waste and License-exempt Radioactive Material

Table 3-3. Non-Radiological Wastes Disposal

Type of Waste	Quantity	Hauler	Disposal Facility
Non-hazardous Bldg 4024 water	14,800 gallons	American Integrated Services Phone: (805) 639-0884	Crosby and Overton. Inc. 1610 W. 17th Street Long beach CA 90813 Facility Phone (562) 432-5445
Non-hazardous purge water from groundwater monitoring wells	11,365 gallons	American Integrated Services Phone: (805) 639-0885	Crosby and Overton. Inc. 1610 W. 17th Street Long beach CA 90813 Facility Phone (562) 432-5446
Universal Waste (aerosol paints, oil based paint)	0.5 gallon of Fogpruf; 29 cans of enamel spray paint; 0.5 liter of White Mineral oil	Clean Harbors Phone: (870) 863-7173	Clean Harbors El Dorado LLC 309 American Circle El Dorado, AR 71730 Facility Phone (870) 863-7173
Universal Waste (dioctyl sebacate liquid)	25 gallons	Clean Harbors Phone: (435) 884-8100	Clean Harbors Aragonite LLC 11600 North Aptus Road Grantsville UT 84029 Facility Phone (435) 884-8100
Non-hazardous Waste Soil	54 pounds	American Integrated Services Phone: (805) 639-0884	Crosby and Overton. Inc. 1610 W. 17th Street Long beach CA 90813 Facility Phone (562) 432-5445

3.2.4 Administrative Order of Consent

In December 2010, the DTSC and DOE signed an AOC for Remedial Action that defines the process for characterization of the soil and the cleanup end-state for Area IV of the SSFL, including regional "background" for chemicals that currently have a background value, and method reporting limits (MRLs) for those chemicals that have no background value. Background values and MRLs have been incorporated into a Look-up Table (LUT), per the AOC, by DTSC. The LUT provides the cleanup standards, per the AOC for Area IV.

In November 2012, EPA made recommendations to DTSC regarding how the AOC LUT values for radionuclides should be calculated based on background soil data (EPA 2012). Subsequently, in January 2013, DTSC issued draft provisional LUTs for 16 radionuclides (DTSC 2013a). In May 2013, the DTSC issued a "Chemical LUT Technical Memorandum" for more than 130 chemicals (DTSC 2013b).

3.2.5 DOE "CleanUpdate"

DOE provides "CleanUpdate" newsletters to update stakeholders on its activities on the ETEC Closure Project. The newsletters may be found at:

https://www.etec.energy.gov/Community_Involvement/Newsletters.php

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4. ENVIRONMENTAL MANAGEMENT SYSTEM

At SSFL, the ETEC Site Closure Program Office has programmatic responsibility for the former radiological facilities, former sodium test facilities, and related cleanup operations, including environmental restoration and waste management. Past environmental restoration activities have included D&D of radioactively contaminated facilities, building demolition, treatment of sodium, assessment and remediation of soil and groundwater, surveillance and maintenance of work areas, and environmental monitoring. Waste management activities include waste characterization and certification, storage, treatment, and off-site disposal. Waste management activities in the past were performed at the RMHF for radioactive and mixed waste. The HWMF was used to handle alkali metal waste, but it is now inactive and awaiting closure.

4.1 Environmental Monitoring Program

The purpose of the environmental monitoring program is to detect and measure the presence of hazardous and radioactive materials; maintain compliance with federal, state, and local laws and regulations; and identify other undesirable impacts on the environment. It includes remediation efforts to correct or improve contaminated conditions at the site and prevent off-site impact. For this purpose, the environment is sampled and monitored, and effluents are analyzed. A goal of this program is to demonstrate compliance with applicable regulations and protection of human health and the environment. Environmental restoration activities at the SSFL include a thorough review of past programs and historical practices to identify, characterize, and correct all areas of potential concern. The key requirements governing the monitoring program are DOE Order 231.1B (DOE 2011a) and DOE Order 458.1 (DOE 2013). Additional guidance is drawn from California regulations and licenses, and appropriate standards.

The basic policy for control of radiological and chemical materials requires that adequate containment of such materials be provided through engineering controls, that facility effluent releases be controlled to federal and state standards, and that external radiation levels be reduced to as low as reasonably achievable through rigid operational controls. The environmental monitoring program provides a measure of the effectiveness of these operational procedures and of the engineering safeguards incorporated into facility designs.

4.1.1 Historical Radiological Monitoring

Monitoring the environment for potential impact from past nuclear operations has been a primary focus of DOE since the inception of operations in the mid-1950s.

In the mid-1950s, the Atomic Energy Commission, in concert with its contractor, Atomics International, then a Division of North American Aviation, began initial plans for nuclear research at its facilities in the west San Fernando Valley. In 1955, prior to initial operations, a comprehensive monitoring program was initiated to sample and monitor environmental levels of radioactivity in and around its facilities.

During the 60-year history of nuclear research and later environmental restoration, on-site and off-site environmental monitoring and media sampling has been extensive. In the early years, soil/vegetation sampling was conducted monthly. Sampling locations extended to the Moorpark freeway to the west, to the Ronald Reagan freeway to the north, to Reseda Avenue to the east, and to the Ventura freeway to the south. Samples were also taken around the Canoga and De Soto facilities as well as around the Chatsworth Reservoir. This extensive off-site sampling program was terminated in 1989 when all nuclear research and operations (except remediation) came to an end.

During the 1990s, extensive media sampling programs were conducted in the surrounding areas, including the Brandeis-Bardin Institute (now known as the American Jewish University) and the Santa Monica Mountains Conservancy to the north, Bell Canyon to the south, the Rocketdyne Recreation Center in West Hills to the east, and various private homes in Chatsworth and West Hills. Samples were also taken from such distant areas as Wildwood Park and Tapia Park. In addition, monitoring of off-site radiation, groundwater, and storm water runoff from the site was routinely performed during this time.

Ongoing radiological environmental sampling and monitoring ensures that DOE operations at the SSFL, including cleanup, do not adversely affect either on-site personnel or the surrounding community.

Additional details about on-site and off-site monitoring are available at:

http://www.etec.energy.gov/Environmental_and_Health/Enviro_Monitoring.php

From 2009 through 2012, EPA conducted extensive radiological sampling in off-site locations (Background Study) and on-site locations (Area IV Radiological Study). Results are available at:

http://www.etec.energy.gov/Char_Cleanup/EPA_Soil_Char.php

4.1.2 Non-radiological Monitoring

Extensive monitoring programs for chemical contaminants in soils, surface water, and groundwater are in effect to assure that the existing environmental conditions and restoration activities do not pose a threat to human health or the environment. Extensive soil sampling has been performed under the RFI and other site-specific remedial programs.

Groundwater beneath Area IV is extensively monitored for chemical groundwater conditions. Groundwater sampling and analysis is conducted using a DTSC-approved sampling and analysis plan and EPA-approved analytical methods and laboratories.

Surface storm water is contained, treated, and monitored, in compliance with Boeing's NPDES permit, which was most recently revised in April 2015. All sources of air emissions were monitored as required by the VCAPCD.

4.2 Integrated Safety Management System

The "ETEC Closure Contract, ISMS Description" details how the Integrated Safety Management System (ISMS) guiding principles and the core functions are met by utilizing North Wind guides and Santa Susana site procedures contained in ETEC Closure Program documents. General

ISMS guidelines are tailored specifically for ETEC closure work. The tailored ISMS integrates safety, health, and environmental protection into management and work practices at all levels so that the ETEC Closure Contract work is accomplished while protecting the worker, the public, and the environment. The Annual ISMS Declaration reviews performance, accomplishments, and improvements to the site ISMS. The 2017 Annual ISMS Report was submitted in January 2018, and the 2018 revision is pending DOE approval.

The site ISMS self-assessment plan incorporates quarterly program assessments, site audits, and the review and distribution of DOE Lessons Learned, Occurrence Reports, and Operating Experience Reports. All safety observations noted during quarterly program assessments during this term were addressed in a timely fashion.

To ensure that the ISMS continues to reflect current policies, procedures, processes, and business organization within the context of the ISMS principles, related program documents continue to be regularly reviewed and updated. No program updates were required during 2018 and no program changes to North Wind's approved ISMS are anticipated for 2019.

4.3 Environmental Training

North Wind conducts training and development programs as an investment in human resources to meet both organizational and individual goals. These programs are designed to improve employee performance, ensure employee proficiency, prevent obsolescence in employee capability, and prepare employees for changing technology requirements and possible advancement.

The North Wind Environmental Safety, Health and Quality (ESH&Q) organization is responsible for the development and administration of formal training and development programs. The Program Manager is responsible for individual employee development through formal training, work assignments, coaching, counseling, and performance evaluation. Managers and employees are jointly responsible for defining and implementing individual training development goals and plans, including on-the-job training.

The ESH&Q organization currently maintains a list of 110 courses for North Wind Santa Susana personnel and contractors. Classes are available as both computer-based training and instructor-led training. Training is available through North Wind's ETEC Training Management website. Specialized training programs on new technological developments and changes in regulations are provided, as needed, to ensure effective environmental protection and worker health and safety. Additional off-site courses are also encouraged.

4.4 Waste Minimization and Pollution Prevention

4.4.1 Program Planning and Development

A Waste Minimization and Pollution Prevention Awareness Plan is in place and serves as a guidance document for all waste generators at ETEC. The plan emphasizes management's proactive policy of waste minimization and pollution prevention, and also outlines goals, processes, and waste minimization techniques to be considered for all waste streams generated at ETEC. The plan requires that waste minimization opportunities for all major restoration projects be identified and that all cost-effective waste reduction options be implemented.

The majority of wastes currently generated at ETEC result from environmental characterization. The typical wastes generated at ETEC during 2018 were:

- Investigation-derived waste (IDW)
- Groundwater and soil sampling disposable equipment, personal protective equipment, rinse water, and purge water
- Well purge water, including the purge water from wells containing low levels of tritium
- Basement water pumped to frac tanks.

4.4.2 Waste Management and Pollution Prevention Activities

The following are some routine activities related to waste minimization and pollution prevention:

- Hazardous waste containers in acceptable condition are reused to the maximum extent possible.
- Empty product drums are returned to the vendor for reuse when practical.

4.4.3 Tracking and Reporting System

Various categories of materials from procurement to waste disposal are tracked. Radioactive and mixed wastes are transferred to the RMHF, logged, characterized, and stored at the RMHF. Documents that accompany the wastes are verified for accuracy and completeness and filed at the RMHF. No radioactive wastes were generated during 2018.

4.5 Public Participation

Throughout 2018, DOE interacted with community members at DTSC Community Update meetings to inform them of plans and progress. Also in 2018, DOE continued its participation in bi-weekly meetings with NASA, Boeing, DTSC, and the LARWQCB staff to coordinate public outreach efforts.

5. ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

The environmental radiological monitoring program at SSFL started before the first radiological facility was established in 1956. The program has continued with modifications to suit the changing operations. The selection of monitoring locations was based on several site-specific criteria such as topography, meteorology, hydrology, and the locations of the nuclear facilities. The prevailing wind direction for the SSFL site is generally from the northwest, with some seasonal diurnal shifting to the southeast quadrant.

Ambient air samples are measured for gross alpha and gross beta for screening purposes. These screening measurements can quickly identify an unusual release and provide long-term historical records of radioactivity in the environment. Air sampling at ETEC during 2018 was performed by North Wind. The individual air samples are screened each week for gross alpha and gross beta activity. Following screening, the air samples are saved, combined into composite samples for each sampling location, and analyzed for specific radionuclides.

Direct radiation is monitored by optically stimulated luminescence detectors (OSLDs). The OSLDs used to monitor direct radiation at ETEC were placed and analyzed by North Wind. These OSLDs are complemented by thermoluminescent dosimeters (TLDs) installed by the State of California DPH/Radiological Health Branch (RHB) for independent surveillance.

Surface water samples collected by Boeing at ETEC are analyzed for radioactivity (as well as chemical constituents) and the results compared with NPDES limits intended to protect aquatic organisms.

Groundwater was sampled by North Wind in Q1 (February/March) of 2018 in accordance with the monitoring programs in place at the site. Samples were analyzed for chemical constituents, and some were also analyzed for radioactivity. The results are compared to the screening values as listed in the various groundwater reports. The analytical data suite used for laboratory analysis is updated annually after review of the previous year’s data.

5.1 Air Effluent Monitoring

The only historical emission source from DOE facilities in Area IV is the exhaust stack at the RMHF. In May 2007, DOE suspended all D&D operations at SSFL. As a result, the entire facility was placed into a safe shutdown mode. No effluents were released to the atmosphere through the stack during 2018.

The EPA limit for emissions of radionuclides to ambient air from a DOE site was established to prevent an effective dose equivalent from exceeding 10 mrem/year, as specified in 40 CFR 61, Subpart H. The regulation also specifies that radiation exposure dose to the Maximally Exposed Individual (MEI) be calculated using the EPA’s CAP88-PC computer model (EPA 2014). Since no effluents were released to the atmosphere from the DOE facility at SSFL, the potential airborne radiation exposure dose to the MEI was zero.

5.2 Environmental Sampling

5.2.1 Ambient Air

Air particulates are collected on filters at six locations. The number of environmental stations was reduced to two locations in 2009 due to the temporary suspension of D&D operations at SSFL. These two locations (ETEC samplers) are within the confines of the ETEC site and are shown in Figure 5-1. Four more sampling stations were installed at the ETEC site perimeter (DOE samplers) and became operational in April 9, 2018. These four are shown in Figure 5-2. All six sampling locations are listed in Table 5-1.

The two ETEC samplers operate on seven-day sampling cycles. The sample volume of a typical weekly ambient air sample is approximately 50.4 m^3. The four DOE sampler filters are changed twice each week. The cycle is three days, then four days. The volume of air sampled is nominally 32 m^3 and 57 m^3 depending on whether the sample interval is three or four days.

Airborne particulate radioactivity on all six samplers is collected on glass fiber (Type A/E) filters. The samples are analyzed for gross alpha and beta radiation following a minimum 120-hour decay period to allow the decay of short-lived radon and thoron daughters.

The ETEC (weekly) ambient air samples are analyzed using a dual-phosphor solid scintillation detector. The solid scintillation detector uses separate phosphors to detect alpha particles and beta particles. This detector simultaneously counts (analyzes for) alpha and beta radiation. The sample-detector configuration provides nearly hemispherical (2π) geometry. A preset time mode of operation is used for counting all samples.

The filters from the DOE samplers were simultaneously counted for gross alpha and beta activity with a thin-window, gas-flow proportional, 2π geometry counting system continually purged with P-10 argon/methane gas over a preset time interval. This detector has a lower background than the dual-phosphor detector, allowing it to achieve a lower minimum detectable concentration (MDC) given the same sample count and background count times. This detector requires stable line electric power. It has not been used since the Woolsey Canyon Wildfire burned in November 2018 because line electric power has not been returned to ETEC. DOE sampler filters were analyzed on the dual-phosphor detector after the fire.

Counting system efficiencies are routinely checked with technetium-99 (Tc-99) and thorium-230 (Th-230) standard sources. The activities of the standard sources are traceable to the National Institute of Standards and Technology (NIST).

Filter samples for all six (ETEC and DOE) samplers are combined separately for each sampler quarterly and analyzed for radionuclide-specific radioactivity. The quarterly air sampling results for specific isotopes for the two ETEC samplers are shown in Table 5-2. The quarterly results for the four DOE samplers for specific isotopes are shown in Table 5-3.

Radionuclide-Specific Sample Results

The weighted average ambient air sampling results for specific isotopes, as shown in Tables 5-2 and 5-3, had radionuclide concentrations well below the DOE derived concentration standard (DCS) based on 100 mrem/year (DOE 2011b), and also well below the U.S. EPA NESHAP based on 10 mrem/year (EPA 2013). The variability in the measurements was primarily due to weather effects, as well as analytical and background variations. The results provided in Tables 5-2 and 5-3 were not corrected for background air concentrations.

It should be noted that these measurements determine only the long-lived particulate radioactivity in the air and, therefore, do not show radon (Rn-222) and most of its progeny. Polonium-210 is a long-lived progeny and is detected by these analyses.

Only naturally occurring radionuclides were detected, in most samples. The concentrations of naturally occurring radionuclides are typical of natural background. Plutonium-239 was detected at 0.34% of its DCS in site sampler ETEC-1 during the third quarter of 2018. Plutonium-239 was also detected in the blank sample for the third quarter. Thus, the sample result may be a false positive.

Cobalt-60 and cesium-137 were detected, both at less than 1/100th of a percent of the DCS, at sampler ETEC-2 during the first quarter. Cobalt-60 was detected at less than 1/100th of a percent of the DCS at DOE-2 during the third quarter. If these radionuclides are present, their concentrations are insignificant.

Manganese-54 was detected at less than 1/10th of a percent DCS at DOE-4 during the fourth quarter. The half-life of manganese-54 is less than one year; thus, this instance of manganese-54 is likely a laboratory false positive result because any manganese-54 at the site would have decayed and would no longer be present.

Gross Alpha and Gross Beta Results

The gross radioactivity alpha and beta guidelines for SSFL site ambient air are based on the DCS specified in DOE-STD-1196-2011 (DOE 2011b). The conservative guideline for alpha activity is 8.1×10^{-14} µCi/mL, and the guideline for beta activity is 1.0×10^{-10} µCi/mL. These values are the DCSs for plutonium-239 and strontium-90, respectively. The results for the gross alpha and gross beta analyses of the ambient air samples are given in Table 5-4. The results reported in Table 5-4 are corrected for instrument background but no corrections are made for background air concentrations. No result exceeded 10% of the most limiting DCS.

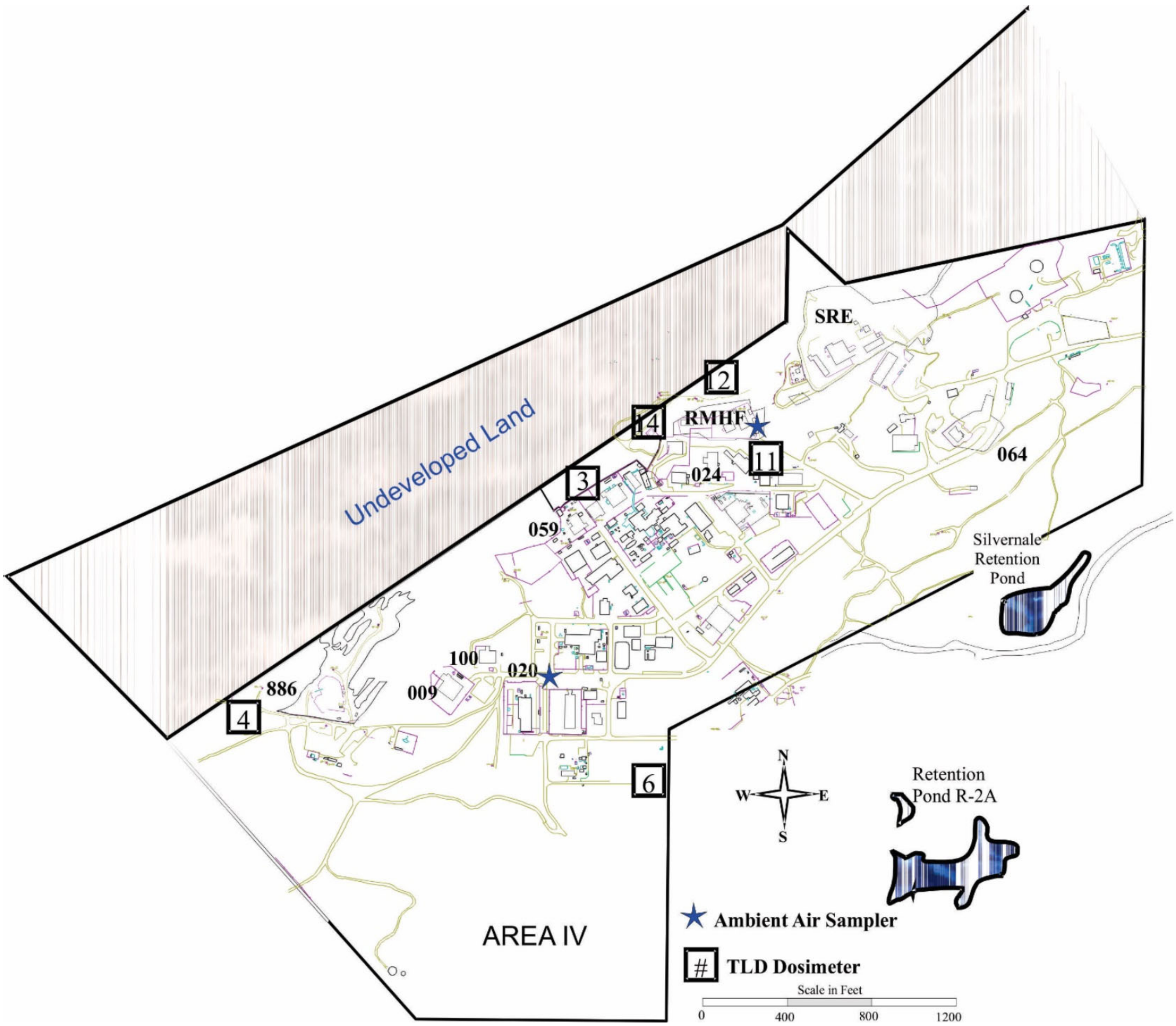

Figure 5-1. Map of Santa Susana Field Laboratory Area IV Sampling Stations

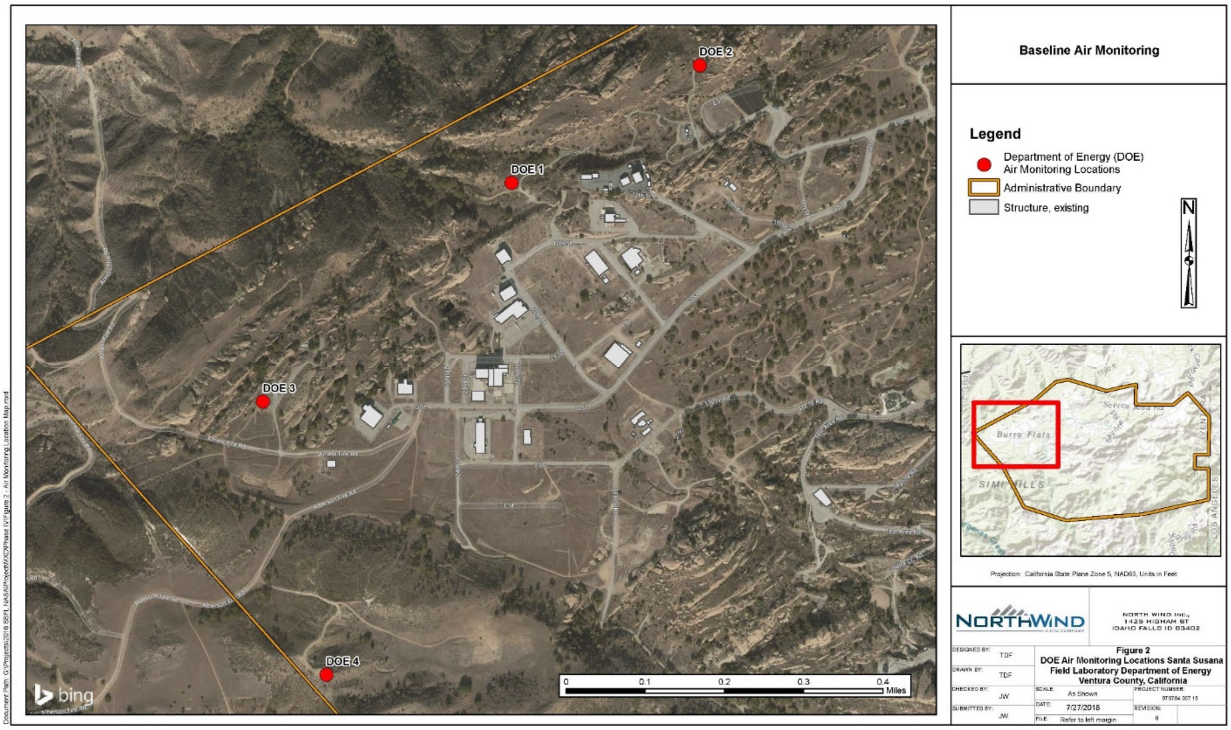

Figure 5-2. Perimeter Sampling Locations

Table 5-1. Sampling Location Description

Station	Location			Sampling Frequency
Ambient Air Sampler Locations				
ETEC-1	SSFL Site, 4020, northeast of former 4020 site			W
ETEC-2	SSFL Site, RMHF Facility, next to 4034			W
DOE-1	North perimeter near RMHF			BW
DOE-2	Northeast perimeter			BW
DOE-3	Northwest perimeter			BW
DOE-4	West-Southwest perimeter			BW
Codes		**Locations**		
ETEC	Energy Technology Engineering Center	SSFL	Santa Susana Field Laboratory	
DOE	Department of Energy	W	Weekly Sample	
BW	Twice Each Week			

Table 5-2. Ambient Air Specific Radionuclides – ETEC Samplers

ETEC-1						
Radionuclide	Derived Concentration Standard[1]	Quarter 1 (1/1/18 – 3/28/18)	Quarter 2 (3/28/18 – 6/27/18)	Quarter 3 (6/27/18 – 9/26/18)	Quarter 4 (9/26/18 – 12/31/18)	Average (% of DCS)[4]
	(µCi/mL)					
Actinium-228	2.5E-10	NE[2]	NE	ND[3]	ND	ND
Beryllium-7	9.3E-8	ND	ND	ND	ND	ND
Cesium-137	8.8E-10	ND	ND	ND	ND	ND
Cobalt-60	3.6E-10	ND	ND	ND	ND	ND
Manganese-54	1.1E-9	ND	ND	ND	ND	ND
Potassium-40	4.6E-11	ND	ND	ND	ND	ND
Polonium-210	1.1E-12	ND	5.504E-15	6.99E-15	6.29E-15	6.26E-15 (0.57%)
Thorium-228	9.4E-14	ND	ND	8.90E-16[j]	1.37E-15[j]	1.13E-15[j] (1.2%)
Thorium-230	2.8E-13	7.66E-16[j]	8.226E-16[j]	7.79E-16[j]	1.32E-15[j]	9.23E-16[j] (0.33%)
Thorium-232	1.6E-13	6.61E-16[j]	3.455E-16[j]	7.19E-16[j]	8.11E-16[j]	6.34E-16[j] (0.039%)
Uranium-234	1.1E-12	1.02E-15	ND	7.44E-16	9.59E-16	9.07E-16 (0.082%)
Uranium-235	1.2E-12	ND	ND	ND	ND	ND
Uranium-238	1.3E-12	ND	9.38E-16	6.10E-16	9.56E-16	8.35E-16 (0.064%)
Plutonium-238	8.8E-14	ND	ND	ND	ND	ND
Plutonium-239	8.1E-14	ND	ND	2.74E-16	ND	2.74E-16 (0.34%)
Americium-241	9.7E-14	ND	ND	ND	ND	ND

Strontium-90	1.0E-10	ND	ND	ND	ND	ND
Radium-228[6]	1.3E-12	NE	NE	ND	ND	ND
Plutonium-241	4.6E-12	ND	ND	ND	ND	ND
Radium-226[7]	1.1E-12	NE	NE	ND	ND	ND
ETEC-2						
Actinium-228	2.5E-10	NE	NE	ND	ND	ND
Beryllium-7	9.3E-8	ND	ND	ND	ND	ND
Cesium-137	8.8E-10	3.94E-14	ND	ND	ND	3.94E-14 (0.0045%)
Cobalt-60	3.6E-10	2.97E-14	ND	ND	ND	2.97E-14 (0.0083%)
Manganese-54	1.1E-9	ND	ND	ND	ND	ND
Potassium-40	4.6E-11	ND	ND	ND	ND	ND
Polonium-210	1.1E-12	9.20E-15	ND	4.44E-15	5.20E-15	6.28E-15 (0.57%)
Thorium-228	9.4E-14	ND	ND	1.10E-15[j]	1.07E-15[j]	1.08E-15[j] (1.1%)
Thorium-230	2.8E-13	8.05E-16[j]	ND	1.31E-15[j]	1.12E-15[j]	1.08E-15[j] (0.39%)
Thorium-232	1.6E-13	7.63E-16[j]	1.127E-15[j]	7.61E-16[j]	1.20E-15[j]	9.62E-16[j] (0.60%)
Uranium-234	1.1E-12	ND	ND	1.03E-15	1.28E-15	1.15E-15 (0.10%)
Uranium-235	1.2E-12	ND	ND	ND	ND	ND
Uranium-238	1.3E-12	1.14E-15	8.578E-16	8.09E-16	8.85E-16	9.22E-16 (0.071%)
Plutonium-238	8.8E-14	ND	ND	ND	ND	ND
Plutonium-239	8.1E-14	ND[5]	ND	ND	ND	ND
Americium-241	9.7E-14	ND	ND	ND	ND	ND
Strontium-90	1.0E-10	ND	ND	ND	ND	ND
Radium-228[6]	1.3E-12	NE	NE	ND	ND	ND
Plutonium-241	4.6E-12	ND	ND	ND	ND	ND
Radium-226[7]	1.1E-12	NE	NE	ND	ND	ND

[1] DOE-STD-1196-2011, Derived Concentration Technical Standard, April 2011.
[2] NE = Not evaluated.
[3] ND = Not detect.
[4] As a conservative measure, ND reported results are excluded from average concentration calculations.
[5] Sample considered non-detect during data validation.
[6] Ra-228 analyzed by chemical extraction and beta counting.
[7] Ra-226 analyzed by chemical extraction and alpha counting.
[j] Sample qualified as "estimated" due to potential spectral interference from Th-229 tracer.

Table 5-3. Ambient Air Specific Radionuclides – DOE Samplers

DOE-1				
Radionuclide	Quarter 1 (4/9/18 – 7/12/18)	Quarter 2 (7/12/18 – 10/11/18)	Quarter 3 (10/11/18 – 1/15/19)	Average[1] (% of DCS)
	(μCi/mL)			
Americium-241	ND[2]	ND	ND	ND
Plutonium-238	ND	ND	ND	ND
Plutonium-239/240	ND	ND	ND	ND
Polonium-210	5.39E-15	8.63E-15	9.25E-15[j]	7.76E-15[j] (0.71%)
Thorium-228	7.07E-16	3.47E-16	4.96E-16[j]	5.17E-16[j] (0.55%)
Thorium-230	1.17E-15	7.69E-16	7.53E-16[j]	8.97E-16[j] (0.32%)
Thorium-232	7.81E-16	4.65E-16	5.48E-16[j]	5.98E-16[j] (0.37%)
Uranium-233/234	9.20E-16	6.01E-16	7.57E-16	7.59E-16 (0.07%)
Uranium-235/236	ND	ND	ND	ND
Uranium-238	7.00E-16	6.66E-16	9.87E-16	7.84E-16 (0.06%)
Beryllium-7	1.10E-15	1.38E-13	1.68E-13	1.02E-13 (0.0001%)
Cesium-137	ND	ND	ND	ND
Cobalt-60	ND	ND	ND	ND
Manganese-54	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND
Strontium-90	ND	ND	ND	ND
Plutonium-241	ND	ND	ND	ND
Actinium-228	NE[3]	ND	ND	ND
Radium-226	NE	ND	7.92E-16[j]	7.92E-16[j] (0.07%)
Radium-228	NE	ND	ND	ND
DOE-2				
Radionuclide	Quarter 1 (4/9/18 – 7/12/18)	Quarter 2 (7/12/18 – 10/11/18)	Quarter 3 (10/11/18 – 1/15/19)	Average (% of DCS)
	(μCi/mL)			
Americium-241	ND	ND	ND	ND
Plutonium-238	ND	ND	ND	ND
Plutonium-239/240	ND	ND	ND	ND
Polonium-210	1.09E-14	7.98E-15	9.27E-15[j]	9.38E-15[j] (0.85%)
Thorium-228	5.32E-16	6.68E-16	4.87E-16[j]	5.62E-16[j] (0.60%)
Thorium-230	7.55E-16	8.31E-16	6.35E-16[j]	7.40E-16[j] (0.26%)
Thorium-232	4.83E-16	6.17E-16	3.96E-16[j]	4.99E-16[j] (0.31%)
Uranium-233/234	6.30E-16	9.52E-16	8.81E-16	8.21E-16 (0.07%)
Uranium-235/236	ND	ND	ND	ND
Uranium-238	6.72E-16	8.51E-16	8.00E-16	7.74E-16 (0.06%)

Beryllium-7	1.21E-15	1.03E-13	1.48E-13[j]	8.41E-14[j] (0.00009%)
Cesium-137	ND	ND	ND	ND
Cobalt-60	ND	ND	8.05E-15[j]	8.05E-15[j] (0.002%)
Manganese-54	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND
Strontium-90	ND	ND	ND	ND
Plutonium-241	ND	ND	ND	ND
Actinium-228	NE	ND	ND	ND
Radium-226	NE	ND	8.42E-16[j]	8.42E-16[j] (0.08%)
Radium-228	NE	ND	ND	ND
DOE-3				
Radionuclide	**Quarter 1 (4/9/18 – 7/12/18)**	**Quarter 2 (7/12/18 – 10/11/18)**	**Quarter 3 (10/11/18 – 1/15/19)**	**Average (% of DCS)**
	(μCi/mL)			
Americium-241	ND	ND	ND	ND
Plutonium-238	ND	ND	ND	ND
Plutonium-239/240	ND	ND	ND	ND
Polonium-210	ND	9.05E-15	8.27E-15[j]	8.66E-15[j] (0.79%)
Thorium-228	ND	4.89E-16	ND	4.89E-16 (0.52%)
Thorium-230	8.88E-16	5.85E-16	5.40E-16[j]	6.71E-16[j] (0.24%)
Thorium-232	4.74E-16	3.33E-16	4.41E-16[j]	4.16E-16[j] (0.26%)
Uranium-233/234	7.40E-16	8.45E-16	8.00E-16	7.95E-16 (0.07%)
Uranium-235/236	ND	ND	ND	ND
Uranium-238	5.78E-16	8.59E-16	8.75E-16	7.71E-16 (0.06%)
Beryllium-7	1.53E-15	ND	1.52E-13[j]	7.68E-14[j] (0.00008%)
Cesium-137	ND	ND	ND	ND
Cobalt-60	ND	ND	ND	ND
Manganese-54	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND
Strontium-90	ND	ND	ND	ND
Plutonium-241	ND	ND	ND	ND
Actinium-228	NE	ND	ND	ND
Radium-226	NE	ND	ND	ND
Radium-228	NE	ND	ND	ND
DOE-4				
Radionuclide	**Quarter 1 (4/9/18 – 7/12/18)**	**Quarter 2 (7/12/18 – 10/11/18)**	**Quarter 3 (10/11/18 – 01/07/19)**	**Average[4] (% of DCS)**
	(μCi/mL)			
Americium-241	ND	ND	ND	ND
Plutonium-238	ND	ND	ND	ND

Plutonium-239/240	ND	ND	ND	ND
Polonium-210	ND	9.20E-15	1.34E-14[j]	1.13E-14[j] (1.03%)
Thorium-228	5.80E-16	6.49E-16	ND	6.15 E-16[j] (0.65%)
Thorium-230	8.99E-16	5.33E-16	ND	7.16E-16[j] (0.26%)
Thorium-232	5.28E-16	4.12E-16	ND	4.70E-16[j] (0.29%
Uranium-233/234	9.54E-16	7.09E-16	1.30E-15	9.88E-16 (0.09%)
Uranium-235/236	ND	ND	ND	ND
Uranium-238	1.33E-15	3.64E-16	ND	8.47E-16 (0.07%)
Beryllium-7	ND	1.82E-13	ND	1.82E-13 (0.0002%)
Cesium-137	ND	ND	ND	ND
Cobalt-60	ND	ND	ND	ND
Manganese-54	ND	ND	1.18E-14[j]	1.18E-14 (0.001%)
Potassium-40	ND	ND	ND	ND
Strontium-90	ND	ND	ND	ND
Plutonium-241	ND	ND	ND	ND
Actinium-228	NE	ND	ND	ND
Radium-226	NE	ND	ND	ND
Radium-228	NE	ND	1.09E-14[j]	1.09E-14[j] (0.84%)

[1] As a conservative measure, ND reported results are excluded from average concentration calculations.
[2] ND = Non-detect.
[3] NE = Not evaluated.
[4] As a conservative measure, ND reported results are excluded from average concentration calculations.
[j] Sample qualified as "estimated" due to potential spectral interference from Th-229 tracer.

Table 5-4. Ambient Air Gross Alpha and Gross Beta – 2018

Area	Activity	Number of Weeks	Gross Radioactivity	
			Average Concentrations[a] (µCi/mL)	Average Percent of Standard[b]
ETEC-1	Alpha	50[c]	2.27E-15	2.8%
	Beta		1.34E-13	0.013%
ETEC-2	Alpha	49[c]	2.74E-15	3.4%
	Beta		8.84E-14	0.0088%
DOE-1	Alpha	38 (sampler was out of service for ½ week)	7.72E-15	9.5%
	Beta		8.69E-14	0.0087%
DOE-2	Alpha	38.5	6.60E-15	8.2%
	Beta		8.17E-14	0.0082
DOE-3	Alpha	38.5	5.80E-15	7.2%
	Beta		7.18E-14	0.0072%
DOE-4	Alpha	31 (sampler went out of service on November 12, 2018)	7.71E-15	9.5%
	Beta		5.89E-14	0.0059%

[a] Values include natural background. As a conservative measure, negative reported results are excluded from average concentration calculations.

[b] Based on the most restrictive derived concentration standard: 8.1E-14 µCi/mL alpha (Pu-239), 1.0E-10 µCi/mL beta (Sr-90), DOE-STD-1196-2011 (April 2011).

[c] Sampler did not operate the entire year due to Woolsey fire.

5.2.2 Groundwater

Wells installed in both the Chatsworth Formation and the shallow subsurface are sampled annually to monitor groundwater conditions in Area IV, in accordance with the WQSAP (Haley and Aldrich 2010). Well locations are shown in Figure 7-1. The purpose of these wells is to monitor concentrations of chemicals and/or radioactivity released by historical DOE operations. Groundwater samples are analyzed for a suite of chemical constituents, while some are selected and analyzed for radioactivity, including gross alpha, gross beta, gamma-emitter radionuclides, Ra-226, Ra-228, Sr-90, H-3, and isotopic uranium. Complete sampling schedules and analytical results are presented in the First Quarter Groundwater Report as well as the Annual Groundwater Reports, which can be found under the RCRA Facility Investigation – Groundwater tab in the SSFL Document library located at the following link:

https://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/ssfl_document_library.cfm

The 2018 Annual Groundwater Report was submitted in February 2019 (North Wind 2019b).

5.2.3 Surface Water

The most significant areas of Area IV (FSDF, RMHF, and SRE) drain to the north, while the remainder drains to the southeast. Runoff to the north is captured in five catch basins (two at the FSDF, one at Building 4100, one at the RMHF, and one at the SRE). Collected water from Area IV is pumped for treatment/filtration and sampling under the Boeing NPDES Permit. Precipitation in Area IV is collected by a series of drainage channels.

Boeing is the land owner as listed in its NPDES Permit No. CA0001309, which mandates the collection of surface water samples each year as well as the presentation of the information in DMRs for the SSFL published quarterly and annually. The DMR provides information and data, including summary tables of surface water sample analytical results, rainfall summaries, liquid waste shipment summaries, and analytical laboratory QA/QC procedures and certifications. Quarterly and Annual NPDES DMRs are found under the LARWQCB tab in the SSFL Document library located at the following link:

https://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/ssfl_document_library.cfm

5.2.4 Soil

The last radiological soil sampling in Area IV was conducted by EPA in 2012. No radiological soil sampling was conducted in Area IV on behalf of DOE during 2018.

5.2.5 Vegetation

No vegetation samples were collected or analyzed in 2018.

5.2.6 Wildlife

No animal samples were collected or analyzed during 2018.

5.2.7 Ambient Radiation

As part of the ETEC Site Closure program during 2018, North Wind deployed OSLDs that use an aluminum oxide (“sapphire”) chip. These OSLDs are capable of measuring doses in increments of 1 mrem. The control badge supplied with these dosimeters was stored in a lead container at ETEC so that any external exposure received during shipment of dosimeters to and from the analytical vendor could be properly subtracted from the measured on-site ambient radiation exposure rate.

The State DPH/RHB deploys calcium sulfate ($CaSO_4$) TLDs for independent monitoring of radiation levels at SSFL and in the surrounding area. These dosimeters are placed at specific locations by DPH/RHB. Some locations are concurrent with placement of the Site OSLDs. Additional dosimeters are also placed by the State DPH/RHB at the ETEC site. The State dosimeters are collected by the Radiologic Health Branch for evaluation each quarter.

The locations of the North Wind OSLDs and the State TLD are shown in Figure 5-3. Locations marked with an "S" have OSLDs and all other locations have TLDs. There is also an OSLD and a TLD at the SSFL front gate.

Figure 5-3. Locations of External Ambient Radiation Dosimeters

All dosimeters are exchanged quarterly. The quarterly results are summed to obtain the annual ambient gamma radiation exposure in milli-Roentgens/year (mR/y). The annual ambient exposure data obtained during 2018 from these Site OSLDs and State TLDs are shown in Table 5-5.

Location identifiers shown in bold font are most representative of ambient background conditions near the ETEC site. These dosimeters were used to calculate the annual average exposure. The monitoring results from the State TLDs are comparable to, but slightly higher than, the OSLDs deployed by North Wind. This is attributed to differences in the dosimeters themselves. Note that the offsite TLD location at Indian Falls Estates is 78 mR/y and the average of the ETEC ambient TLDs dosimeters is 76.625 mR/y as measured by the TLDs. Ambient conditions at ETEC may reasonably be considered representative of natural background.

OSLD location 12 is collocated with TLD location 008. These dosimeters measured 80 and 81 mR/y, respectively. These two locations are farthest away from the RMHF and are likely measuring natural background radioactivity from the sandstone rock formation and not the influence of elevated radiation levels within the RMHF.

Four of the TLDs were deployed near elevated radiation sources at ETEC. Three were near Building 4021 that is posted as a Contamination Area and Radiation Area. One was near an area of fixed contamination near the northwestern RMHF boundary fence. No member of the public spends any significant time, if any time at all, near these four locations. However, when natural background of 78 mR/y is subtracted from the highest measurement of 141 mR/y, this is below the DOE public dose limit of 100 mrem/y. This satisfies the requirements specified in DOE Order 458.1 (DOE 2013). These dosimeter results demonstrate that the potential external exposure at the site boundary is below the DOE's dose limit.

Table 5-5. 2018 SSFL Ambient Radiation Dosimetry Data.

Location Identifier	OSLD (mR/y)	TLD (mR/y)	Comment
SS-1/017	61	70	OSLD and TLD collocated at SSFL front gate. Away from ETEC, not included in average.
SS-3/001	56	80	OSLD and TLD collocated at electric substation boundary fence.
SS-4/002	66	76	OSLD and TLD collocated W of former sodium disposal facility.
SS-6/003	65	76	OSLD and TLD collocated NE corner Bldg 4353 former location.
006	NA	75	Near sodium disposal facility, NE site boundary at Bldg 4133.
SS-11/007	68	71	OSLD and TLD collocated BLDG 4036, east side.
SS-12/008	80	81	OSLD and TLD collocated RMHF NW property line boundary.
009	NA	95	RMHF N boundary fence, middle. Close to elevated radiation sources from Bldg 4021. Excluded from annual average.
SS-14/010	67	77	RMHF NW property line boundary.
013	NA	84	RMHF, NE fence line. Close to elevated radiation sources from Bldg 4021. Excluded from annual ambient average.
014	NA	121	RMHF, N central fence line. Close to elevated radiation sources from Bldg 4021. Excluded from annual ambient average.
015	NA	141	RMHF, NW fence line. Close to elevated radiation sources from Bldg 4021. Excluded from annual average.
016	NA	107	RMHF, Bldg 4075, N fence line. Near fixed contamination area, excluded from annual ambient average.
018	NA	77	RMHF north boundary west
Average	**67**	**76.6**	
019	NA	78	Offsite, Indian Falls Estates

*Bolded location identifiers are included in the annual averages.

5.3 Estimation of Radiation Dose

5.3.1 Individual Dose

In accordance with regulations, the total effective dose equivalent to any member of the public from all pathways (combining internal and external dose) shall not exceed 100 mrem/year (above background) for any DOE facility. The four TLDs deployed along the RMHF fence line near elevated sources of radiation at ETEC have an annual average exposure of 113 mrem/y. Even if a person spent the entire year at this fence line, the hypothetical external dose with background subtracted would be 35 mrem (113 mrem minus 78 mrem at the background location). This is less than the 100 mrem dose limit. In reality, because no member of the public spends any appreciable time near the RMHF fence line, the external dose to a member of the public is zero.

Since no effluents were released to the atmosphere through the RMHF stack and there was no decontamination and demolition work performed in 2018, the potential internal dose from airborne releases is zero mrem. For DOE operations, the air pathway standard is 10 mrem/year committed effective dose equivalent (CEDE), as established by EPA.

Public exposure to radiation and radioactivity is shown in Table 5-6. The table presents the estimated exposures in comparison to the regulatory standards. Dose values in the table represent both internal and external exposures.

5.3.2 Population Dose

Since no effluents were released to the atmosphere during 2018, the potential collective dose to the general population was zero person-rem.

Table 5-6. Public Exposure to Radiation from DOE Operations at SSFL

1. All pathways	
1. Maximum estimated external dose to an individual from direct radiation	0 mrem/yr
2. Maximum estimated internal dose to an individual	0 mrem/yr
Limit ("Radiation Protection of the Public and the Environment," DOE Order 458.1)	100 mrem/yr
2. Air pathway (reported in NESHAP report)	0 mrem/yr
Limit (40 CFR 61, Subpart H)	10 mrem/yr

5.4 Protection of Biota

DOE Order 458.1, "Radiation Protection of the Public and the Environment," requires that populations of aquatic organisms be protected using a dose limit of 1 rad/day. While there is no formal DOE dose limit for terrestrial biota, DOE strongly recommends that its site activities meet the internationally recommended dose limits for terrestrial biota, which are:

- The absorbed dose to aquatic animals will not exceed 1 rad/day (10 mGy/day) from exposure to radiation or radioactive material.

- The absorbed dose to terrestrial plants will not exceed 1 rad/day (10 mGy/day) from exposure to radiation or radioactive material.
- The absorbed dose to terrestrial animals will not exceed 0.1 rad/day (1 mGy/day) from exposure to radiation or radioactive material.

There is no aquatic system in the Area IV of SSFL. Therefore, the protection of aquatic organisms on-site is not an issue.

The terrestrial biota, i.e., vegetation and small wild animals, are abundant at SSFL. They are subject to potential exposure from radioactivity in the soil. The DOE Technical Standard, "A Graded Approach for Evaluating Doses to Aquatic and Terrestrial Biota" (DOE 2002), provides a methodology for demonstrating compliance with the requirement for protection of biota. RESRAD-BIOTA, a computer program developed by DOE, implements the graded approach for biota dose evaluation. There are three levels of dose evaluations in RESRAD-BIOTA. The first level is a conservative screening tool for compliance demonstration. Once the screening test in Level 1 is met, no further evaluation is necessary.

In the Level 1 dose evaluation, measured radionuclide concentrations in environmental media are compared with the biota concentration guides (BCGs). Each radionuclide-specific BCG represents the limiting concentration in environmental media that would not cause the biota dose limits to be exceeded.

EPA soil concentrations in Area IV, taken in 2011 and 2012, are used for the Level 1 dose evaluation. Table 5-7 summarizes the comparison results. The total BCG fraction in Area IV, as shown in Table 5-7, is less than 1, indicating that the potential exposure is less than the dose limit recommended by the DOE.

Table 5-7. Terrestrial Biota Radiation Exposure as a Fraction of Dose Limit

Isotope	Soil			
	Draft LUT (pCi/g)	BCG Limit (pCi/g)	Avg. Soil Concentration above LUT (pCi/g)	Avg. Site Isotopic Partial Fraction
Am-241	3.86E-02	3.89E+03	1.50E-05	3.966E-09
Cm-243/244	3.96E-02	4.06E+03	9.00E-06	2.223E-09
Co-60	3.63E-02	6.92E+02	4.00E-06	6.080E-09
Cs-137	2.25E-01	2.08E+01	2.11E-01	1.012E-02
Eu-152	7.39E-02	1.52E+03	3.40E-05	2.252E-08
Pu-238	2.54E-02	5.27E+03	9.00E-06	1.624E-09
Pu-239/240	2.30E-02	6.11E+03	1.65E-04	2.705E-08
Sr-90	1.17E-01	2.25E+01	4.68E-02	2.082E-03
Th-230	2.38E+00	9.98E+03	9.85E-04	9.872E-08
Th-232	3.44E+00	1.51E+03	0.00E+00	0.00E+00
Th-234	3.54E+00	2.16E+03	1.30E-03	6.026E-07
U-233/234	2.18E+00	5.13E+03	2.56E-03	4.991E-07
U-235/236	1.52E-01	2.77E+03	1.47E-04	5.322E-08
U-238	1.96E+00	1.58E+03	1.49E-03	9.445E-07
Sum of Partial Fraction				**0.012**

6. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

SSFL maintains a comprehensive environmental program to ensure compliance with all applicable regulations, to prevent adverse environmental impact, and to restore the quality of the environment from past operations.

The LARWQCB regulates discharges through Boeing's NPDES permit. Surface water runoff is collected in the water reclamation/pond system, with discharges from this system being subject to effluent limitations and monitoring requirements as specified in Boeing's NPDES permit. The significant areas of Area IV discharge storm water runoff to five northern catchment basins (Figure 6-1), where water is contained and pumped to the central treatment system at Silvernale Pond in Area III.

The VCAPCD regulates the air program, and must comply with all permit conditions contained in FESOP No. 00232, which implement applicable VCAPCD rules and regulations. In 2008, the former Permit to Operate No. 00271 for DOE was consolidated into FESOP No. 00232.

6.1 Surface Water Discharge

The LARWQCB granted Boeing a discharge permit pursuant to the NPDES and Section 402 of the Federal Water Pollution Control Act. NPDES Permit No. CA0001309 initially became effective on September 27, 1976, was most recently renewed on June 16, 2010, and became effective on July 19, 2010.

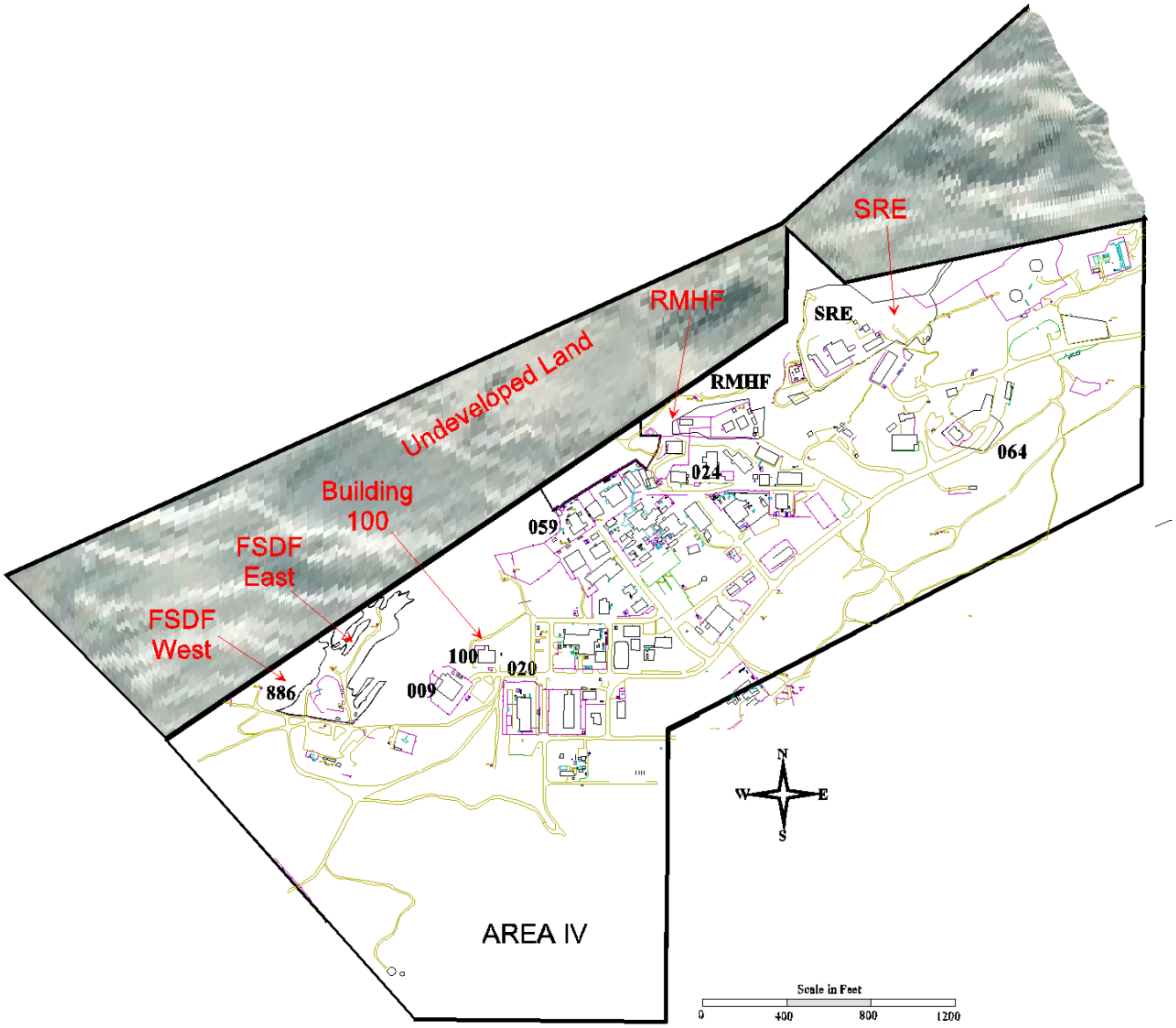

Figure 6-1. Locations of Surface Water Runoff Collectors

The NPDES permit allows the discharge of storm water runoff from retention ponds into Bell Creek, a tributary of the Los Angeles River. Storm water from the southeastern portion of Area I is permitted to discharge to Dayton Creek and from the northeastern locations of Area II into the Arroyo Simi, a tributary of Calleguas Creek. The permit also allows for the discharge of stormwater runoff from the northwest slope (Area IV) locations into the Arroyo Simi. Since 2012, storm water from the northwest slope (RMHF: Outfall 003; SRE: Outfall 004; FSDF #1: Outfall 005; FSDF #2: Outfall 006; and T100: Outfall 007) is pumped to a retention pond in Area III (Silvernale Pond). Discharge from these outfalls occurs only if the pumps fail or the systems get overwhelmed by heavy rainfall.

Of the two retention ponds (R-1 and Silvernale) at SSFL that have approved discharge points in the NPDES permit (i.e., Outfalls 011 and 018), only one, Silvernale Pond (Outfall 018), receives influent (storm water) from Area IV. When there is discharge from either the R-1 or Silvernale ponds, grab and composite samples are collected by Boeing and sent to a California State-certified testing laboratory for analysis. Analyses include chemical constituents such as heavy metals, volatile organics, base/neutral and acid extractables, general chemistry, E. coli and fecal coliform, and specified radionuclides. Toxicity testing is also conducted in the form of acute and chronic toxicity bioassays.

There is no sanitary sewer connection to a publicly owned treatment works from SSFL. Portable toilet facilities are currently in use in Area IV and have been for the prior four years.

Details on the NPDES discharge from the SSFL for the period of January 1, 2018, through December 31, 2018, are available in the 2018 quarterly DMR reports. These reports provide information and data, including summary tables of surface water sample analytical results, rainfall summaries, liquid waste shipment summaries, and analytical laboratory QA/QC procedures and certifications.

6.2 Air

The SSFL is regulated by the VCAPCD and must comply with all permit conditions contained in FESOP No. 00232, which implement applicable VCAPCD rules and regulations. In 2008, the former Permit to Operate No. 00271 for DOE was consolidated into FESOP No. 00232. No substantive changes or modifications from the previous permit were made as a result of the permit consolidation (i.e., an Administrative Change). However, as permitted equipment is removed from the site, it is removed from the permit, along with any conditions applicable to the equipment. Per FESOP monitoring, recordkeeping, reporting requirements, calculated emissions of criteria air pollutants and precursors were under the mass limits defined in the permit conditions. As a present-day remediation site, the SSFL is not a major source of air pollutants under CAA Title V (i.e., Synthetic Minor source per FESOP conditions) and is not subject to 40 CFR 63 Subpart GG – National Emission Standards for Aerospace Manufacturing and Rework Facilities.

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7. GROUNDWATER PROTECTION AND MONITORING PROGRAM

A site-wide groundwater monitoring program has been in place at the SSFL site since 1984. Area IV contains 121 shallow and deep wells and 12 seep wells. Routine chemical and radiological monitoring of the wells and seep wells is conducted according to the monitoring plan submitted to DTSC for the Site-Wide Groundwater Monitoring Program and the RFI Program.

The overall groundwater monitoring program at SSFL addresses collection and analysis of groundwater samples and measurement of the water levels. The locations of the wells and piezometers within and around DOE areas in Area IV are shown in Figure 7-1. Groundwater quality parameters and sampling frequency have been determined on the basis of historical water quality data, location of known or potential sources of groundwater contamination, operational requirements of groundwater extraction and treatment systems, and regulatory direction. Wells are gauged quarterly for groundwater levels and sampled annually. The specific analysis dictated for each well is modified annually by DOE and is determined by review of existing data and conditions. Ongoing coordination with the DOE, state and federal regulators ensures that all applicable analysis is being performed, and that the analysis for each location including emerging contaminants is carefully considered and addressed. The groundwater monitoring program for Area IV includes the analysis of following parameters, which are analyzed using the appropriate EPA methods:

- Volatile organic compounds, including 1,4-dioxane
- Metals (including sodium)
- Fluoride
- Perchlorate
- Nitrate
- Petroleum hydrocarbons
- 1,2,3-Trichloropropane (TCP)
- Radionuclides (gross alpha, gross beta, H-3, Sr-90, total combined Ra-226 and Ra-228, K-40, Cs-137, and uranium isotopes).

Groundwater reports are submitted to the regulatory agencies following each sampling event. Summaries of groundwater monitoring activities and sampling results for Area IV during 2018 are presented in Tables 7-1 and 7-2. Historical Time Series Plots are located in Appendix A.

Table 7-1. Groundwater Monitoring at Area IV in 2018

	Remediation[a]	Waste Management[b]	Environmental Surveillance	Other Drivers
Number of active wells monitored	1	NA	54	0
Number of samples taken	12	2	75	0
Number of method analyses	498	128	4,729	0
% of analyses non-detect	30	100	60	NA

[a] RS-54 extraction and sampling data provided in the Groundwater Interim Monitoring (GWIM) Technical Memorandum (CDM Smith 2018a).
[b] Water stored in Baker tank pumped from Building 4024 sump. 14,800 gallons were sampled and disposed of.

Table 7-2. Ranges of Detected Non-Radiological Analytes in 2018 Groundwater Samples

Analytes	Ranges of Results for Positive Detections
Fluoride (mg/L)	0.27J to 0.89
Metals (mg/L)	0.000033 to 210
Perchlorate (ug/L)	0.011J to 2.3J
1,1-Dichloroethane (µg/L)	0.39J to 2.3
1,1-Dichloroethene (µg/L)	0.54J to 30J
1,4-Dioxane (µg/L)	0.22J to 3.1J
Acetone (µg/L)	3.7J to 8.7J
cis-1,2-Dichloroethene (cis-1,2-DCE) (µg/L)	0.44J to 28J
trans-1,2-Dichloroethene (µg/L)	3.2 to 24
Tetrachloroethene (PCE) (µg/L)	0.25J to 72
Toluene (µg/L)	None detected
1,1,1-Trichloroethane	None detected
Trichloroethylene (TCE) (µg/L)	0.22J to 1,100
Other Volatile Organic Compounds (µg/L)	0.22J to 11
Diesel Range Organics (µg/L)	43J to 520
Gasoline Range Organics (µg/L)	10J to 57J

J = Estimated value. Analyte detected at a level less than the reporting limit and greater than or equal to the MDL.

Groundwater wells are screened in alluvium, weathered bedrock, and unweathered bedrock (Figure 7-1). For regulatory purposes, “near-surface groundwater” is defined to occur perched or vertically continuous with deeper groundwater within the site’s unconsolidated deposits (e.g., alluvium) and shallow weathered bedrock, whereas deep groundwater, referred to as “Chatsworth Formation groundwater,” occurs in unweathered bedrock. The alluvium is indicated to generally consist of unconsolidated sand, silt, and clay. Groundwater is ephemeral in some portions of the alluvium and upper weathered Chatsworth Formation. The principal water-bearing system at the Facility is the fractured Chatsworth Formation, predominantly composed of weak- to well-cemented sandstone with interbeds of siltstone and claystone. Several hydraulically significant features, such as fault zones and shale beds, are present at SSFL and may act as aquitards or otherwise influence the groundwater flow system.

Figures 7-2 and 7-3 present areas that have historically been impacted by TCE and H-3, respectively. One location between SNAP, DOE Landfill 2, and the RMHF has been impacted by tritium. During 2018, tritium was above the MCL of 20,000 picocuries per liter (pCi/L) in wells RD-90 and RD-95 at concentrations of 31,600 and 31,000 pCi/L, respectively. The concentration at RD-90 is similar to the 2017 detection and the concentration at RD-95 is an increase from 19,600 pCi/L detected during 2017. All other wells sampled during 2018 for tritium had results that were nondetect or below the MCL.

The Groundwater RFI Report (CDM Smith 2018a) identified five distinct areas in Area IV roughly defined by monitoring well locations with historical TCE results equal to or above the MCL of 5 µg/L. These areas include the Former Sodium Disposal Facility (FSDF), Building 4100/Building 56 Landfill, Metals Clarifier/DOE Leach Field 3 (DOE LF3), the HMSA, and the RMHF (Figure 7-2). The 2018 TCE results for these areas are discussed below.

FSDF Area

TCE concentrations detected above the MCL of 5 µg/L for this area in 2018 include wells:

- RD-23 at 1,100 µg/L
- C-8 at 82 µg/L
- RD-21 at 45J µg/L
- RD-65 at 10 µg/L.

The 2018 TCE concentration detected in RD-23 is a new maximum, increasing orders of magnitude from 34 µg/L detected in 2017. The 2018 detection in corehole C-8 was also a new maximum at 82 µg/L, increasing from 2.5 µg/L detected in 2017. The 2018 result at RD-21 increased from 27 µg/L in 2017. The RD-65 detection decreased from 47 µg/L detected during 2017. TCE in RD-33A remained below the MCL in 2018, 7 µg/L detected during the first quarter of 2016. Well RD-64 was dry during 2018 and had a detection of 25 µg/L during 2017.

Building 4100 / Building 56 Landfill Area

The one instance of a TCE concentration detected above the MCL of 5 µg/L for this area in 2018 was well:

- RD-07 at 32 µg/L.

The 2018 TCE concentration at RD-07 was similar in concentration to the result detected in 2017 (29 µg/L).

Metals Clarifier / DOE Leach Field 3 Area

The one instance of a TCE concentration detected above the MCL of 5 µg/L for this area in 2018 was well:

- PZ-105 at 11 µg/L.

The 2018 detection at PZ-105 was similar in concentration to the result detected in 2017 (7.9 µg/L).

HMSA Area

TCE concentrations detected above the MCL of 5 µg/L for this area in 2018 include wells:

- DD-144 at 200 µg/L
- PZ-108 at 160 µg/L
- PZ-120 at 5.6 µg/L.

The concentrations detected at DD-144 and PZ-108 are similar to those detected during 2017 (170 and 160 µg/L, respectively). The 2018 concentration at DD-144 is a new maximum. PZ-120 decreased from 13 µg/L in 2017.

Radioactive Materials Handling Facility (RMHF) Area

The one instance of a TCE concentration detected above the MCL of 5 µg/L for this area in 2018 was well:

- RD-63 at 6 µg/L.

The TCE detection in RD-63 is similar to the result detected in 2017 (6.2 µg/L).

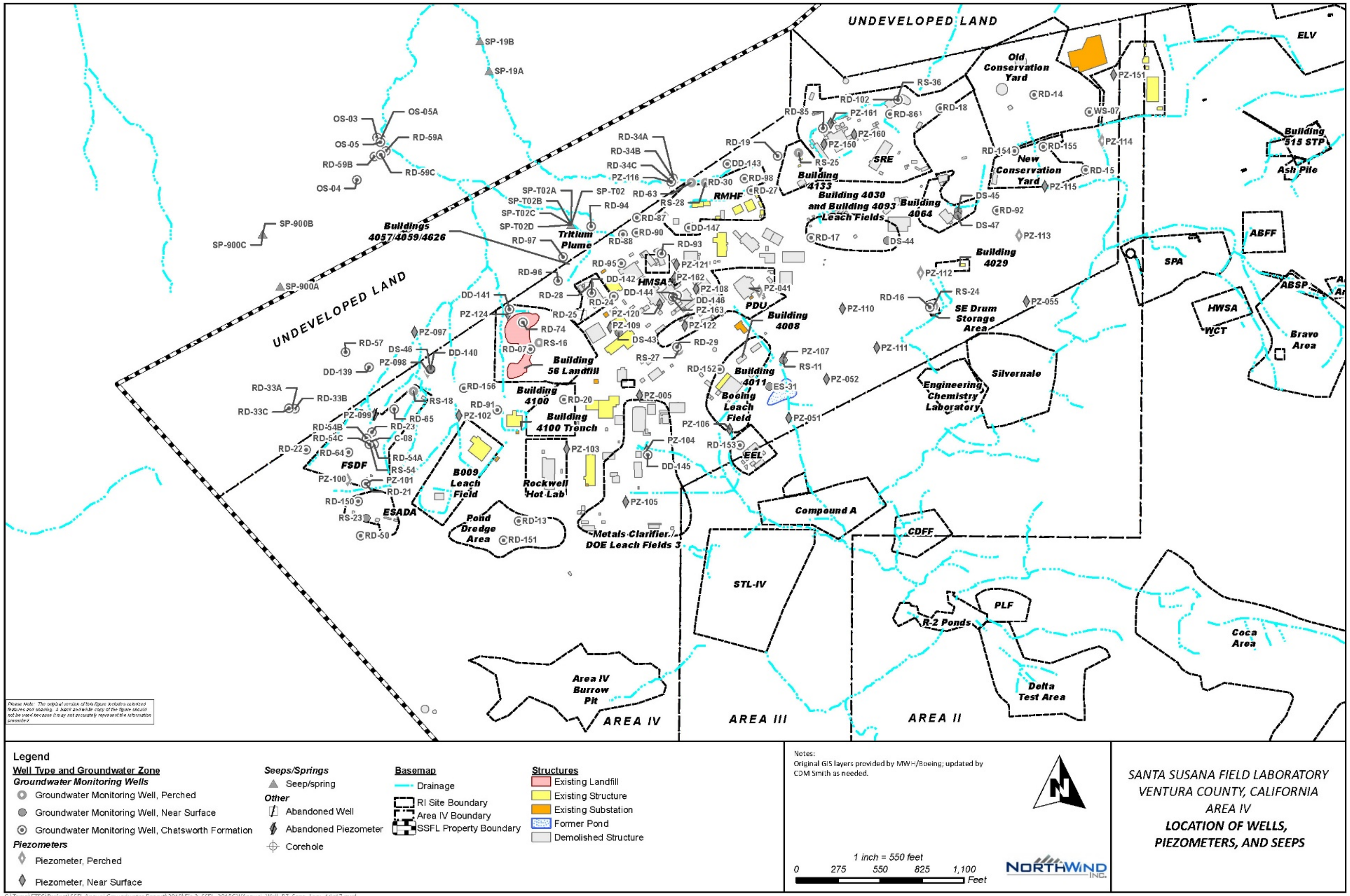

Figure 7-1. Area IV Well and Piezometer Locations

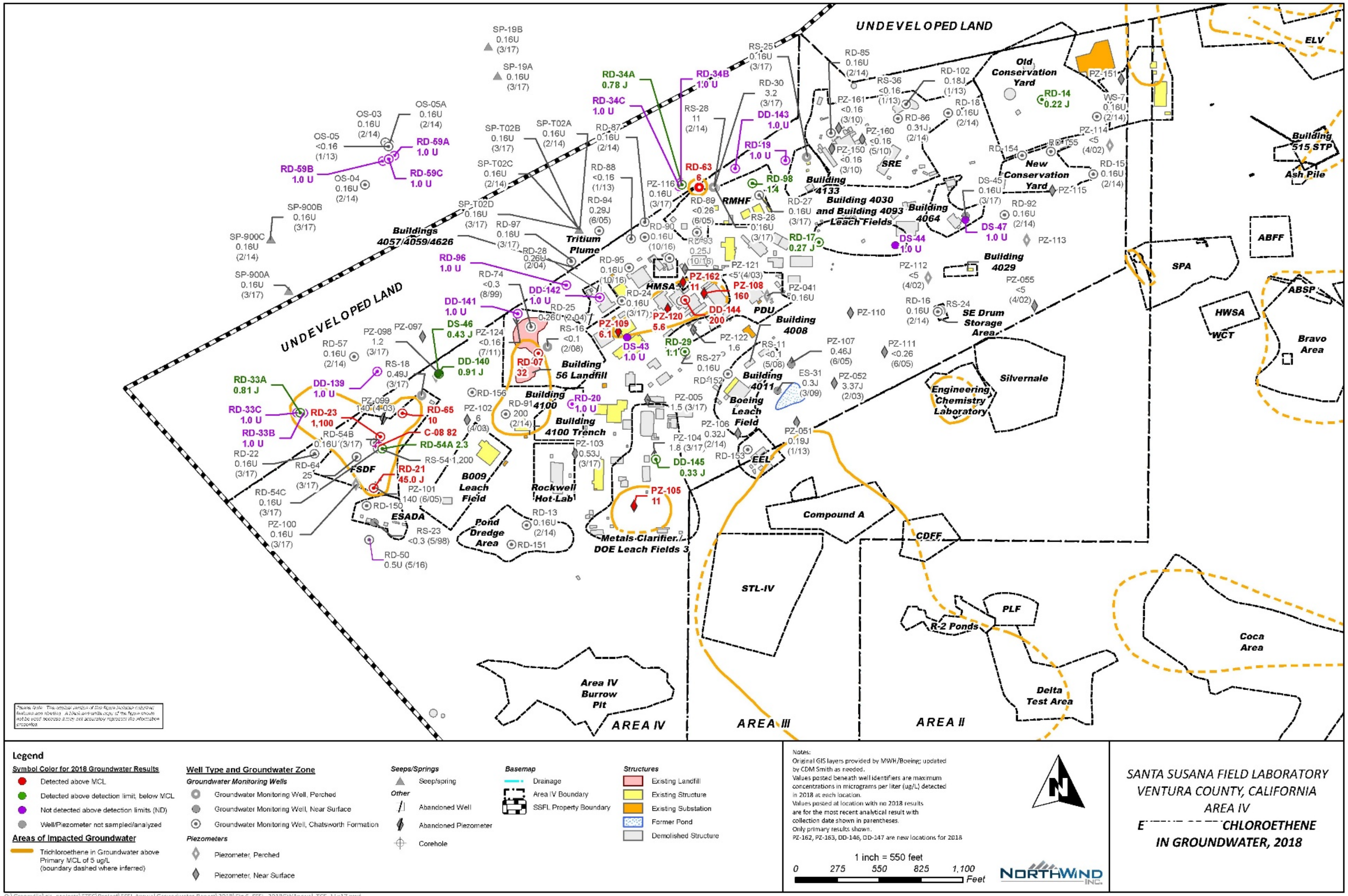

Figure 7-2. 2018 TCE Occurrences in Groundwater at SSFL, Area IV

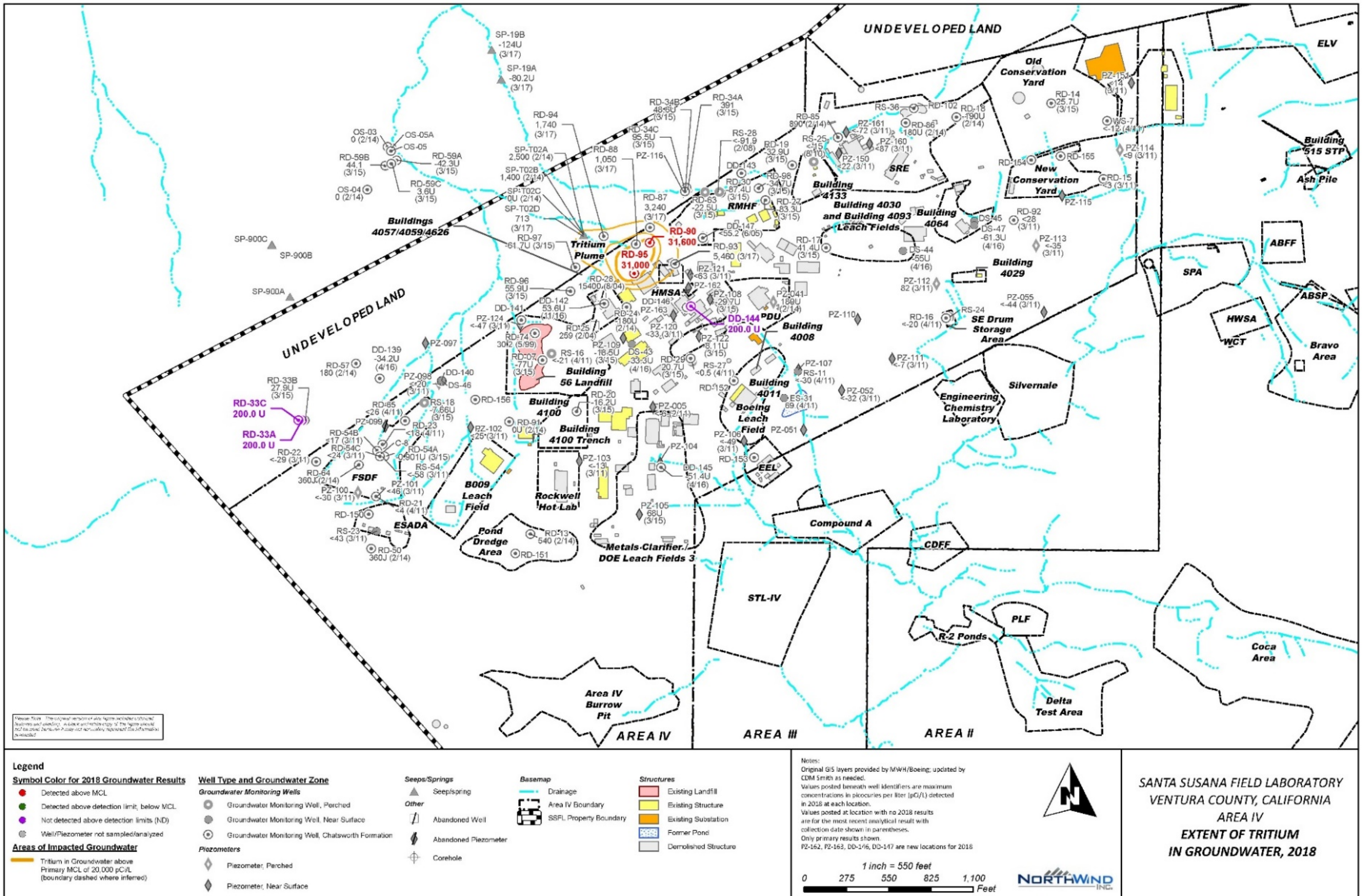

Figure 7-3. 2018 Tritium Occurrences in Groundwater at SSFL, Area IV

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8. SOIL INVESTIGATION PROGRAM

The soils investigation program started at the SSFL site in 1996 and was completed in late 2014. Future remedial action is being planned for impacted soils at the site. From 2010 to 2014, potential chemically contaminated soils in Area IV were evaluated under the DTSC/DOE AOC sampling program. The agreement between the DOE and DTSC outlines an approach to investigate and clean up soil contamination in Area IV to specified cleanup levels (LUT) under DTSC oversight, with the objectives of determining the nature and extent of chemicals in soil and assessing the potential threat to groundwater quality in Area IV, the adjacent undeveloped land in the NBZ, and in contiguous areas where soil contamination has migrated. Prior to the signing of the AOC on December 6, 2010, investigation of chemical contamination in soil was performed as part of the RFI program under DTSC oversight. Per the AOC and as described above, investigation and cleanup of groundwater are continuing under the RCRA corrective action program under DTSC oversight.

The Phase 3 Chemical Data Gap Sampling Investigation was completed in 2015; however, a VOC source investigation was conducted at the FSDF to locate the VOC source to groundwater observed in well RS-54. Twenty passive soil gas samplers were installed by CDM Smith via direct-push rig in temporary vapor wells at the alluvial soil / bedrock interface in the FSDF area to locate the VOC source of impacted groundwater observed in well RS-54. The samplers were left in place for 48 hours, retrieved, and shipped to the analytical laboratory. The results indicated that the primary bedrock VOC source is in the vicinity of well RS-54 (CDM Smith 2018c). Recent information regarding the Phase 3 Chemical Data Sampling investigation may be found at:

http://www.etec.energy.gov/char_cleanup/Phase3.php

The Draft Chemical Data Summary Report, which summarizes the data from all soil samples collected to date, was prepared in 2016 and released by DOE in January 2017 for DTSC review and approval. The Draft Chemical Data Summary Report may be found at:

http://www.etec.energy.gov/char_cleanup/Chemical_Data.php

Additionally, DOE will continue evaluation of Area IV sampling data and results of the soils treatability studies for soil cleanup remedial alternatives. DOE will continue to support soil treatability studies by university researchers and conduct Soil Treatability Investigation Group public meetings. The Draft EIS was released by DOE on January 6, 2017, and the final EIS was issued November 2018. Recent information regarding the Final EIS may be found at:

http://www.ssflareaiveis.com

Information regarding the 2010 AOC requirements and AOC soil sampling efforts may be found at:

http://www.etec.energy.gov/char_cleanup/AOC.php

http://www.etec.energy.gov/char_cleanup/Co-located.php

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9. QUALITY ASSURANCE PROGRAM

Quality assurance (QA) and quality control (QC) practices encompass all aspects of the SSFL environmental monitoring and surveillance activities. SSFL contractors, subcontractors, and multiple U.S. DOE organizations are involved in and conduct environmental monitoring and surveillance activities independently, each driven by different missions and regulatory requirements but with the same goal in mind. The Environmental Surveillance program includes environmental surveillance and monitoring across multiple media types both on and off the SSFL. The program conducts multimedia environmental monitoring to assess SSFL and off-site human health exposures to radionuclides and chemicals and evaluate the potential impact of site operations on the environment.

The Quality Assurance Program Plan (QAPP) (North Wind 2017) and Field Quality Assurance Project Plan for Groundwater Monitoring (QAPjP) (North Wind 2015) represent site-specific implementation of quality requirements in support of the environmental monitoring activities at SSFL, including the EM-QA-001, EM Quality Assurance Program. The QAPP and QAPjP present the QA/QC procedures associated with tracking, reviewing, and auditing to ensure that the data collected in the field and in the off-site laboratory are of sufficient quality, as well as ensuring that the project work meets the outlined QA requirements for intended data use. The QAPP and QAPjP are formatted to provide a direct correlation to the management/ performance/assessment criteria specified in Title 10 of the CFR and DOE O 414.1D, with references to the applicable requirements of American Society of Mechanical Engineers (ASME) NQA-1.

Together, Rev. 1 of EM-QA-001, the criterion of 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE Order 414.1D, "Quality Assurance," are achieved through the application of ASME NQA-1-2008 with the NQA-1a-2009 addenda, Quality Assurance Requirements for Nuclear Facility Applications, as the basis for the QA Program described in the plan.

The primary goal of an Environmental Surveillance program is to provide high-quality data so that the necessary assessments and decisions based on the data can be made. This section presents information on measures taken by the environmental monitoring programs in 2018 to ensure the high quality of data collected and presented in this annual report.

9.1 Quality Control Results for 2018

9.1.1 Background

The following summarizes the inorganic, metals, organic, and radiochemical data validation completed for 20 EPA Level IV data packages containing results from the SSFL Area IV in Ventura County, CA. The data for this effort were acquired from sampling efforts completed from October 15, 2018, through January 14, 2019. The data for this summary were generated by GEL Laboratories, LLC, for one data package, and the remaining data for this summary was generated by Test America Laboratories.

The data were validated using the requirements and protocols outlined in the following documents and analytical methods:

- *Statement of Work Data Validation Services Santa Susana Field Laboratory Area IV, Ventura County, California.*
- Haley & Aldrich, 2010, *Report on Annual Groundwater Monitoring, 2009, Santa Susana Field Laboratory, Simi Hills, Ventura County, California.*
  - Haley & Aldrich, 2010a, *Appendix A, Site-Wide Water Quality Sampling and Analysis Plan, Revision 1, Santa Susana Field Laboratory, Ventura County, California,* December.
  - Haley & Aldrich, 2010b, *Appendix B, Groundwater Monitoring, Quality Assurance Project Plan, Revision 1, Santa Susana Field Laboratory, Ventura County, California,* December.
- U.S. EPA, 2008, *U.S. EPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review,* OSWER 9240.1-48 EPA 540/R-08/01, February.
- U.S. EPA, 2010, *U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review,* OSWER 9240.1-45 EPA 540-R-04-004, October.
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015).
- *Multi Agency Radiological Laboratory Analytical Protocols, MARLAP, Manual*, EPA 402-B-04-001A, July 2004.
- *Evaluation of Radiochemical Data Usability, ES/ER-MS-5,* April 1997.

The following provides an overview of the data set and findings of the data package validation effort.

9.1.2 Summary

The SSFL data set consists of 20 EPA Level IV sample delivery groups (SDGs) with a total of 89 water samples. SDGs 160-26903-1, 160-27060-1, 280-106860-1, and 280-106978-1 underwent a Level IV EPA validation and comprised more than 20% of the overall data per an analysis for this sampling effort. The remaining SDGs underwent an EPA Level III validation.

Table 9-1 shows the number and type of samples collected for the SSFL ETEC groundwater 2018 sampling effort.

Table 9-1. Samples Collected for SSFL ETEC Groundwater Sampling, 2018

Sample Type	Number of Samples
Field Samples	46 Samples (17 were designated on the chain-of-custody forms as matrix spike/matrix spike duplicate (MS/MSD))
Trip Blanks	10 Samples
Rinsates	15 Samples
Field Blank	1 Sample
Field Duplicates	17 Samples

The samples were analyzed for VOCs, 1,4-dioxane, 1,2,3-trichloropropane, gasoline-range organics (GRO), diesel-range organics (DRO), dissolved and total metals including mercury, perchlorate, nitrate, fluoride, and radiochemical (RAD) analyses (tritium and total/dissolved for the remaining RAD analyses). Table 9-2 shows the requested analyses, analytical methods, and number of samples analyzed for each analysis compiled from the chain-of-custody forms.

Table 9-2. Summary of Analyses for SSFL ETEC Groundwater Sampling, 2018

<table>
<tr><th>Analysis</th><th colspan="2">Method</th><th>Number of Samples Analyzed</th></tr>
<tr><td>Volatile Organic Compounds</td><td colspan="2">EPA SW-846 Method 8260B</td><td>71</td></tr>
<tr><td>1,4-Dioxane</td><td colspan="2">EPA SW-846 Method 8260B
Selective Ion Monitoring (SIM)</td><td>19</td></tr>
<tr><td>1,2,3-Trichloropropane</td><td colspan="2">EPA Method 524.2 SIM</td><td>10</td></tr>
<tr><td>Gasoline-Range Organics</td><td colspan="2">EPA SW-846 Method 8015B</td><td>28</td></tr>
<tr><td>Diesel-Range Organics</td><td colspan="2">EPA SW-846 Method 8015B</td><td>20</td></tr>
<tr><td>Perchlorate</td><td colspan="2">EPA SW-846 Method 6860</td><td>20</td></tr>
<tr><td>Nitrate as N</td><td colspan="2">EPA Method 300.0</td><td>11</td></tr>
<tr><td>Fluoride</td><td colspan="2">EPA Method 300.0</td><td>15</td></tr>
<tr><td>Metals (Total & Dissolved)</td><td colspan="2">EPA SW-846 Method 6010C
EPA SW-846 Method 6020A
EPA SW-846 Method 7470A</td><td>51 Total Metals
51 Dissolved Metals</td></tr>
<tr><td rowspan="3">Radiochemical Analyses (Total & Dissolved)</td><td>Isotopic U</td><td>Method A-01-R U</td><td>36 Total Isotopic U
36 Dissolved Isotopic U</td></tr>
<tr><td>Gamma Spectroscopy</td><td>EPA Method 900.1</td><td>36 Total Gamma Spectroscopy
36 Dissolved Gamma Spectroscopy</td></tr>
<tr><td>Gross Alpha/Beta</td><td>EPA Method 900.0</td><td>37 Total Gross Alpha/Gross Beta</td></tr>
</table>

Analysis	Method		Number of Samples Analyzed
			37 Dissolved Gross Alpha/Beta
	Strontium-90 (Sr-90)	EPA Method 905.0	42 Total Sr-90 42 Dissolved Sr-90
	Tritium	EPA Method 906.0	15 Tritium
	Radium-226 (Ra-226)	EPA Method 903.0	36 Total Ra-226 36 Dissolved Ra-226
	Radium-228(Ra-228)	EPA Method 904.0	36 Total Ra-228 36 Dissolved Ra-228

9.1.3 Data Quality Summary

Anions (Fluoride and Nitrate as N) by EPA Method 300.0:

The SSFL anions data set consists of 11 water samples analyzed for nitrate as N and 15 water samples analyzed for fluoride, which resulted in 26 data points. All 26 data points are considered usable for evaluating site conditions and indicated that:

- 10 data points for nitrate as N and 8 data points for fluoride (18 data points, 69.2% of the total) were either non-detect and identified as "U" or were evaluated and remain unqualified. These results can be considered qualitative data.
- 7 fluoride and 1 nitrate data points (5 data points, 30.8% of the total) were qualified with a "J" validation flag and can be considered as quantitative data.

Perchlorate by USEPA SW-846 Method 6860:

The SSFL perchlorate data set consists of 20 water samples. All 20 data points are considered usable for evaluating site conditions and indicated that:

- 15 perchlorate data points (75% of the total) were either non-detect and identified as "U" or were evaluated and remain unqualified. These results can be considered qualitative data.
- 5 perchlorate data points (25% of the total) were qualified with a "UJ", "J", or "J-"validation flag and can be considered quantitative data.

Total and Dissolved Metals by USEPA SW-846 Methods 6010C, 6020A, and 7470A:

The SSFL metals data set consists of 51 water samples analyzed for total metals and dissolved metals and resulted in 2,754 data points. All 2,754 data points are considered usable for evaluating site conditions and indicated that:

- 2,265 total and dissolved metals data points (82.2% of the total) were either qualified with a "U" validation flag due to blank detections, were non-detect, or were detected in the samples and can be considered as qualitative data.
- 489 total and dissolved metals data points (17.8% of the total) were qualified with a "UJ", "J+", "J-", or "J" validation flag and can be considered as quantitative data.

Gasoline-Range Organics and Diesel-Range Organics by USEPA SW-846 Method 8015B:

The SSFL GRO and DRO data set consists of 28 GRO samples and 20 DRO samples, which resulted in 48 data points. All 48 data points are considered usable for evaluating site conditions and indicated that:

- 22 GRO data points and 10 DRO data points (66.7% of the total) were either non-detect and identified as "U" or were evaluated and remain unqualified. These results can be considered as qualitative data.
- 11 DRO and 5 GRO data points (33.3% of the total) were qualified with a "J" or "UJ" validation flag and can be considered as quantitative data.

1,4-Dioxane by USEPA SW-846 Method 8260B SIM and 1,2,3-Trichloropropane by EPA Method 524.2 (SIM):

The SSFL 1,4-dioxane data set consists of 19 water samples and the 1,2,3-trichloropropane data set consists of 10 water samples. All 19 data points are considered usable for evaluating site conditions and indicated that:

- 10 data points for 1,2,3-trichloropropane (100% of the total) were non-detect and can be considered as qualitative data.
- 9 data points for 1,4-dioxane results (47.4% of the total) were either non-detect and identified as "U" or were evaluated and remain unqualified. These results can be considered as qualitative data.
- 10 data points for 1,4-dioxane results (52.6% of the total) were qualified with a "J" or "UJ" and can be considered as quantitative data.

Volatile Organic Compounds by USEPA SW-846 Method 8260B:

The SSFL VOC data set consists of 71 water samples, which resulted in 1,491 data points. All 1,491 data points are considered usable for evaluating site conditions and indicated that:

- 1,412 data points (94.7% of the total) were non-detect, qualified "U" due to method, trip, or field blank detections, or were detections above the quantitation limit and can be considered qualitative data.
- 79 data points (5.3% of the total) were qualified "UJ" or "J" and can be considered quantitative data.

Radiochemical Analyses:

The SSFL radiochemical data set consists of 36 samples for total and dissolved isotopic uranium and Sr-90, 36 samples for total and dissolved gamma spectroscopy, 37 samples for total and dissolved gross alpha/gross beta, 42 samples for total and dissolved Sr-90, 15 samples for H-3, and 36 samples for total and dissolved Ra-226 and Ra-228, which resulted in 1,632 data points. All 1,632 data points are considered usable for evaluating site conditions and indicated that:

- 1,607 data points (98.5% of the total) were statistical non-detects or were considered as truly present in the samples and can be considered qualitative data.
- 25 data points (1.5% of the total) were qualified with a “UJ” or “J” validation flag and can be considered as quantitative data.

Trip Blanks and Field Blanks:

Ten trip blank samples and one field blank sample were collected for the SSFL ETEC groundwater 2018 sampling effort and are listed in Table 9-3.

Table 9-3. Trip/Field Blanks for SSFL ETEC Groundwater Sampling, 2018

SDG	Sample Identification (ID)	Analysis	QC Type
280-106660-1	DD-139_022218_78_L	VOC	Trip Blank
280-106726-1	DD-144_022218_78_L	VOC	Trip Blank
280-106848-1	DS-46_022718_78_L	VOC, 1,4-Dioxane, GRO	Trip Blank
280-106589-1	PZ-108_021918_78_L	VOC and GRO	Trip Blank
280-106810-1	PZ-120_022618_78_L	VOC and 1,4 Dioxane	Trip Blank
280-106620-1	RD-33B_022018_78_L	VOC and GRO	Trip Blank
280-106976-1	RD-34B_030118_78_L	VOC, GRO, 1,4-Dioxane,and 1,2,3-Trichloropropane	Trip Blank
	RD-34B_030118_19_L	VOC, Metals, Perchlorate, GRO, DRO, RAD Analyses, Anions, 1,4-Dioxane, 1,2,3-Trichloropropane, & Tritium	Field Blank
280-106860-1	RD-98_022818_78_L	VOC and GRO	Trip Blank
280-113433-1	RD-33_082118_78_L	VOC, GRO, 1,4-Dioxane,and 1,2,3-Trichloropropane	Trip Blank
280-113521-1	RD-33C_082218_78_L	VOC, GRO, 1,4-Dioxane,and 1,2,3-Trichloropropane	Trip Blank

The following compounds were detected in the trip blank and field blank samples:

- GRO in samples RD-34B_030118_78_L, RD-33B_022018_78_L, DS-46_022718_78_L, and RD-98_022818_78_L.
- Acetone, U-233/234, total and dissolved boron, total and dissolved calcium, and total strontium in RD-34B_030118_19_L.
- Acetone and GRO in RD_33_082118_78_L.

No data qualification has been warranted based on these detections.

Field Duplicates:

Seventeen pairs of field duplicates were collected during the SSFL ETEC groundwater 2018 sampling effort and are listed in Table 9-4.

Table 9-4. Field Duplicates for SSFL ETEC Groundwater Sampling, 2018

SDG#	Parent ID	Field Duplicate ID	Analysis
280-106589-1	DD-145_021918_01_L	DD-145_021918_36_L	GRO
	RD-20_022018_01_L	RD-20_022018_36_L	Nitrate
160-26984-1	DS-47_022318_01_L	DS-47_022318_36_L	Rad Suite
	RD-90_022218_01_L	RD-90_022218_36_L	Tritium
160-27060-1 (RAD) 280-106860-1 (VOCs)	RD-59C_022818_01_L	RD-59C_022818_36_L	RAD Analyses and VOC
280-106620-1	RD-33B_022018_01_L	RD-33B_022018_36_L	Perchlorate
	RD-63_022118_01_L	RD-63_022118_36_L	VOC and GRO
	RD-96_022118_01_L	RD-96_022118_36_L	Metals and DRO
280-106660-1	DD-139_022218_01_L	DD-139_022218_36_L	VOC
280-106810-1	DD-143_022618_01_L	DD-143_022618_36_L	Metals
280-106848-1	DD-140_022718_01_L	DD-140_022718_36_L	VOC
280-106860-1	RD-59B_022818_01_L	RD-59B_022818_36_L	Metals and Fluoride
280-106976-1	RD-14_030218_01_L	RD-14_030218_36_L	1,2,3-Trichloropropane
	RD-34A_030218_01_L	RD-34A_030218_36_L	1,4-Dioxane
160-32091-1	RD-59A_082018_01_L	RD-59A_082018_36_L	Sr-90
160-30331-1 (RAD) 280-113433-1 (Remaining Analyses)	RD-33A-082118_01_L	RD-33A-082118_36_L	RAD Analyses Including Tritium, Nitrate, Fluoride, Perchlorate, Metals, GRO, DRO, VOCs, 1,4-Dioxane, and 1,2,3-Trichloropropane
457885 (GEL)	RD-59A_082018_03_G	RD-59A_082018_03_36_G	Sr-90

The field duplicate precision for perchlorate (42.8% relative percent difference, RPD) in field duplicate pair RD-33B_022018_01_L/ RD-33B_022018_36_L exceeded the 35% RPD criterion. The remaining field duplicate precision criteria were met.

9.1.4 Data Validation Qualifications

Qualifications were assigned in accordance with the *U.S. EPA Contract Laboratory Program National Functional Guidelines* and resulted from preparation and chain-of-custody issues; poor initial and continuing calibration criteria; positive blank detections; poor laboratory control sample (LCS), laboratory control sample duplicate (LCSD), MS, MSD, and serial dilution sample (SDS) performance; and results reported below the quantitation limits. Table A-5 summarizes the findings and data qualifications assigned to SSFL ETEC Groundwater 2018 data results. Please refer to Attachment B for definitions of the data validation qualifiers.

Table 9-5. Summary of Data Validation Qualifications for SSFL ETEC **Groundwater Sampling, 2018**

Analyte	Total # of	Analyte	Total # of
Nitrate as N	11	10	"U" or No Qualification
		1	J
Fluoride	15	8	"U" or No Qualification
		7	J
Perchlorate	20	15	"U" or No Qualification
		2	UJ
		1	J-
		2	J
Metals	2754	2265	"U" or No Qualification
		13	UJ
		25	J+
		1	J-
		450	J
GRO	28	22	"U" or No Qualification
		5	J
		1	UJ
DRO	20	10	"U" or No Qualification
		10	**J**
1,2,3-Trichloropropane	10	10	"U"
1,4-Dioxane	19	9	"U" or No Qualification
		5	**UJ**

Analyte	Total # of	Analyte	Total # of
		5	**J**
VOCs	1491	1412	"U" or No Qualification
		41	**UJ**
		38	**J**
Radiochemical Data (including Tritium)	1632	1607	"U" or Positively Detected in the Sample
		20	**UJ**
		5	**J**

9.1.5 Data Review Process

Data produced by the analytical laboratories were subject to multiple review steps to coincide with the start of distinct tasks. These steps were performed in a timely manner to ensure appropriate feedback and correction of errors. These steps included:

- Cross-reference check of sample chain-of-custody documents against the laboratory acknowledgement of sample receipt form. The laboratory acknowledgement of sample receipt was typically transmitted to the data manager via e-mail 2 to 3 days after sample receipt and log-in and included a summary of the requested analyses to be performed per sample. Sample log-in errors were identified and corrected at this step.
- Tracking of sample collection, receipt, and laboratory SDG numbers on a sample tracking spreadsheet. This spreadsheet also included field QC sample information and well sample location coordinates.
- Laboratory consultation with the project chemists on data quality issues during sample analyses such as missed holding times, poor spike recoveries, etc. These issues were discussed between the project chemists and the laboratory and were resolved based on technical merit and determined if usable in the evaluation.

Upon receipt of the laboratory report (delivered via e-mail), a preliminary review of the data was performed. This review consisted of:

- Reconciliation of the reported analyses against the analyses that were requested on the chain-of-custody documents.
- Review of the laboratory case narratives. The case narrative identified and explained quality issues encountered during the analysis of the samples. Quality issues may include (but not be limited to) expired holding times, poor spike recoveries in matrix or batch-specific QC samples, instrument calibration exceedances, and blank contamination.
- Review of the laboratory-specific QC data. These data were provided by the laboratory in summary form. Any unanticipated deviations from the project or method-specific criteria were reconciled with the laboratory at this stage.

9.1.6 Data Quality Indicators

This section summarizes the validation performed.

Achievement of the data quality objectives (DQOs) was determined in part by the use of data quality indicators (DQIs). The DQIs for measurement data are expressed in terms of what are collectively referred to as the PARCCS parameters (precision, accuracy, representativeness, comparability, completeness, and sensitivity). The DQIs provide a mechanism for ongoing control to evaluate and measure data quality throughout the project. These criteria are defined in the sections below.

I. Precision

Precision is the measurement of the ability to obtain the same value on re-analysis of a sample through the entire analytical process. The closer the measurement results, the greater the precision. Precision has nothing to do with accuracy or true values of the sample. Instead, it is focused on random errors inherent in the analysis that stem from the measurement process and are compounded by the non-homogeneous nature of some samples. Precision is measured by analyzing two portions of the sample (sample and duplicate) and then comparing the results. This comparison can be expressed in terms of RPD. RPD is calculated as the absolute difference between the two measurements divided by the average of the two measurements.

$$\mathbf{RPD} = \frac{[(A-B)/\underline{A+B}] \times 100}{2}$$

A condition with this formula is that it depends on the average of the two measurements, and the magnitude of the calculated RPD is intimately linked to the magnitude of the results. When sample results are close to the reporting limit (RL), the RPD is greater but does not necessarily indicate that the precision is out of control limits, just that the sample concentrations are low.

RPD as a measure of precision works very well in those cases where the same level of analyte is present in all samples; however, it does not work well as a quantitative tool when varying levels are present. Another option that is used for evaluating the differences between sample results that are close to the RL is calculating the absolute difference between the results. In this situation, the difference between the sample results is compared to the RL and if the difference is greater, the sample results are qualified as estimated “J/UJ.” Sample results are also qualified as estimated “J/UJ” if the RPD is outside of criteria.

Because of the limitations with the use of RPDs for field duplicate precision evaluation, precision is also calculated on spike samples, either on an MS and MSD or on an LCS/LCSD. For spike samples, a known concentration of analyte has been added to each sample and evaluations of RPD can be made that are more applicable to variations in environmental measurements. The drawback is that the precision measurement is applicable only to the particular spike level used.

For the groundwater samples, precision was evaluated by reviewing RPD results for MS/MSDs, LCS/LCSDs, laboratory duplicates, and field duplicates.

Laboratory RPD control limits are presented in the WQSAP (Haley & Aldrich 2010a) or are laboratory specific. For laboratory duplicates, if one or both of the sample results were less than five times the RL, a control limit of the absolute difference value equal to the RL was used for comparison. The field duplicate RPD criterion is 35%.

Based on laboratory and/or field duplicate precision criteria during the validation process, qualifiers were applied to applicable sample results.

II. Accuracy

Accuracy is a concept from quantitative analysis that attempts to address the question of how close the analytical result is to the true value of the analyte in the sample. Accuracy is determined through a spike procedure, where a known amount of the target analyte is added to a portion of the sample and then the sample and the spiked sample are analyzed. The quantitative measure of accuracy is percent recovery (%R), calculated as follows:

$$\textbf{Percent Recovery} = \frac{\textbf{(Total Analyte Found – Analyte Originally Present)}}{\textbf{Analyte Added}} \times 100$$

Each measurement performed on a sample is subject to random and systematic error. Accuracy is related to the systematic error. Attempts to assess systematic error are always complicated by the inherent random error of the measurement.

Analytical accuracy for the entire data collection activity is difficult to assess because several sources of error exist. Errors can be introduced by any of the following:

- Sampling procedure
- Field contamination
- Sample preservation and handling
- Sample matrix
- Sample preparation
- Analytical techniques.

Accuracy is maintained to the extent possible by adhering to the EPA method and approved field and analytical standard operating procedures.

The following QC samples are used to assess laboratory accuracy:

- Matrix Spikes: These are samples with a known amount of a target analyte added to them. Analysis of the sample that has been spiked and comparison with the results from the unspiked sample (background) gives information about the ability of the test procedure to generate a correct result from the sample.
- Post-Digestion Spikes: Post-digestion spikes are performed after the sample has been prepared and is ready for analysis. These are also termed “analytical spikes.” The technique

is used in conjunction with an MS to provide data that can separate interferences produced as part of the sample preparation from interferences that are innate qualities of the sample.

- Laboratory Control Samples: LCSs consist of a portion of analyte-free water spiked with target analytes at a known concentration.
- Surrogates: Surrogate recovery is a QC measure limited to use in organics analysis. Surrogates are compounds added to every sample at the beginning of the sample preparation to monitor the success of the sample preparation and analytical procedures on an individual sample basis. Individual compounds used as surrogates are selected based on their ability to mimic the behavior of specific target analytes held to be particularly sensitive to the sample preparation manipulations.
- Interference Check Samples: Interference check sample analysis is a QC measure unique to metals analysis using inductively coupled plasma atomic emission spectrometry. This QC sample verifies the analytical instrument's ability to overcome interferences typical of those found in samples.
- Calibrations: Method requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data for metals. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analytical run. Continuing calibrations demonstrate that the initial calibration is still valid by checking the performance of the instrument on a continuing basis.
- Internal Standards: Internal standards measure the gas chromatograph/mass spectrometer sensitivity and response stability during each analysis.
- Serial Dilution: Serial dilutions are performed on at least one sample from every batch of analyses for metals to determine if physical or chemical interferences exist in the analyte determinations.

For the groundwater samples, accuracy was evaluated by reviewing the %R values and relative response factors of initial and continuing calibration (percent difference or percent drift [%D] for organic analyses), the initial and continuing calibration recoveries for inorganic analyses, internal standards, surrogate spikes (organic analyses only), MS/MSD, LCS/LCSD, inductively coupled plasma (ICP) interferences, and by performing serial dilution checks during metals analyses, in conjunction with method blank, calibration blank, equipment rinsate blank, and trip blank results. These QC results assist in identifying the type and magnitude of effects that may have contributed to system error introduced from field and/or laboratory procedures.

Qualifiers were applied to applicable sample results during the validation process based on laboratory accuracy results. Results were qualified based on calibrations, surrogates, internal standards, ICP serial dilutions, LCS/LCSD recoveries, and MS/MSD recoveries.

Sample preservation, handling, and holding times are additional measures of accuracy of the data. Holding times are defined as the amount of time that elapses from collection of the sample in the field to the start of the analysis. Preservation is defined as techniques used to maintain the target analytes at concentrations representative of the source sampled.

In summary, sample results that have been qualified as estimated "J, J+, J-, or UJ" due to accuracy criteria are usable for project decisions. No sample results were rejected.

Blank Contamination

Blanks are used to determine the level of laboratory and field contamination introduced into the samples, independent of the level of target analytes found in the sample source. Sources of sample contamination can include the containers and equipment used to collect the sample; preservatives added to the sample; cross contamination from other samples in transport coolers and laboratory sample storage refrigerators; standards used to calibrate instruments; glassware and reagents used to prepare samples for analysis; airborne contamination in the laboratory preparation area; and the analytical instrument sample introduction equipment. Each analyte group has its own particular suite of common laboratory contaminants. Active measures must be performed to continually measure the ambient contamination level and steps taken to discover the source of the contamination and to eliminate or minimize the levels. Random spot contamination can also occur from analytes that are not common laboratory problems but that can arise as a problem for a specific project or over a short period of time. Field blanks, equipment blanks, trip blanks, and laboratory method blanks are analyzed to identify possible sources of contamination.

The data validation reports discuss the specific results that were qualified as non-detect "U" based on field and laboratory blank contamination.

9.1.7 Representativeness, Comparability, and Sensitivity

Representativeness, comparability, and sensitivity are achieved by using EPA-approved sampling procedures and analytical methodologies. By following the procedures described in the WQSAP and Groundwater Monitoring, Quality Assurance Project Plan (Haley & Aldrich 2010a, 2010b) for this sampling event and future sampling events, sample analysis should yield results representative of environmental conditions at the time of sampling. Similarly, reasonable comparability of analytical results for this and future sampling events can be achieved if approved EPA analytical methods and standardized reporting units are employed.

I. Representativeness

Representativeness is a qualitative term that expresses the degree to which the sample data accurately and precisely represent the environmental conditions corresponding to the location and depth interval of sample collection. Requirements and procedures for sample collection are designed to maximize sample representativeness.

Representativeness also can be monitored by reviewing field documentation and/or performing field audits. For this report, a detailed review was performed on the chain-of-custody forms, laboratory sample confirmation logs, and data validation packages.

The most significant measure of representativeness is the accuracy of the sampling network and selection of appropriate locations and depths, etc. Field sampling accuracy was attained through adherence to the approved WQSAP and Groundwater Monitoring, Quality Assurance Project Plan (Haley & Aldrich 2010a, 2010b) for sample location and collection and by using approved standard operating procedures for field data collection. The data should represent, as near as possible, the actual field conditions at the time of sampling.

Representativeness has been achieved by the performed field work and laboratory analyses. The analytical data generated are viewed to be a representative characterization of the project area. No sample results were rejected.

II. Comparability

Comparability is a qualitative term that expresses the confidence with which a data set can be compared with another. Strict adherence to standard sample collection procedures, analytical detection limits, reporting units, and analytical methods assures that data from like samples and sample conditions are comparable. This comparability is independent of laboratory personnel, data reviewers, or sampling personnel. Comparability criteria are met for the project if, based on data review, the sample collection and analytical procedures are determined to have been followed, or defined to show that variations did not affect the values reported.

To ensure comparability of data generated for the site, standard sample collection procedures were utilized by North Wind. Department of Toxic Substances Control–approved analytical methods were performed by Test America Laboratories. Similar methods and concentration levels to those used for previous sampling events also allow for comparable data. Utilizing such procedures and methods enables the current data to be comparable with previous and future data sets generated.

III. Sensitivity

Sensitivity is related to the ability to compare analytical results with project-specific levels of interest, such as risk-based screening levels or action levels. Analytical detection limits for the various sample analytes should be below the level of interest to allow an effective comparison.

Detection Limits

The MDL study attempts to answer the question, "What is the lowest level of analyte in a sample that will result in a signal different than zero?" The study is based upon repetitive analysis of an interference-free sample spiked with a known amount of the target analyte. The MDL is a measure of the ability of the test procedure to generate a positive response for the target analyte in the absence of any other interferences from the sample.

The RL is generally defined as the lowest concentration at which an analyte can be detected in a sample and its concentration reported with a reasonable degree of accuracy and precision. For samples that do not pose a particular matrix problem, the RL is typically about three to five times higher than the MDL.

Laboratory results are reported according to rules that provide established certainty of detection and RLs. The result for an analyte is flagged with a "U" if that analyte was not detected, or qualified with a "J" flag if associated QC results fall outside the appropriate tolerance limits. Also, if an analyte is present at a concentration between the MDL and the RL, the analytical result is flagged with a "J," indicating an estimated quantity. Qualifying the result as an estimated concentration reflects increased uncertainty in the reported value.

Qualifiers were applied to applicable sample results by the laboratory and during the validation process based on sample results being reported as detected below the RL/MDL. Details of the validation and specific sample analytes qualified are discussed in the data validation reports.

In summary, for the collected groundwater samples, results for some of the analytes were qualified as estimated due to RL criteria. For the data validated in the 2017 groundwater sampling, RLs for a majority of the sample results were low enough to compare to the RL objectives stated in the WQSAP and Groundwater Monitoring, Quality Assurance Project Plan (Haley & Aldrich 2010a, 2010b). RLs above those stated in these documents are considered usable for project purposes.

9.1.8 Data Completeness

Completeness of the data collection program is defined as the percentage of samples planned for collection as listed in the WQSAP and Appendix B, Groundwater Monitoring, Quality Assurance Project Plan (Haley & Aldrich 2010a, 2010b) versus the actual number of samples collected during the field program (see Equation A).

Completeness for acceptable data is defined as the percentage of acceptable data obtained judged to be valid versus the total quantity of data generated (see Equation B). Acceptable data include both data that pass all the QC criteria (unqualified data) and data that may not pass all the QC criteria but had appropriate corrective actions taken (qualified but usable data).

Equation A.

$$\%\text{Completeness} = C x \frac{100}{n}$$

Where:

C = actual number of samples collected

n = total number of samples planned

Equation B.

$$\%\text{Completeness} = V x \frac{100}{n'}$$

Where:

V = number of measurements judged valid

n' = total number of measurements made

The overall completeness goal, as defined in the WQSAP and Appendix B, Groundwater Monitoring, Quality Assurance Project Plan (Haley & Aldrich 2010a, 2010b), for this sampling event is 90% for each analytical test for all project data.

The completeness goal achieved for acceptable data was 100% of the groundwater sample results for the number of measurements judged to be valid versus the total number of measurements made for all samples analyzed. No sample results were rejected. The completeness goal for the number of measurements judged to be valid was met for 2018 groundwater monitoring sampling.

The data reported and not rejected are suitable for their intended use for characterization of groundwater in Area IV of SSFL.

9.1.9 Assessment of Data Usability and Reconciliation with the Site-Wide WQSAP Goals

One hundred percent of the data validated for the 2018 groundwater sampling, and reported in this QA summary, are suitable for their intended use for site characterization. No sample results were rejected.

The RLs reported generally met the expected limits proposed by the analytical laboratories in their subcontract agreements with North Wind except for the analytes identified previously. Sample results that were qualified as estimated are usable for project decisions. The field duplicate precision criteria were met. Decisions based on results close to the RL should be made with a degree of caution.

The achievement of the completeness goal for the number of samples collected was met. The completeness goal for the number of sample results acceptable for use provides sufficient quality data to support project decisions for the wells that were sampled during this sampling event.

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Appendix A

Time Series Plots of Analytical Data

Time series plots for trichlorothene (TCE), perchlorate, and tritium are presented in this Appendix. Only primary sample results for the following wells are presented in the plots.

TCE

FSDF/ESADA
RD-21
RD-33A
RD-54A
RD-54B
RD-54C
RD-64
RD-65
RS-18
RS-54

Bldg 56 Landfill
RD-07

B4057/59/626
PZ-109

RMHF
RD-30
RD-34A
RD-34B
RD-63
RD-98
RS-28

HMSA/PDU
PZ-108
PZ-120

OCY
RD-14

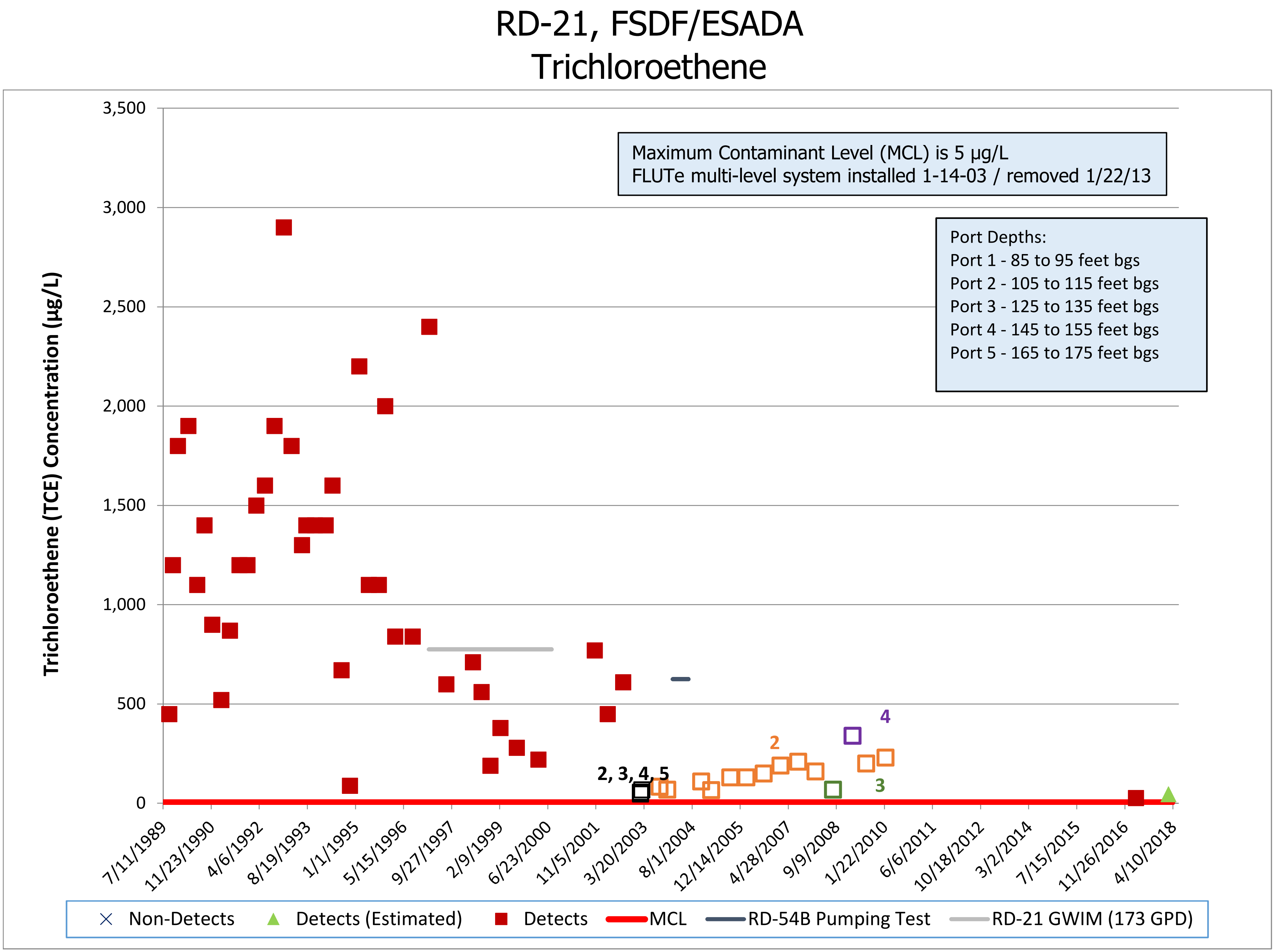
Bldg 65 Metals Clarifier
PZ-005
PZ-104
PZ-105

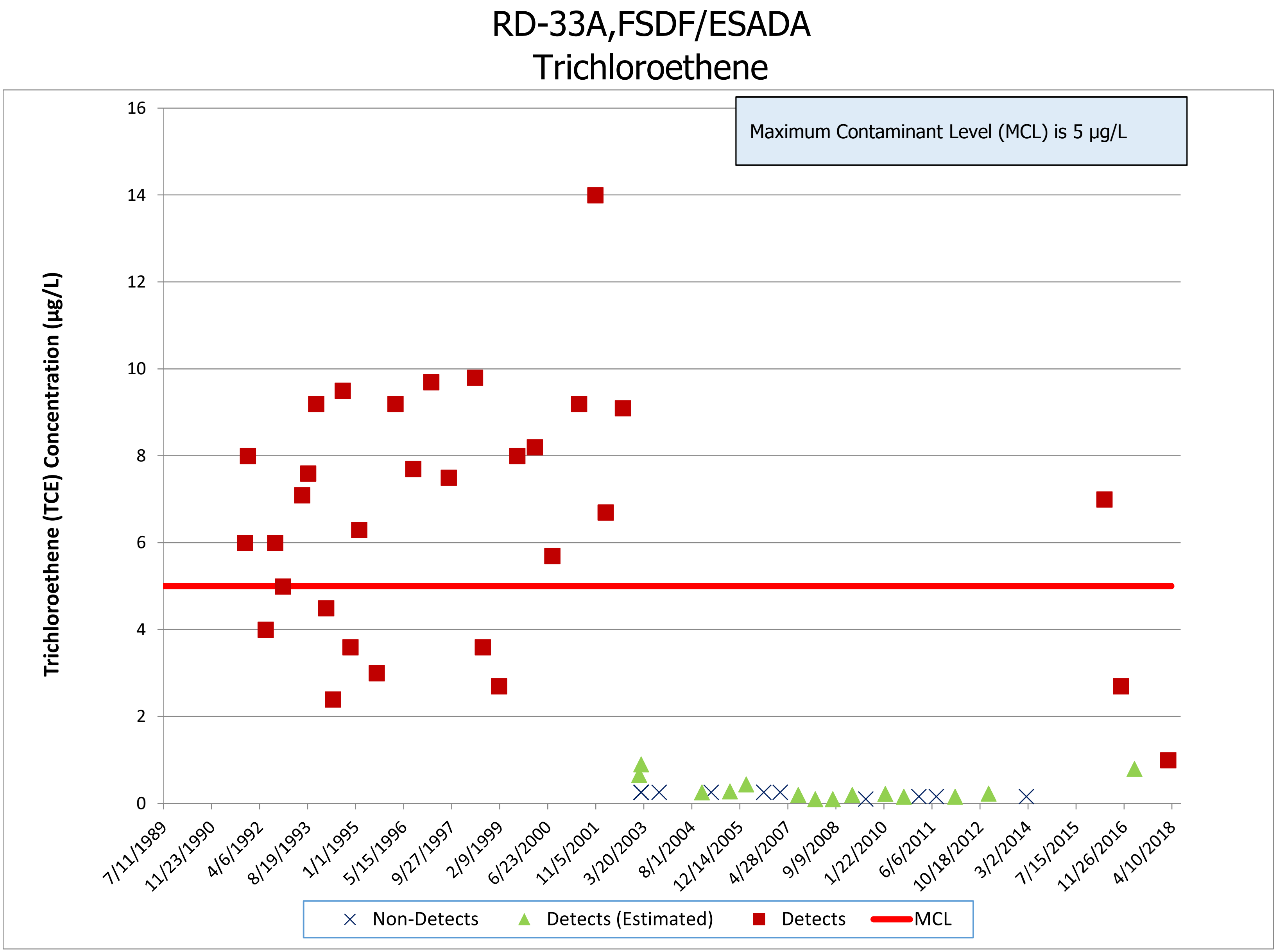
Bldg 4100/4009
RD-91

Perchlorate

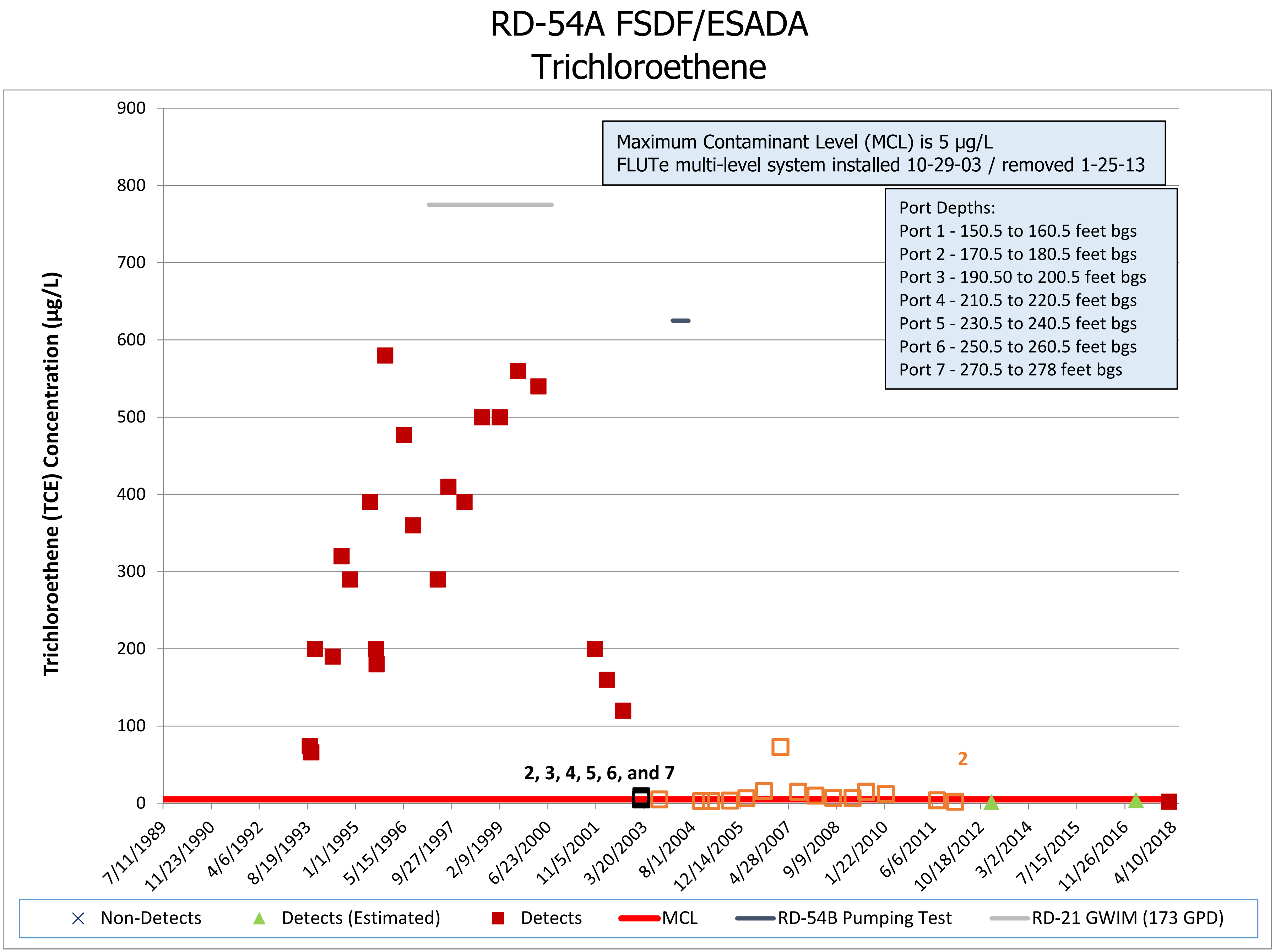
FSDF/ESADA
RD-21
RD-54A
RS-18
RS-54

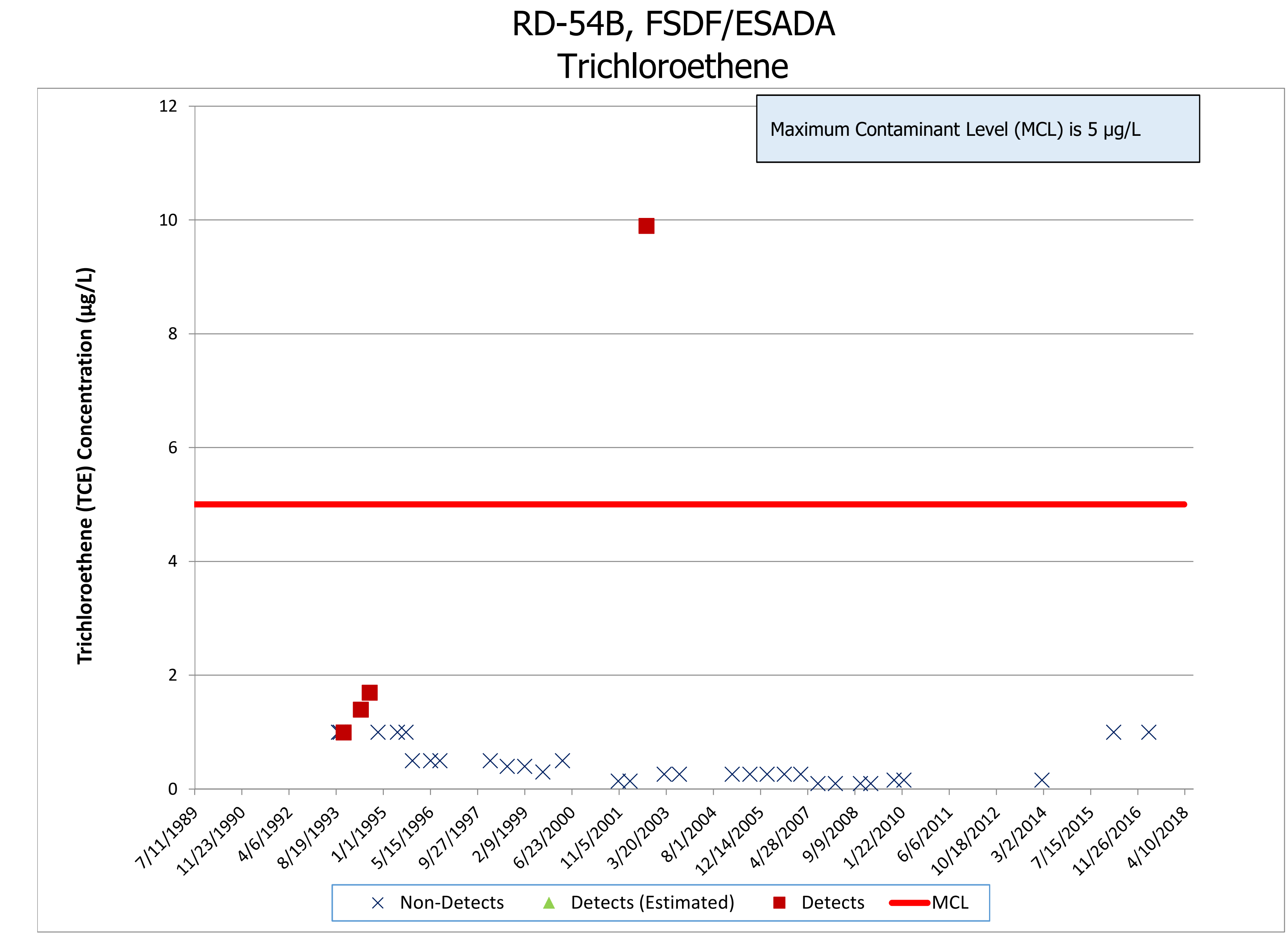
Tritium Plume
RD-34A
RD-88
RD-90
RD-93
RD-94
RD-95


RD-21, FSDF/ESADA
Trichloroethene
Trichloroethene (TCE) Concentration (µg/L)
Maximum Contaminant Level (MCL) is 5 µg/L
FLUTe multi-level system installed 1-14-03 / removed 1/22/13
Port Depths:
Port 1 - 85 to 95 feet bgs
Port 2 - 105 to 115 feet bgs
Port 3 - 125 to 135 feet bgs
Port 4 - 145 to 155 feet bgs
Port 5 - 165 to 175 feet bgs
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2, 3, 4, 5
2
3
4
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL
RD-54B Pumping Test
RD-21 GWIM (173 GPD)

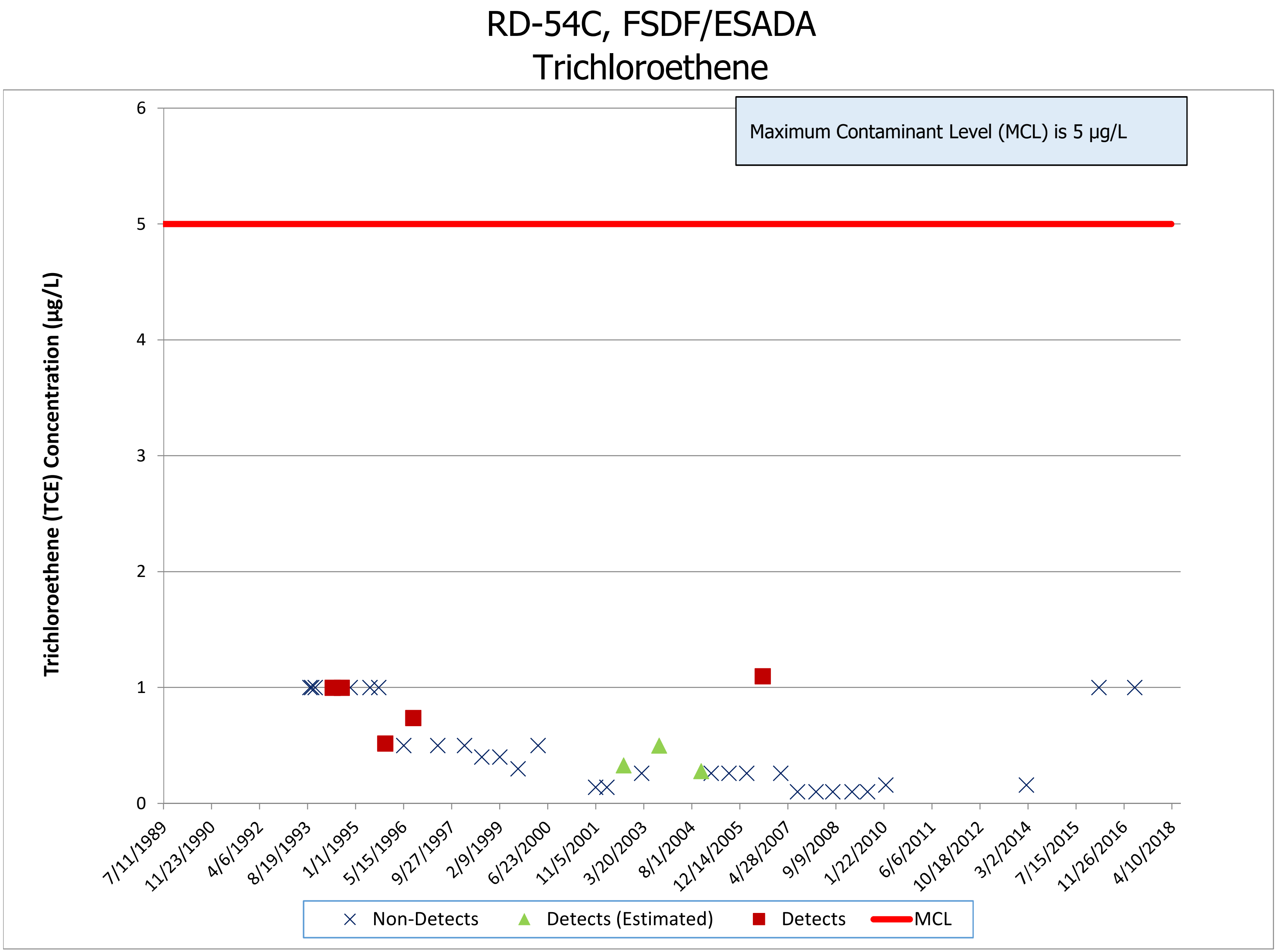


RD-33A,FSDF/ESADA
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
16
14
12
10
8
6
4
2
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

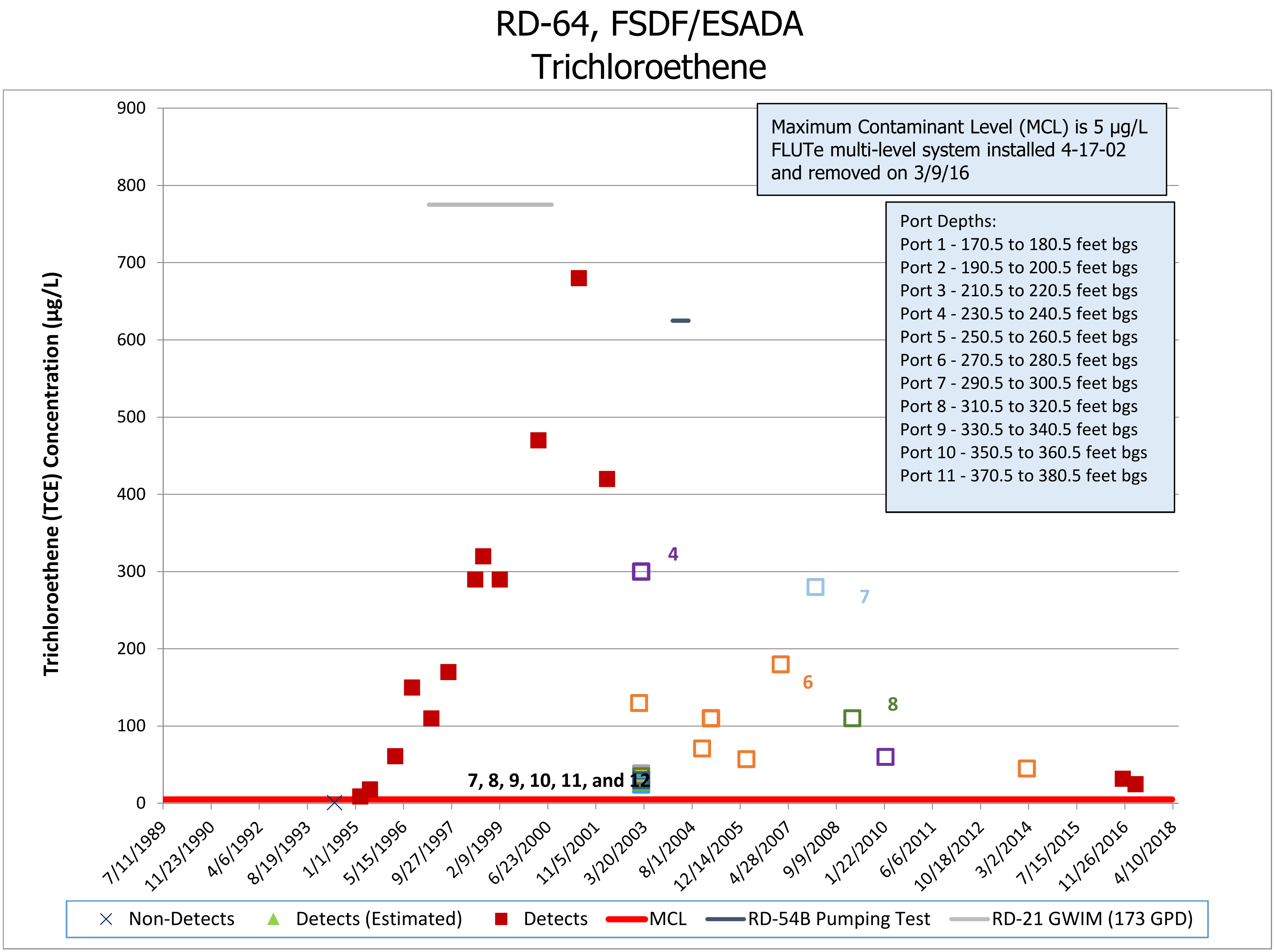

RD-54A FSDF/ESADA
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
FLUTe multi-level system installed 10-29-03 / removed 1-25-13
Port Depths:
Port 1 - 150.5 to 160.5 feet bgs
Port 2 - 170.5 to 180.5 feet bgs
Port 3 - 190.50 to 200.5 feet bgs
Port 4 - 210.5 to 220.5 feet bgs
Port 5 - 230.5 to 240.5 feet bgs
Port 6 - 250.5 to 260.5 feet bgs
Port 7 - 270.5 to 278 feet bgs
Trichloroethene (TCE) Concentration (µg/L)
900
800
700
600
500
400
300
200
100
0
2, 3, 4, 5, 6, and 7
2
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL
RD-54B Pumping Test
RD-21 GWIM (173 GPD)



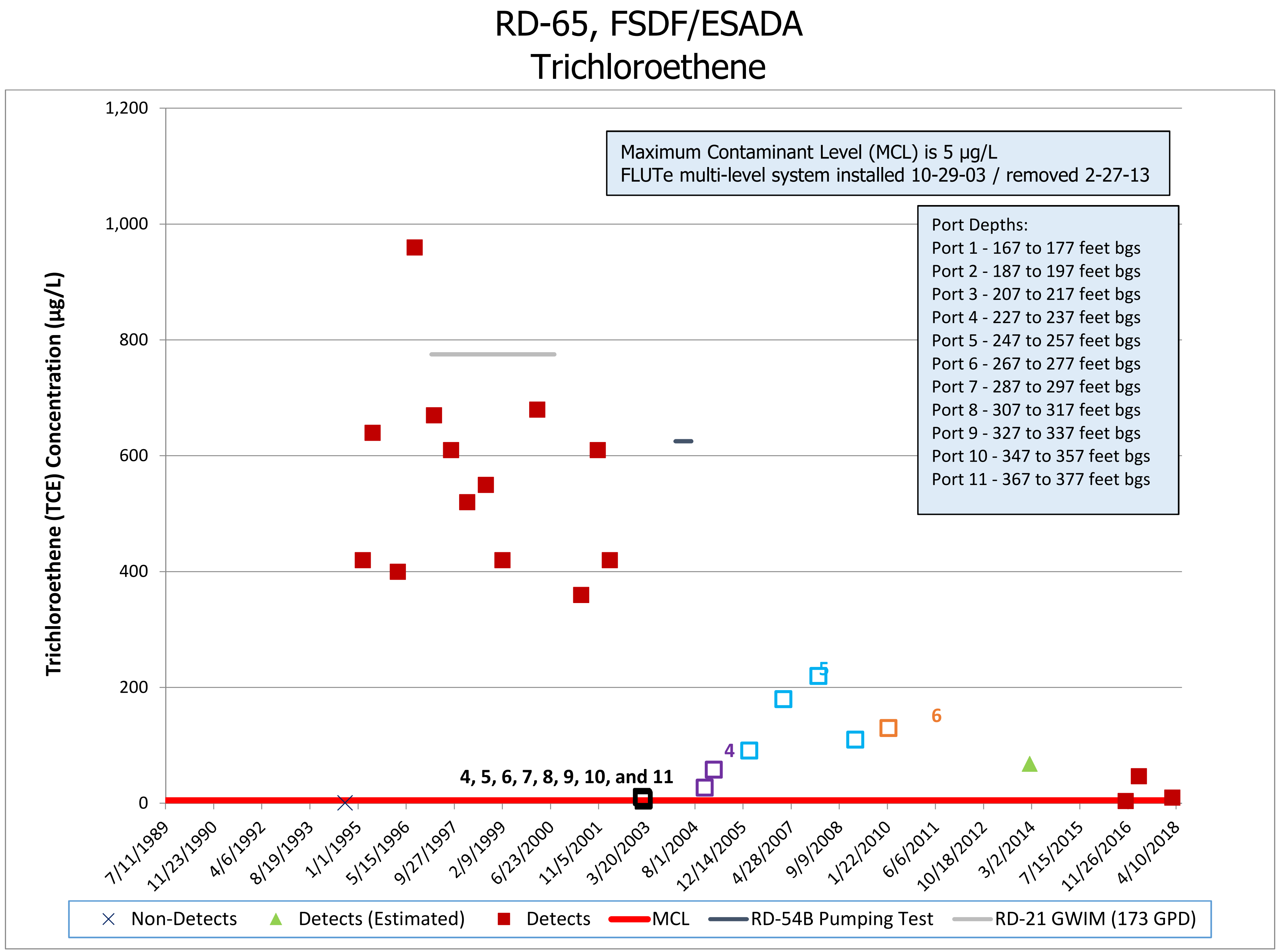
RD-54B, FSDF/ESADA
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
0
2
4
6
8
10
12
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL



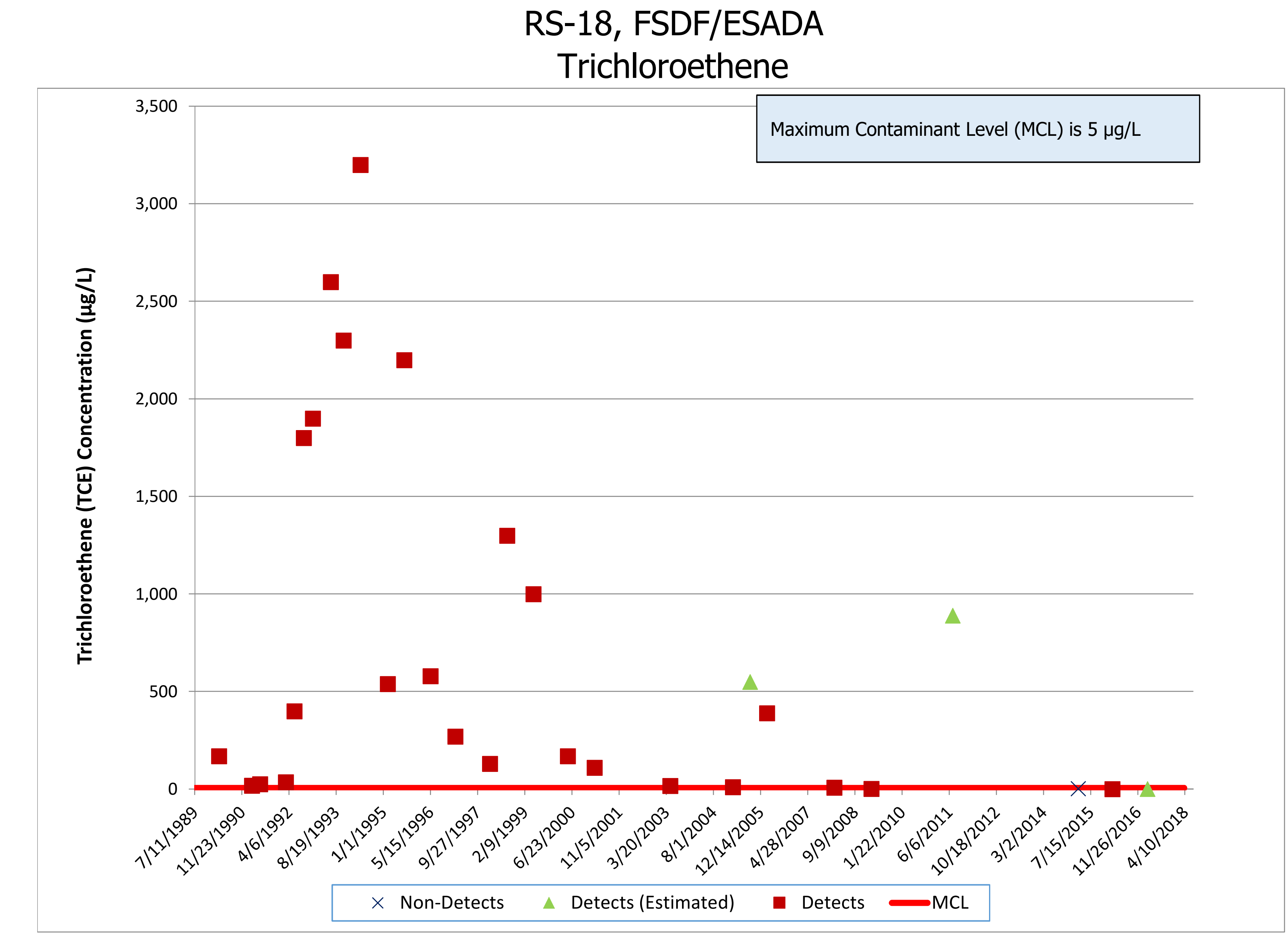
RD-54C, FSDF/ESADA
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
6
5
4
3
2
1
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL



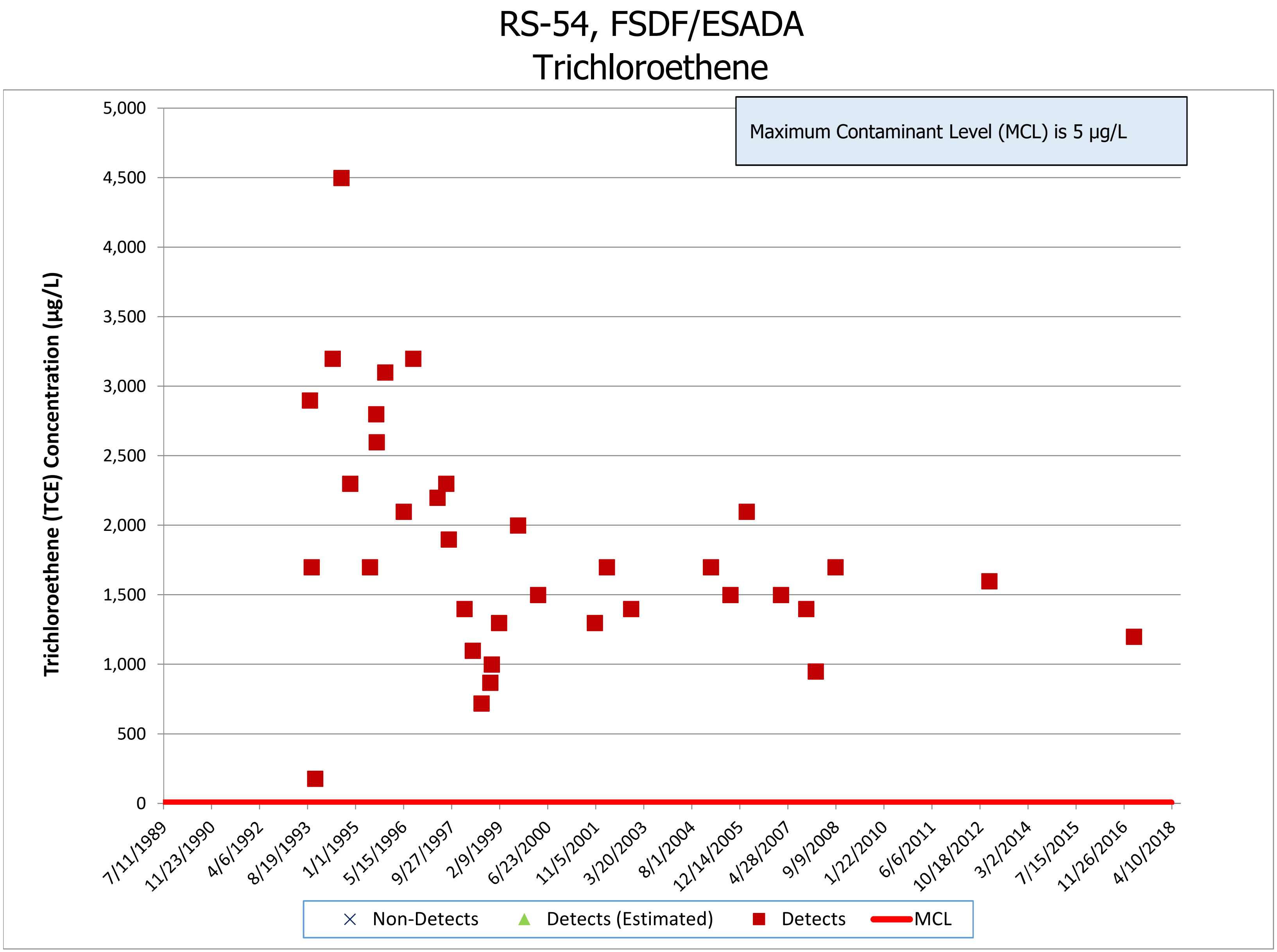
RD-64, FSDF/ESADA
Trichloroethene
Trichloroethene (TCE) Concentration (µg/L)
900
800
700
600
500
400
300
200
100
0
Maximum Contaminant Level (MCL) is 5 µg/L
FLUTe multi-level system installed 4-17-02
and removed on 3/9/16
Port Depths:
Port 1 - 170.5 to 180.5 feet bgs
Port 2 - 190.5 to 200.5 feet bgs
Port 3 - 210.5 to 220.5 feet bgs
Port 4 - 230.5 to 240.5 feet bgs
Port 5 - 250.5 to 260.5 feet bgs
Port 6 - 270.5 to 280.5 feet bgs
Port 7 - 290.5 to 300.5 feet bgs
Port 8 - 310.5 to 320.5 feet bgs
Port 9 - 330.5 to 340.5 feet bgs
Port 10 - 350.5 to 360.5 feet bgs
Port 11 - 370.5 to 380.5 feet bgs
4
7
6
8
7, 8, 9, 10, 11, and 12
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL
RD-54B Pumping Test
RD-21 GWIM (173 GPD)

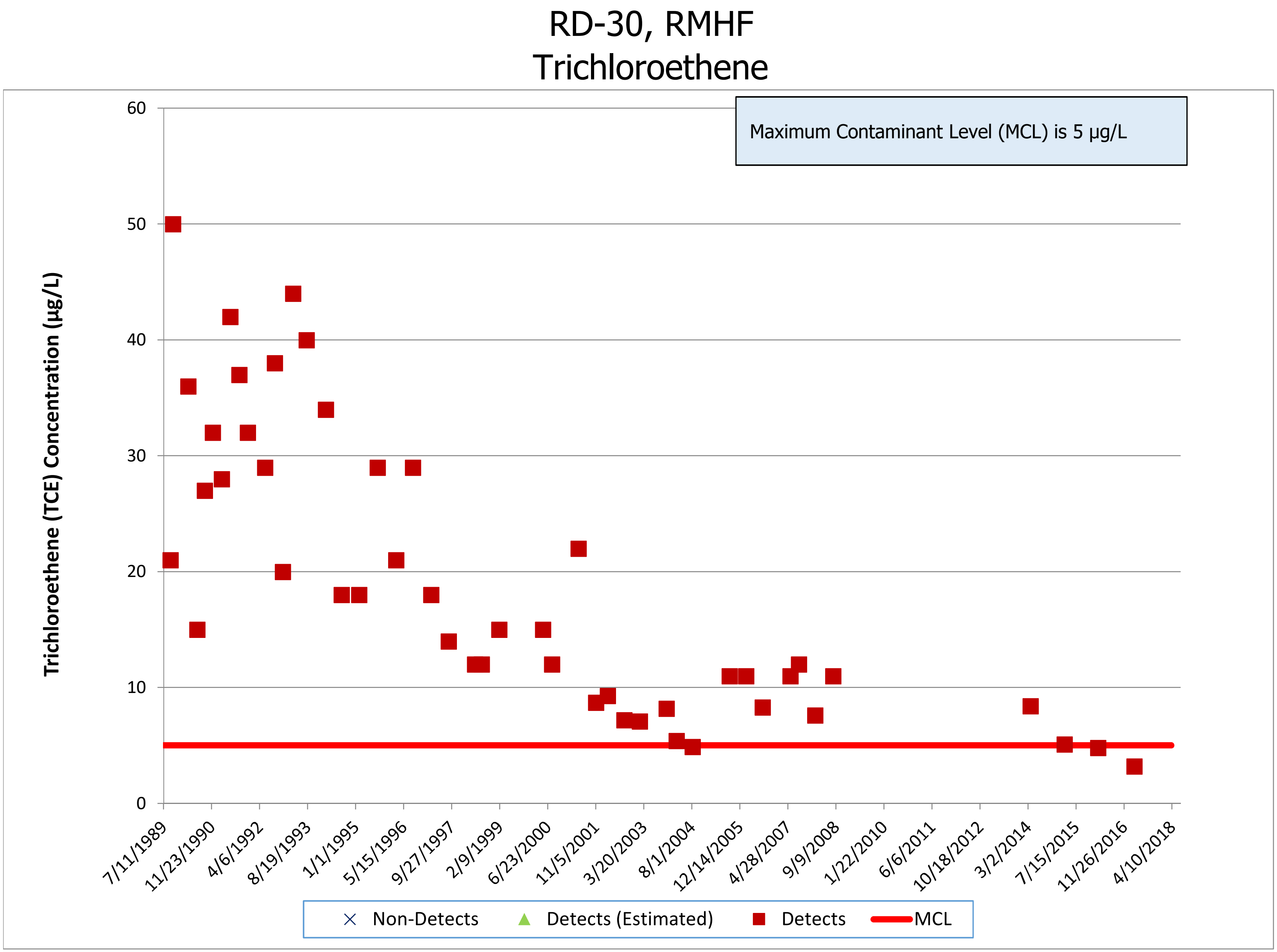


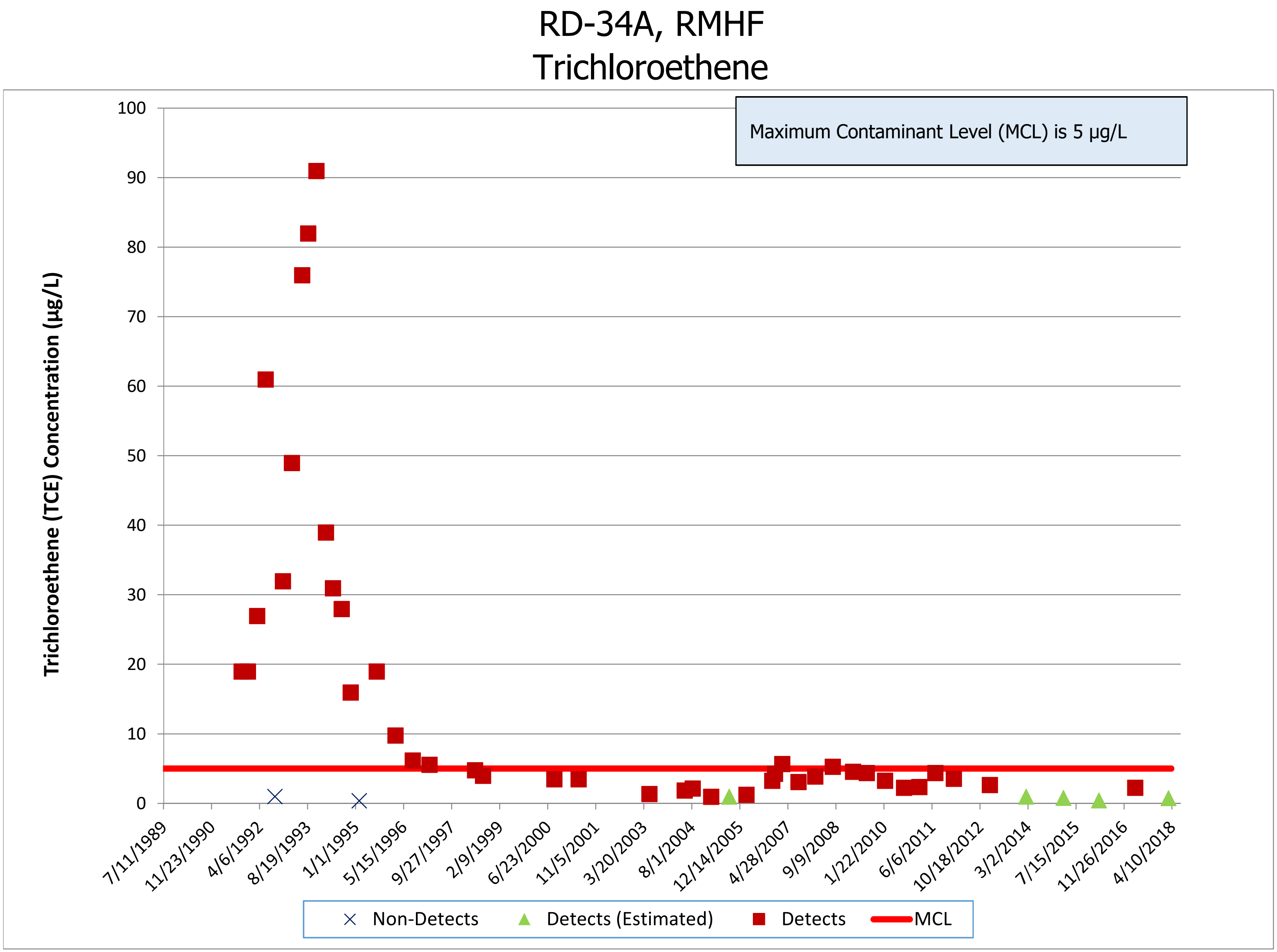
RD-65, FSDF/ESADA
Trichloroethene
Trichloroethene (TCE) Concentration (µg/L)
1,200
1,000
800
600
400
200
0
Maximum Contaminant Level (MCL) is 5 µg/L
FLUTe multi-level system installed 10-29-03 / removed 2-27-13
Port Depths:
Port 1 - 167 to 177 feet bgs
Port 2 - 187 to 197 feet bgs
Port 3 - 207 to 217 feet bgs
Port 4 - 227 to 237 feet bgs
Port 5 - 247 to 257 feet bgs
Port 6 - 267 to 277 feet bgs
Port 7 - 287 to 297 feet bgs
Port 8 - 307 to 317 feet bgs
Port 9 - 327 to 337 feet bgs
Port 10 - 347 to 357 feet bgs
Port 11 - 367 to 377 feet bgs
4, 5, 6, 7, 8, 9, 10, and 11
4
5
6
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL
RD-54B Pumping Test
RD-21 GWIM (173 GPD)



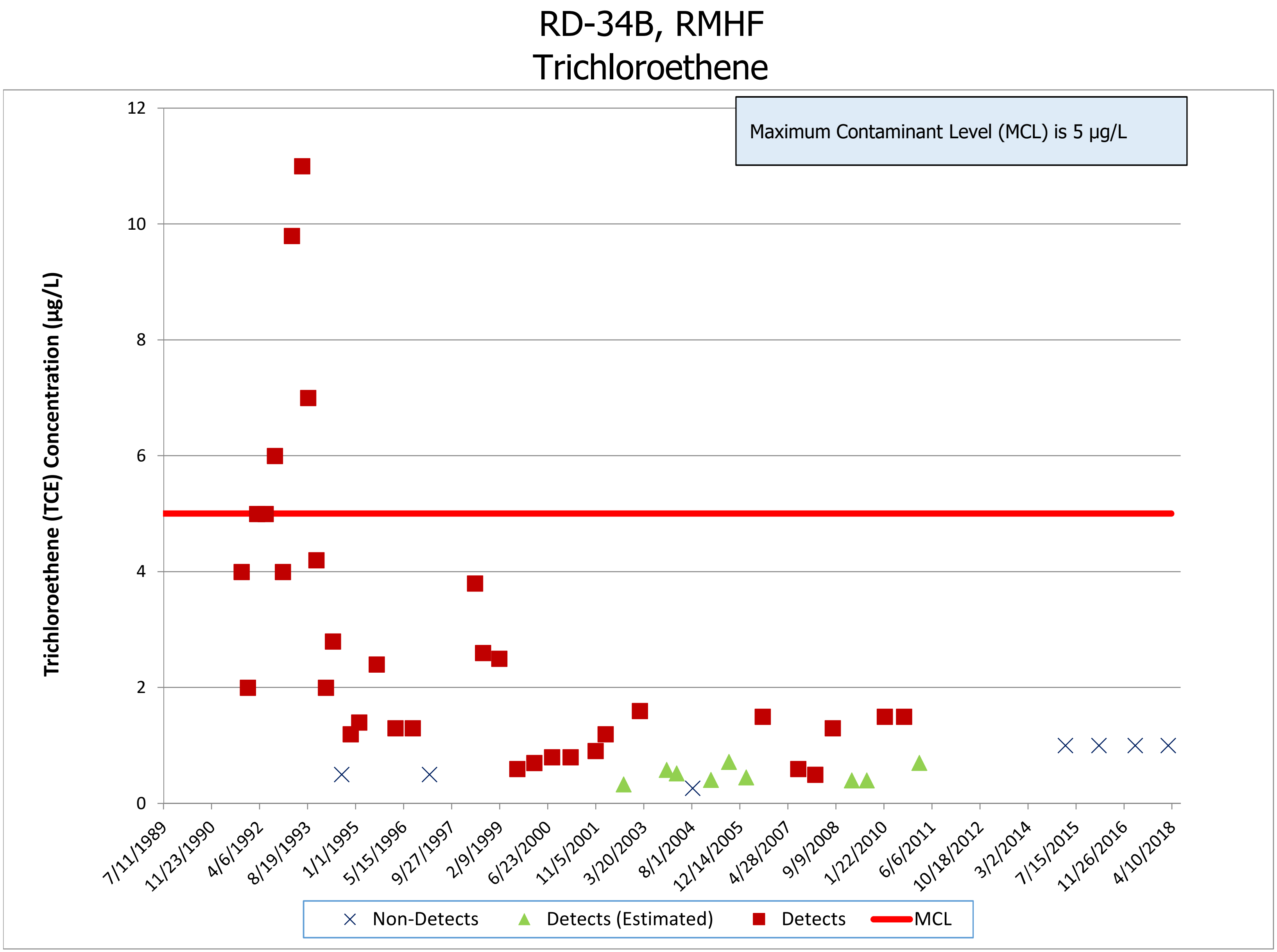
RS-18, FSDF/ESADA
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL


RS-54, FSDF/ESADA
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

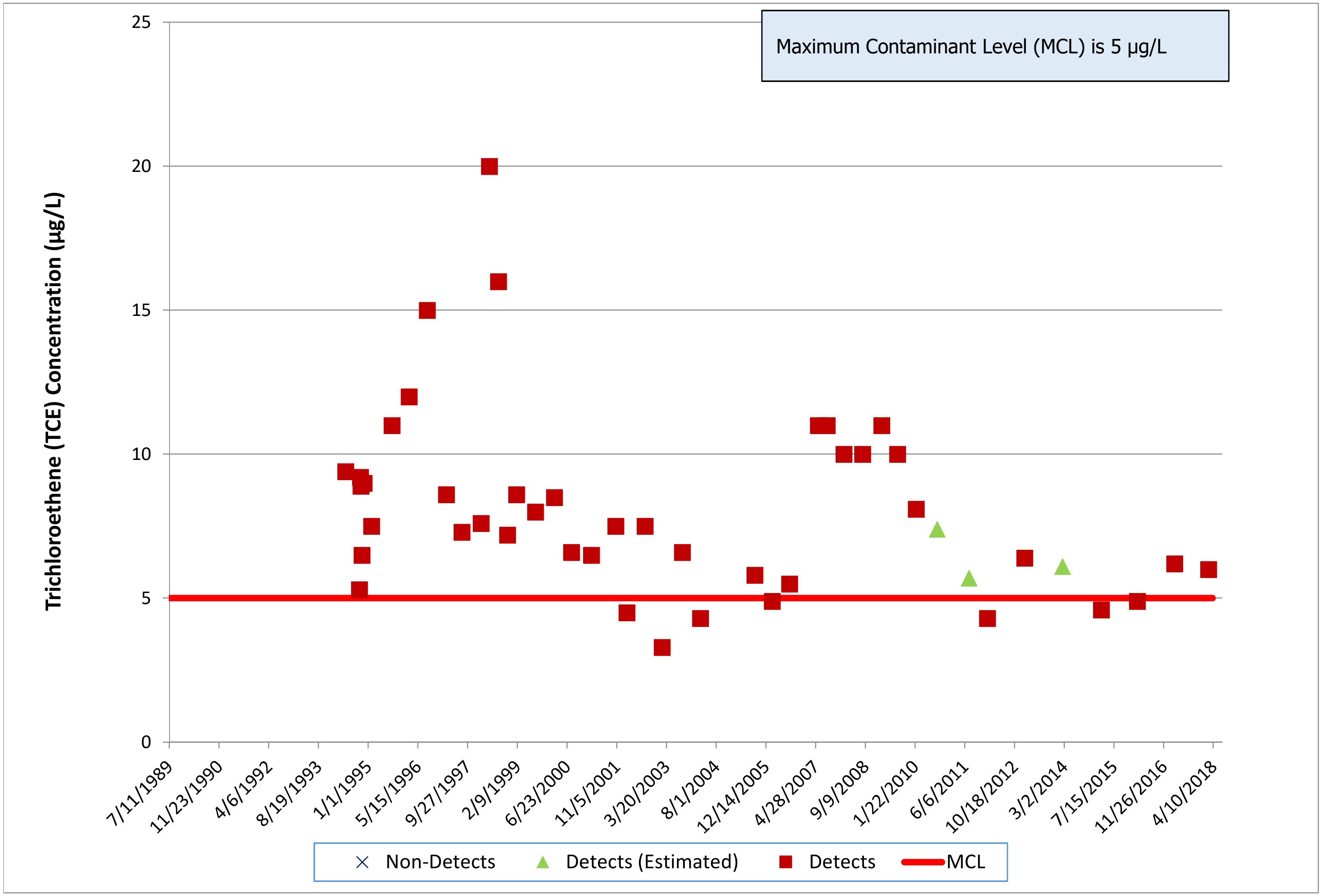

RD-30, RMHF
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
60
50
40
30
20
10
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

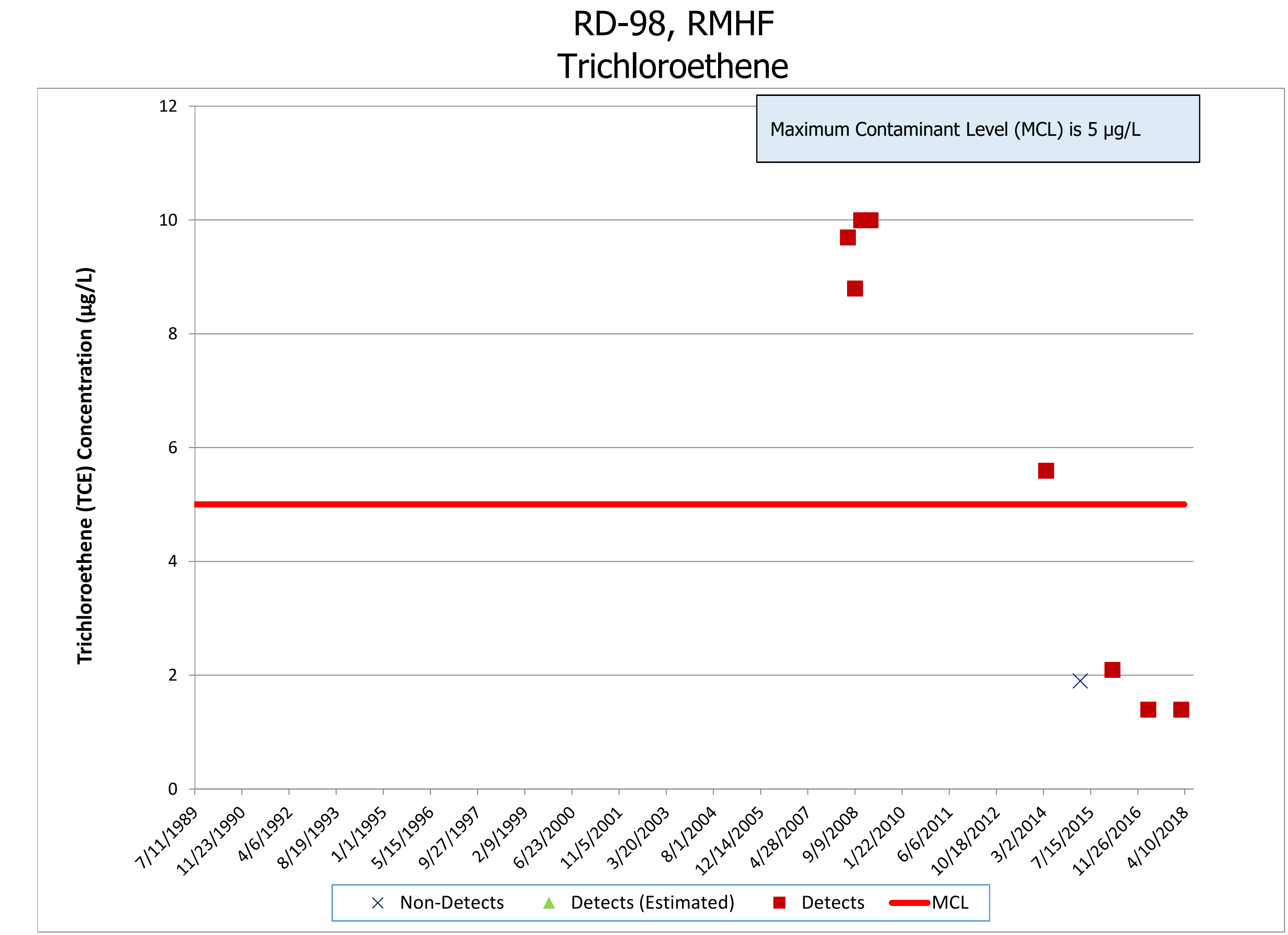


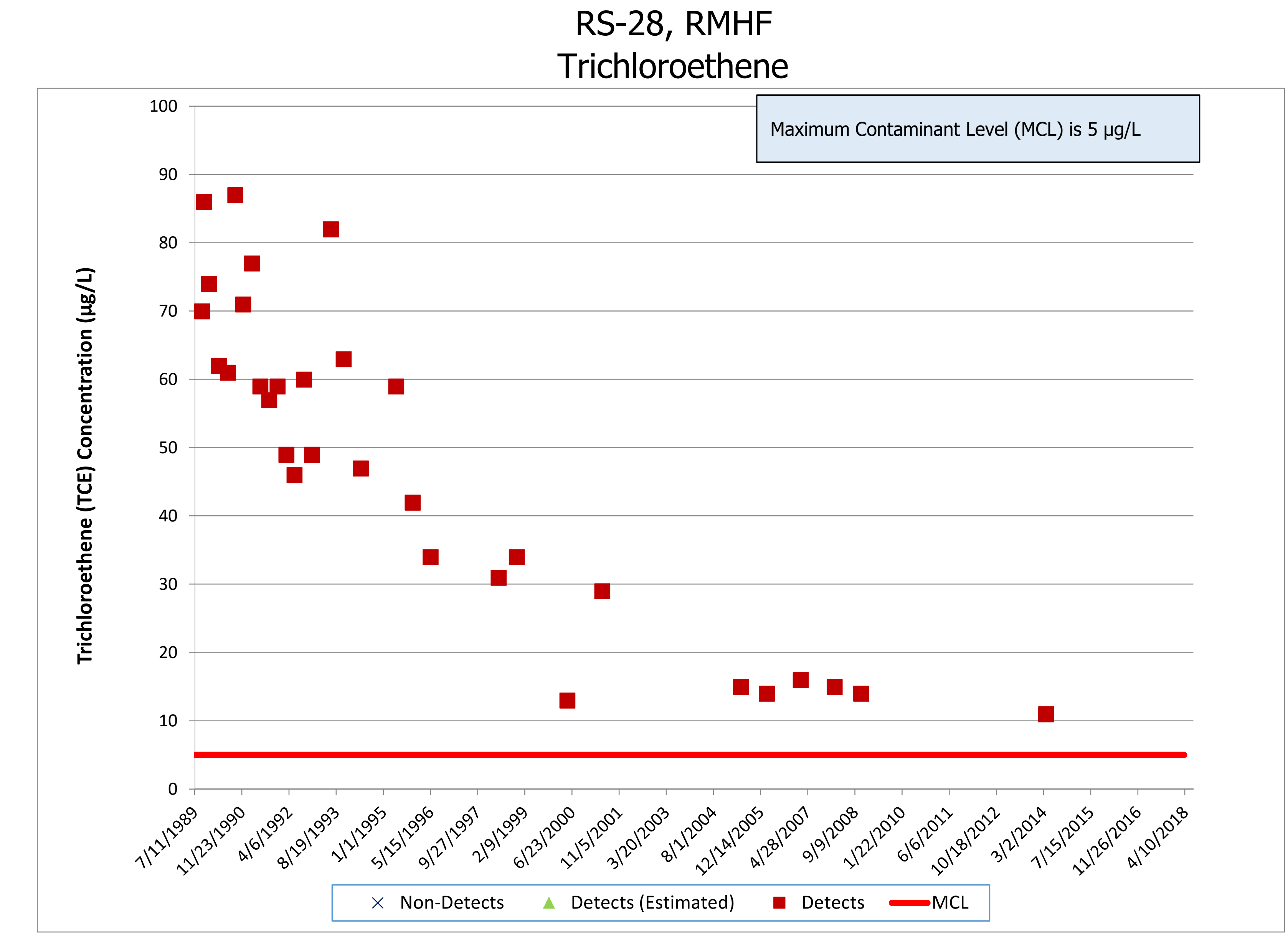
RD-34A, RMHF
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
100
90
80
70
60
50
40
30
20
10
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL


RD-34B, RMHF
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
0
2
4
6
8
10
12
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

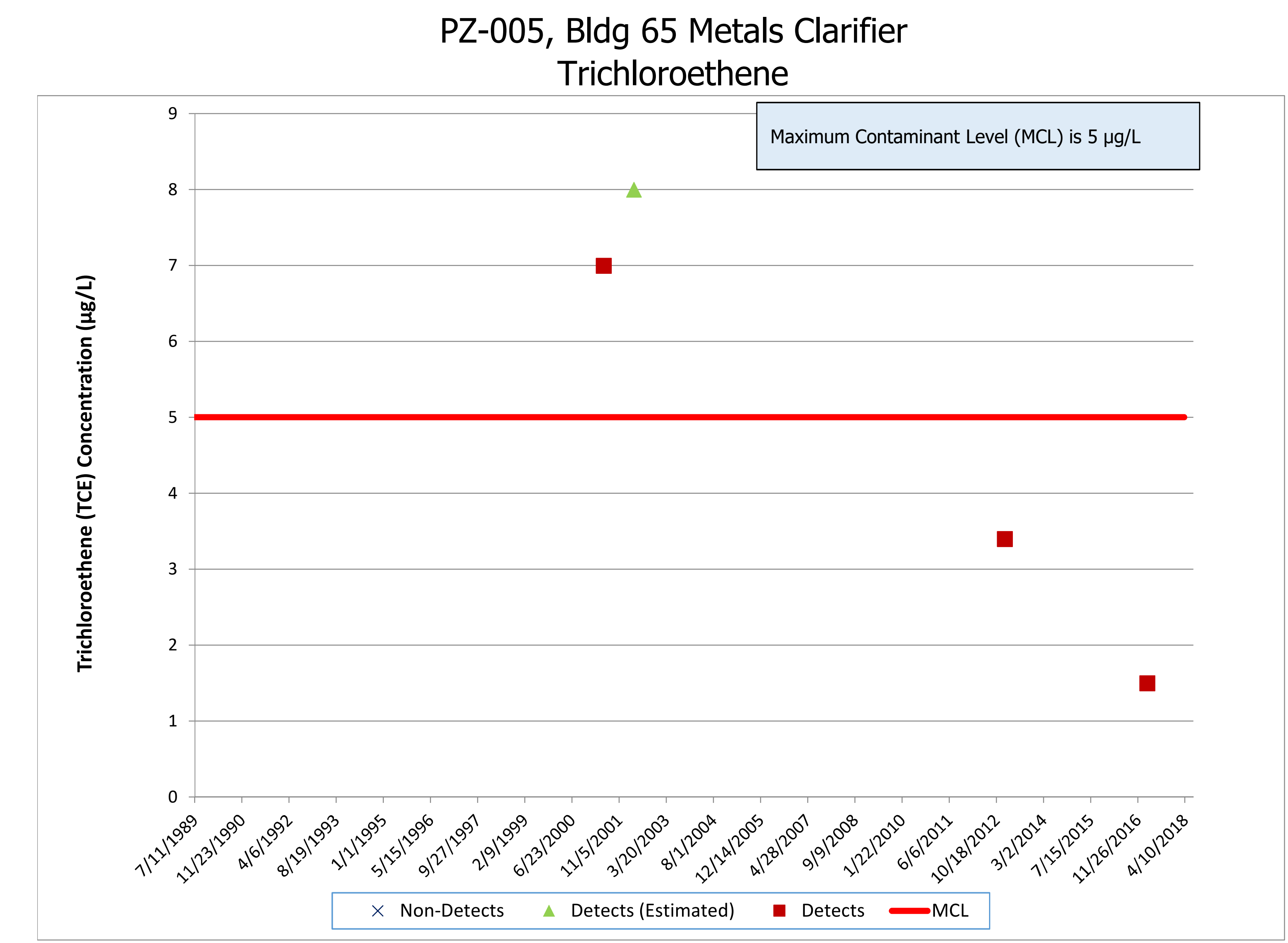
RD-63, RMHF
Trichloroethene

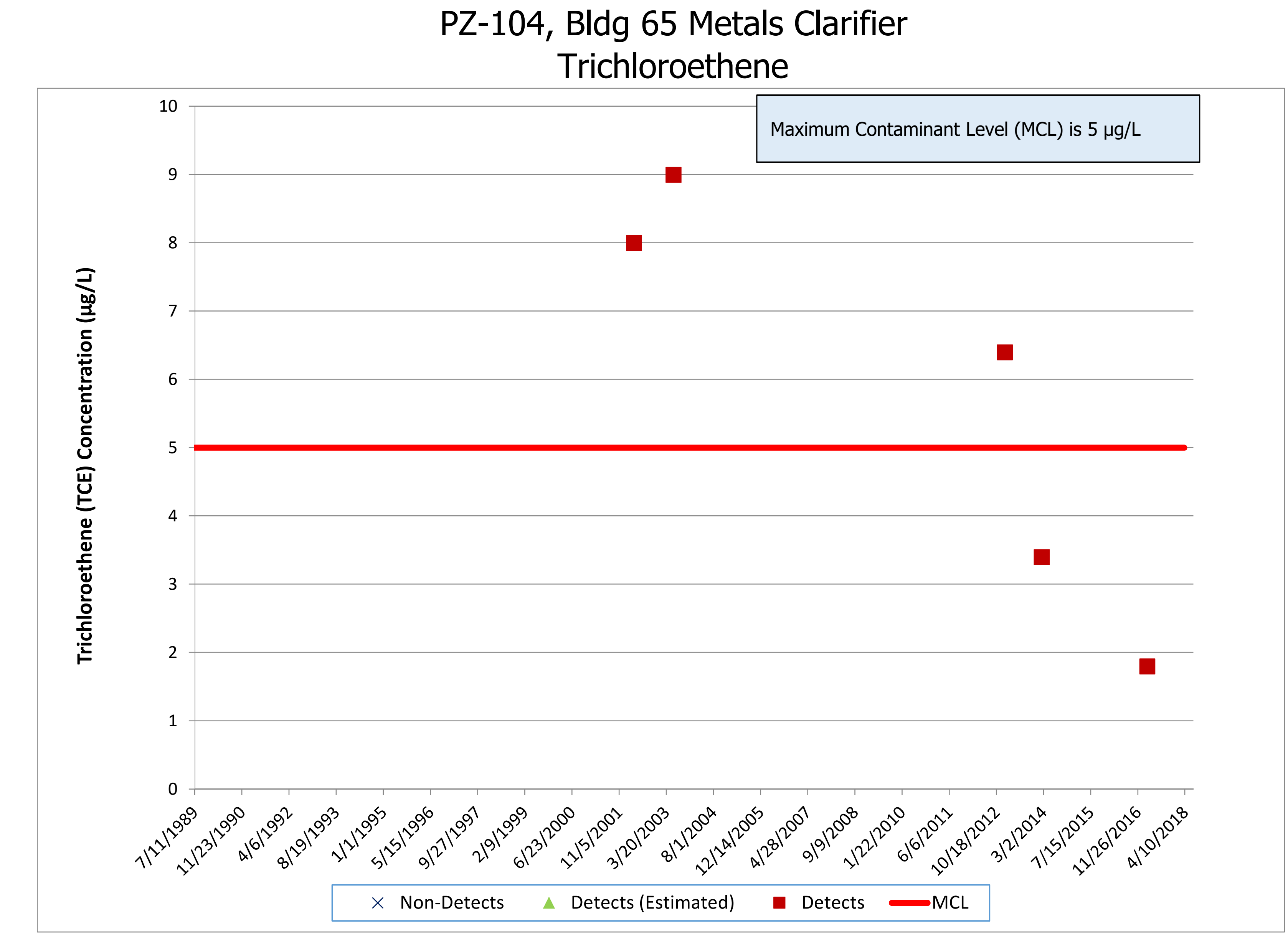


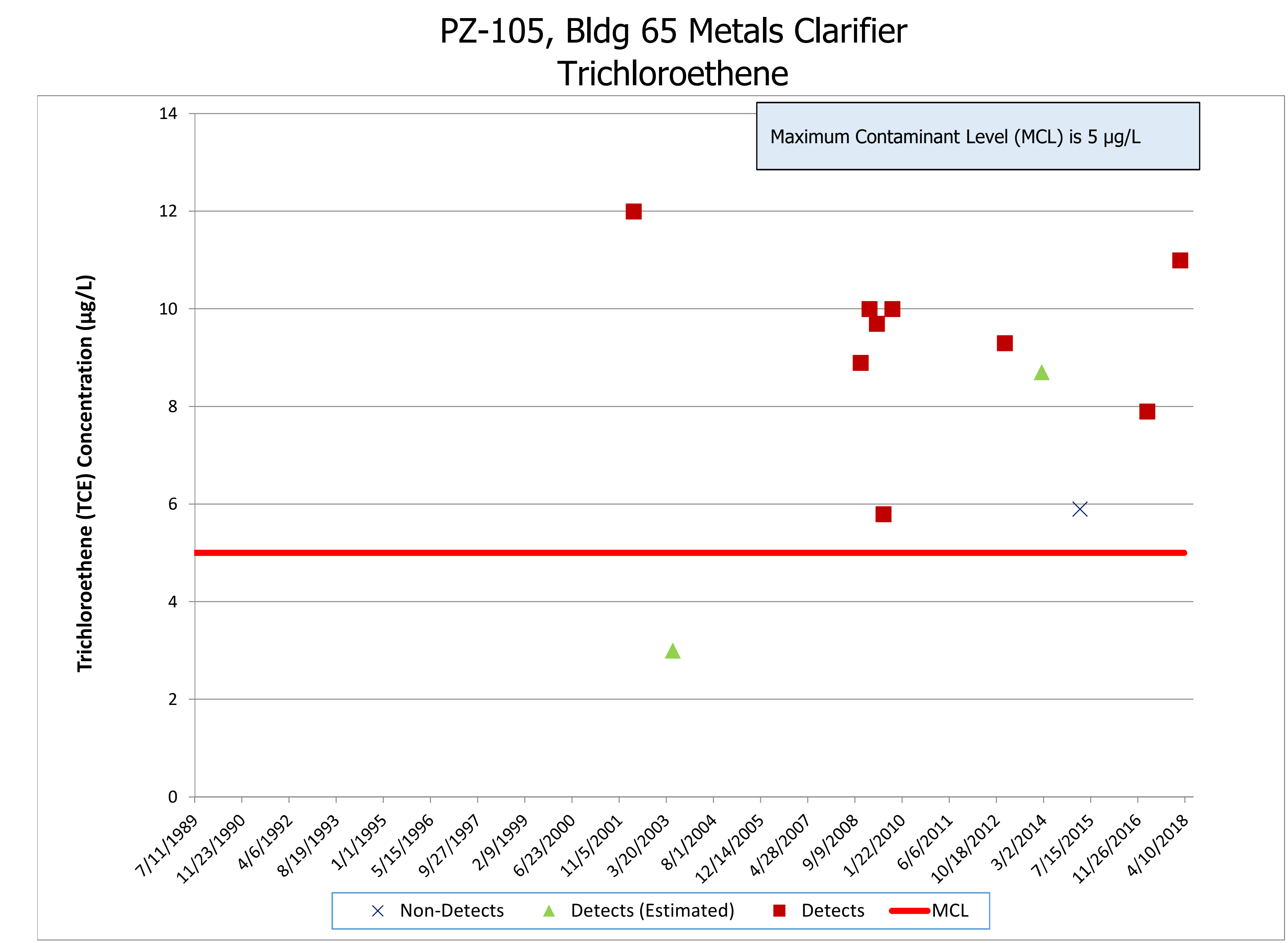

RD-98, RMHF
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
0
2
4
6
8
10
12
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL



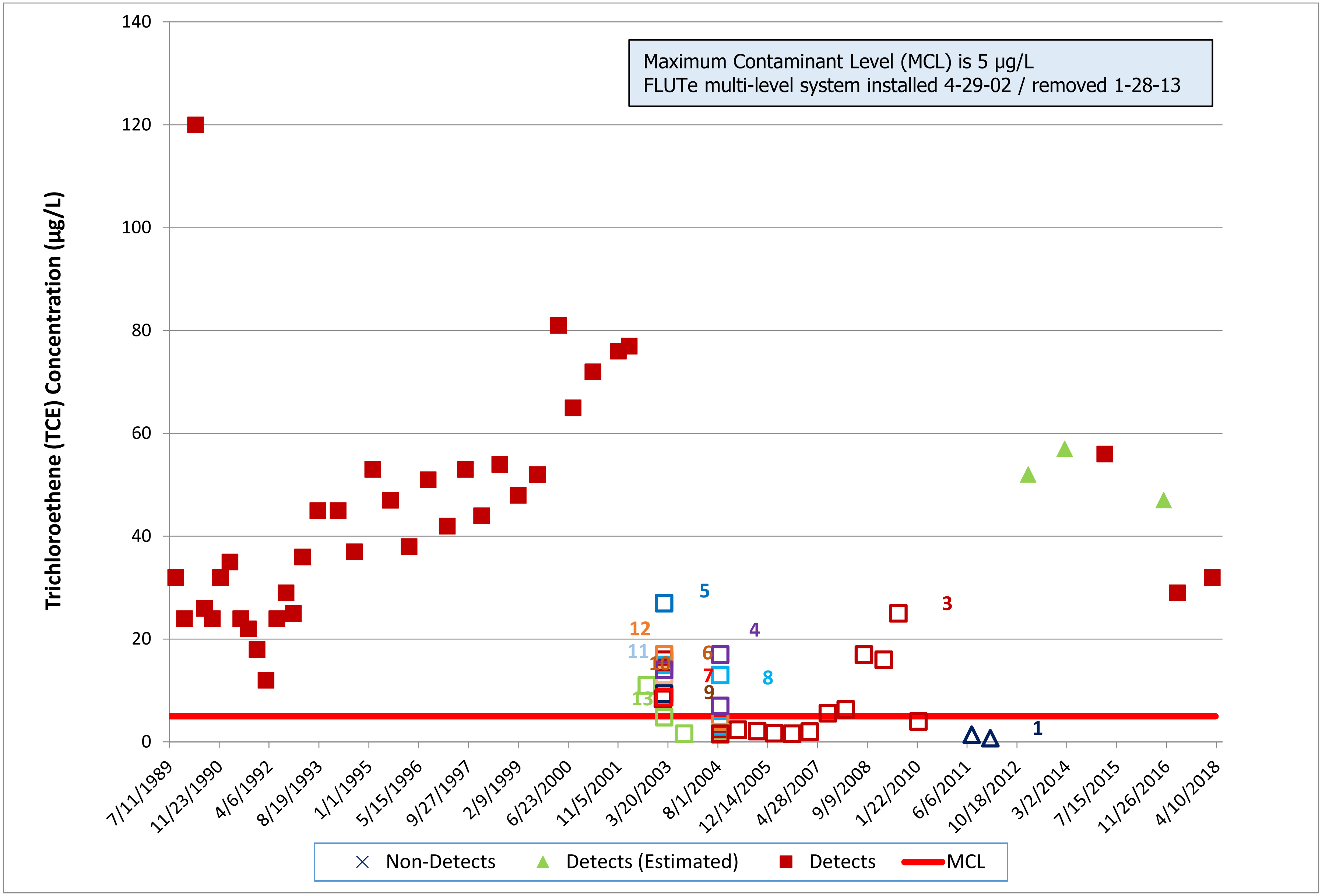
RS-28, RMHF
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
100
90
80
70
60
50
40
30
20
10
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

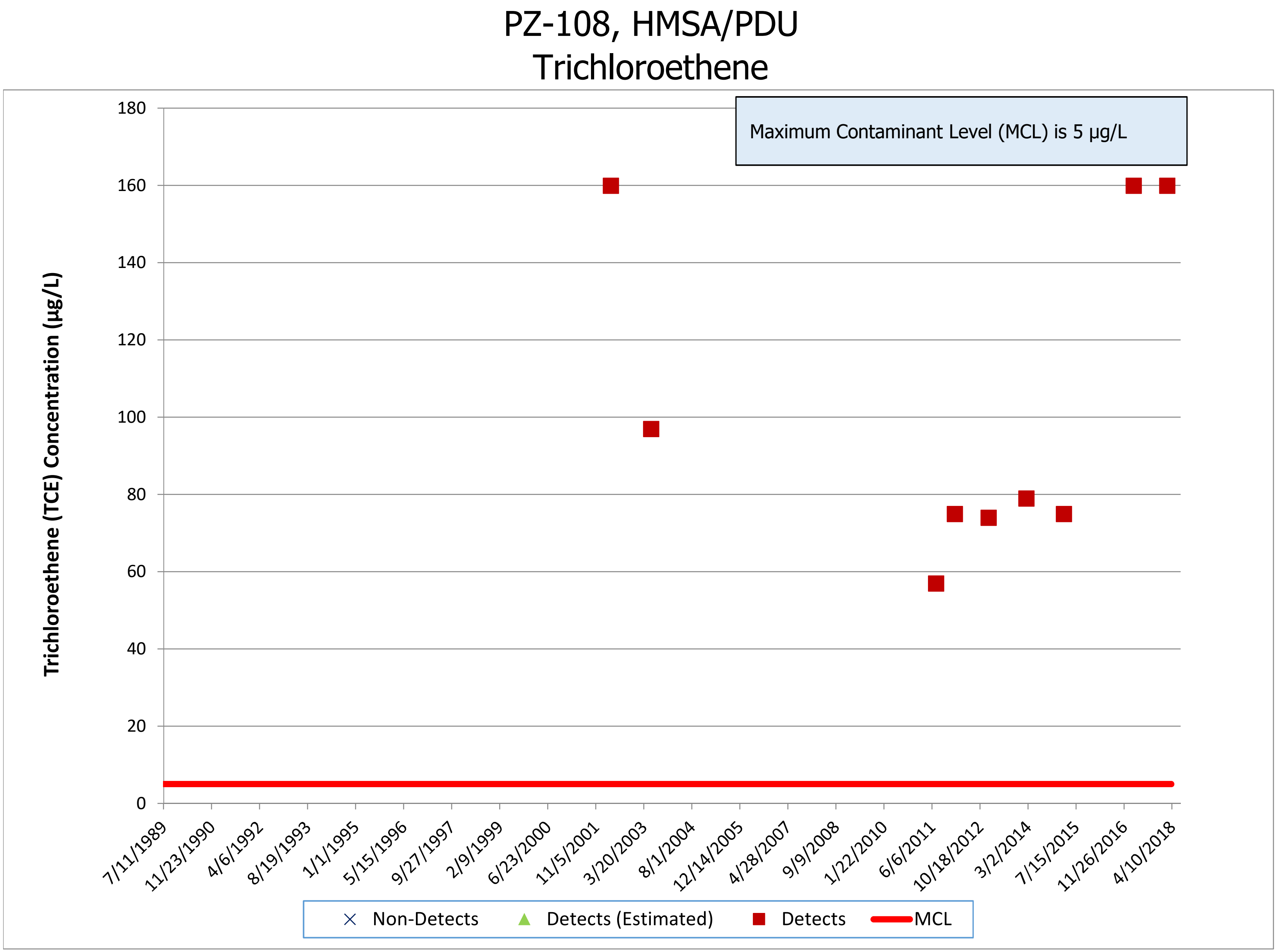

PZ-005, Bldg 65 Metals Clarifier
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
0
1
2
3
4
5
6
7
8
9
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL


PZ-104, Bldg 65 Metals Clarifier
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
10
9
8
7
6
5
4
3
2
1
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL


PZ-105, Bldg 65 Metals Clarifier
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
0
2
4
6
8
10
12
14
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

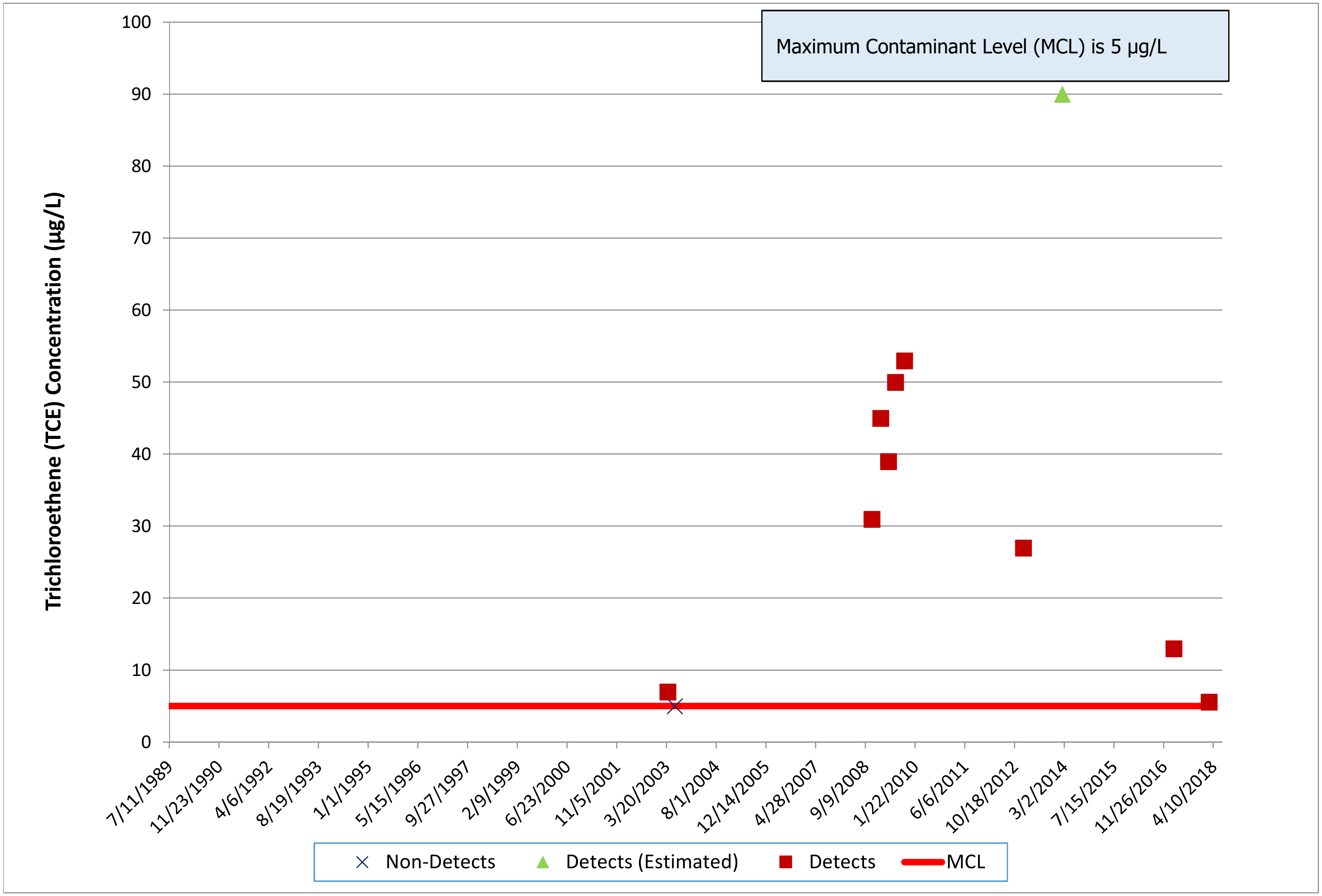
RD-07, Bldg 56 Landfill
Trichloroethene

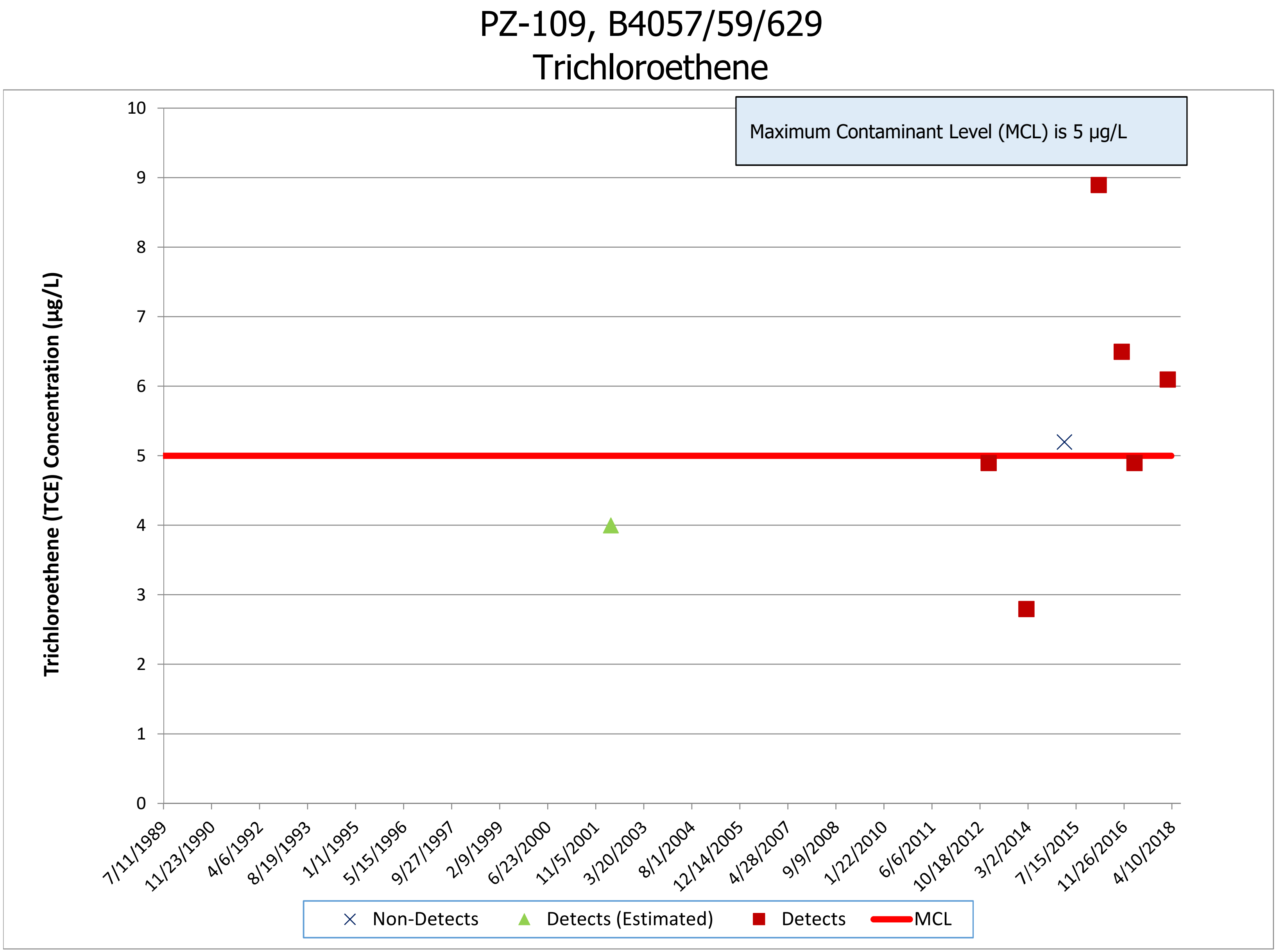


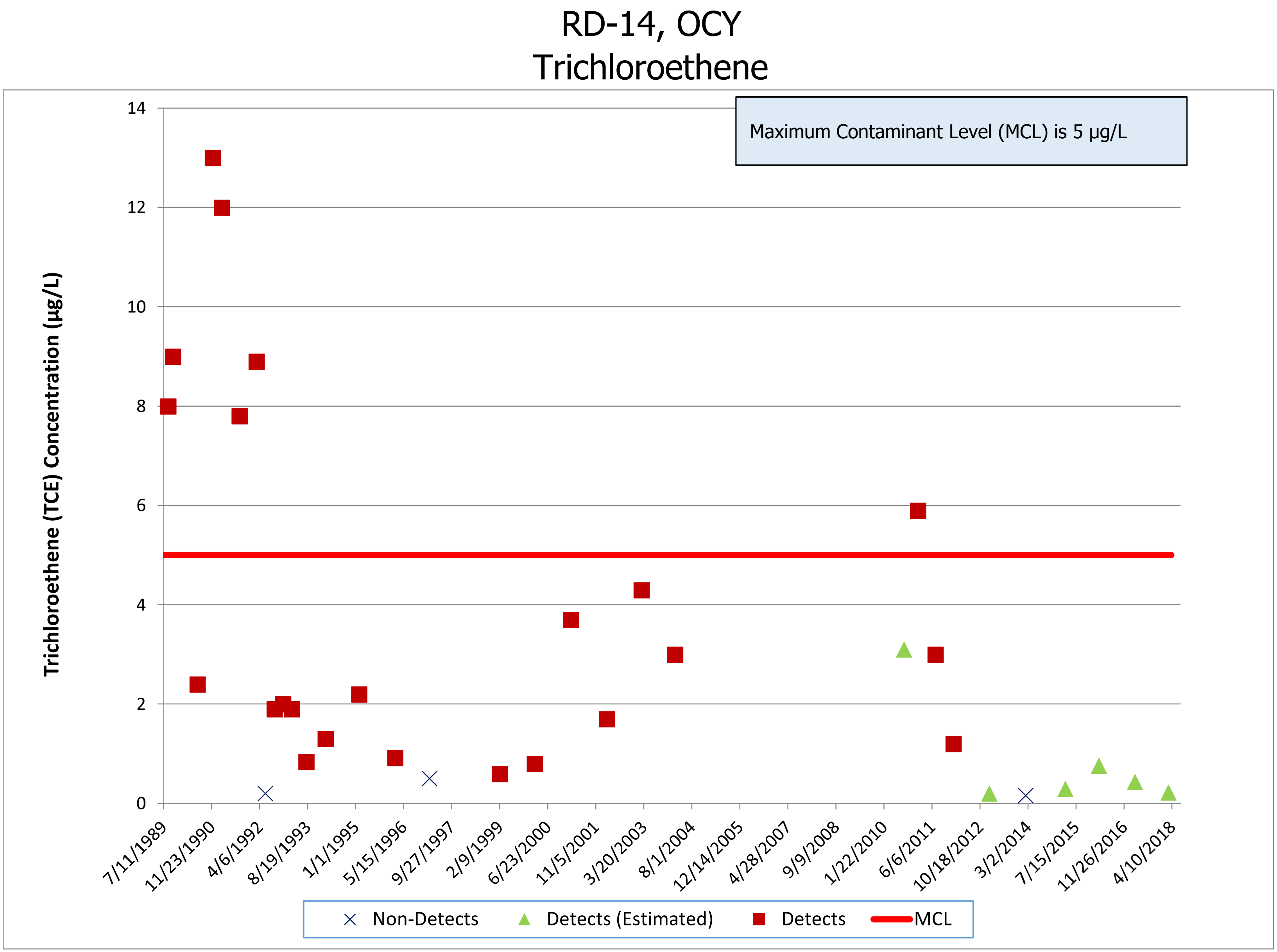


PZ-108, HMSA/PDU
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
180
160
140
120
100
80
60
40
20
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

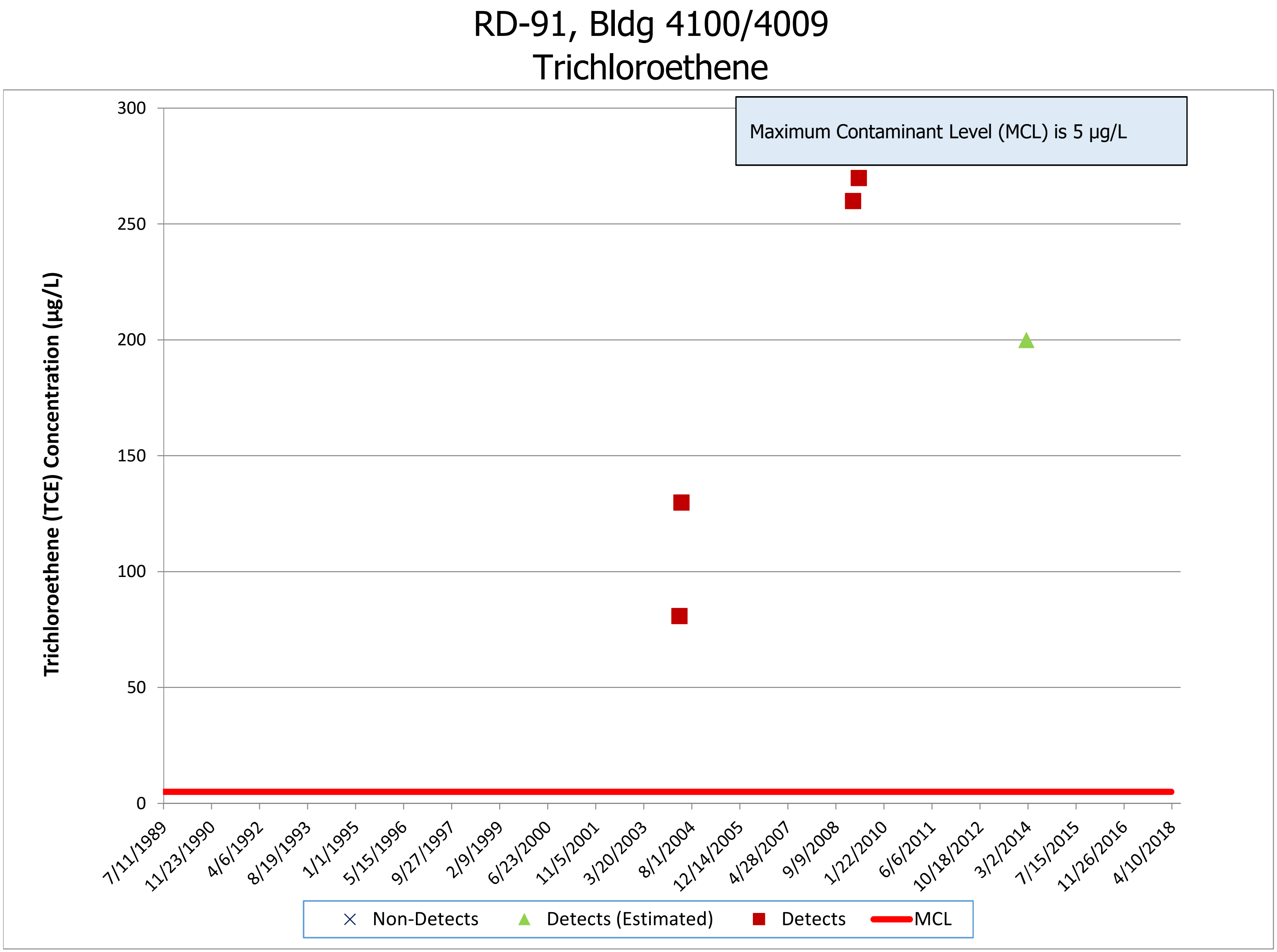
PZ-120, HMSA/PDU
Trichloroethene

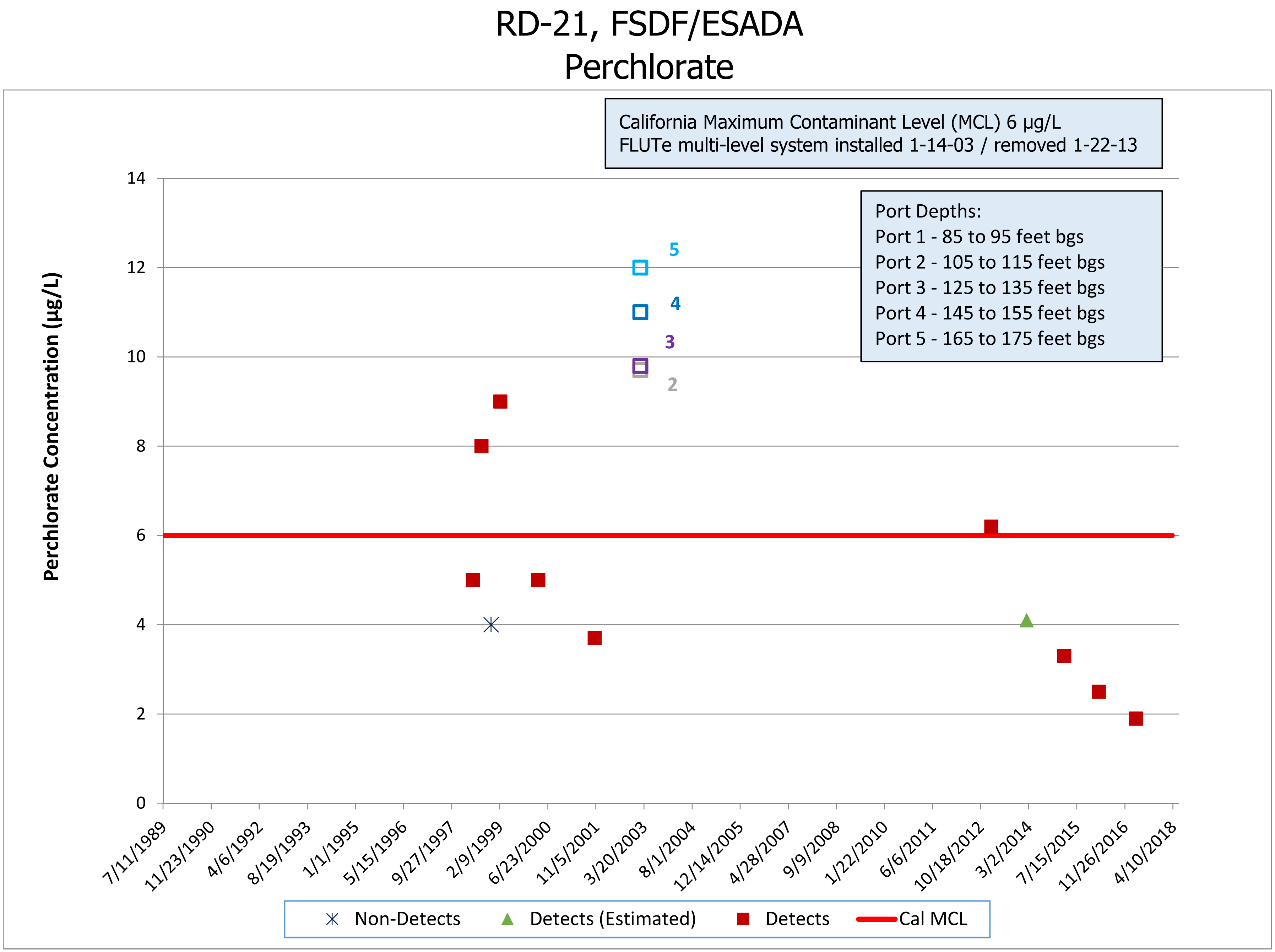



PZ-109, B4057/59/629
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
0
1
2
3
4
5
6
7
8
9
10
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

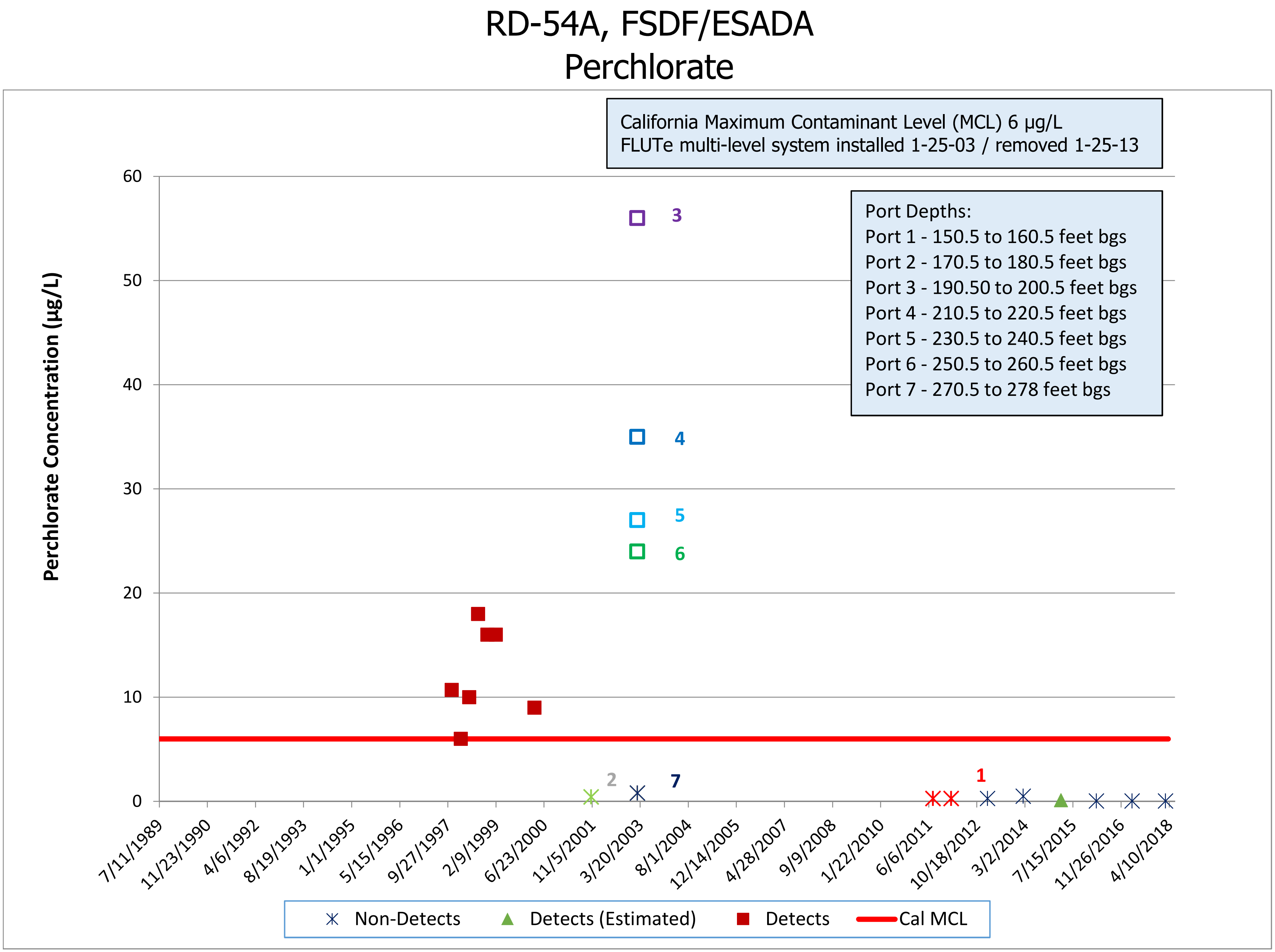


RD-14, OCY
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
14
12
10
8
6
4
2
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

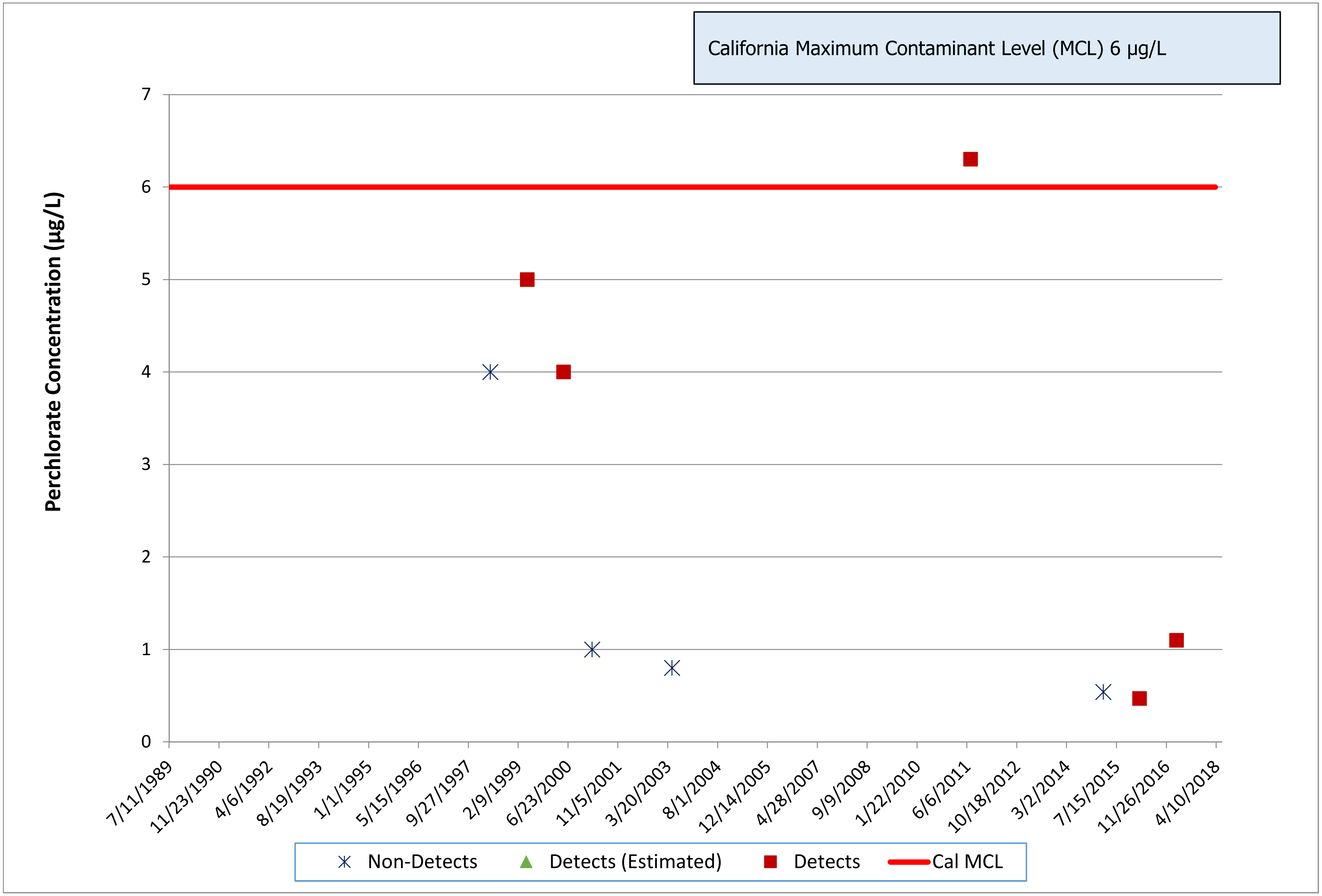

RD-91, Bldg 4100/4009
Trichloroethene
Maximum Contaminant Level (MCL) is 5 µg/L
Trichloroethene (TCE) Concentration (µg/L)
300
250
200
150
100
50
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
MCL

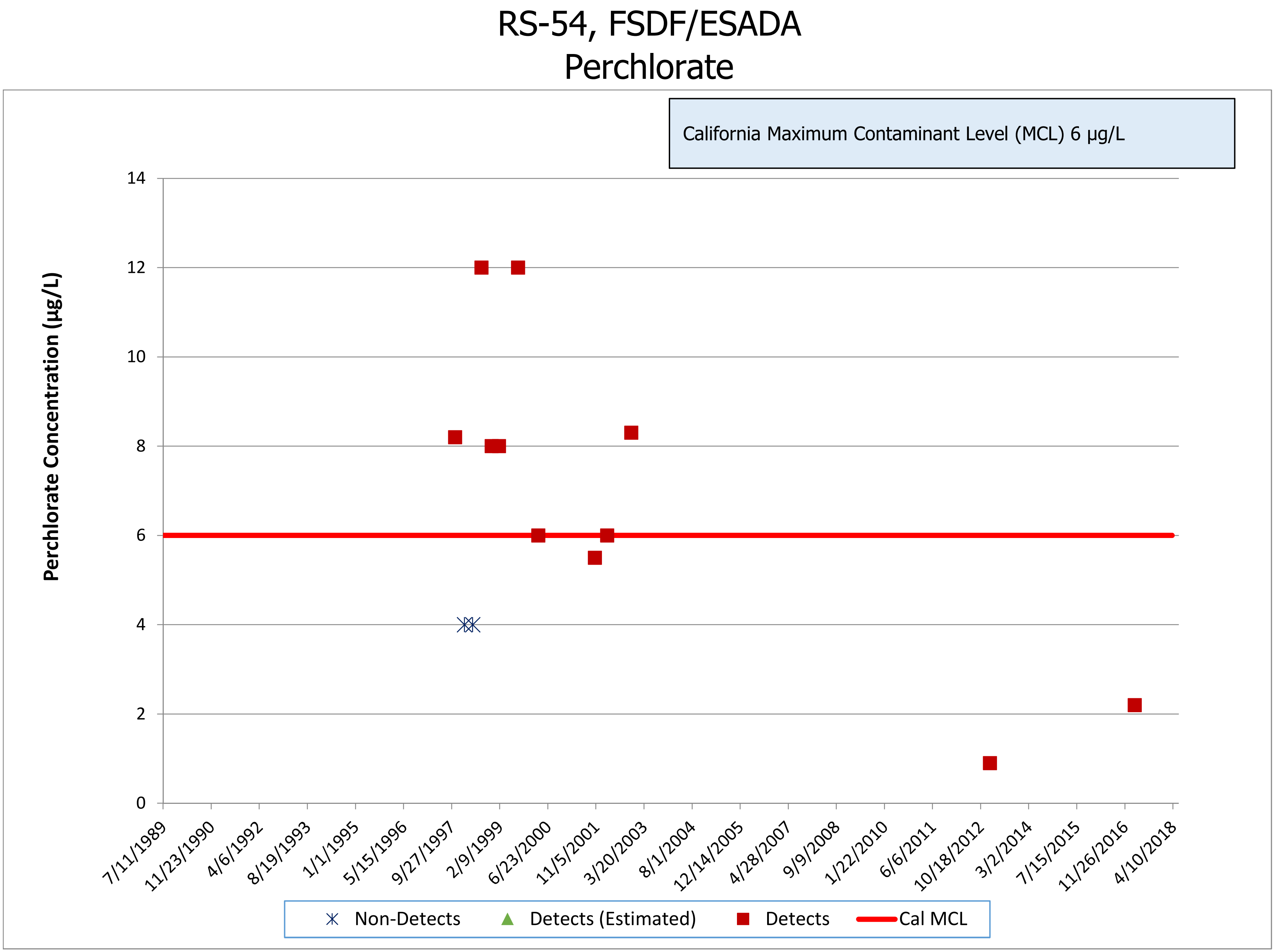


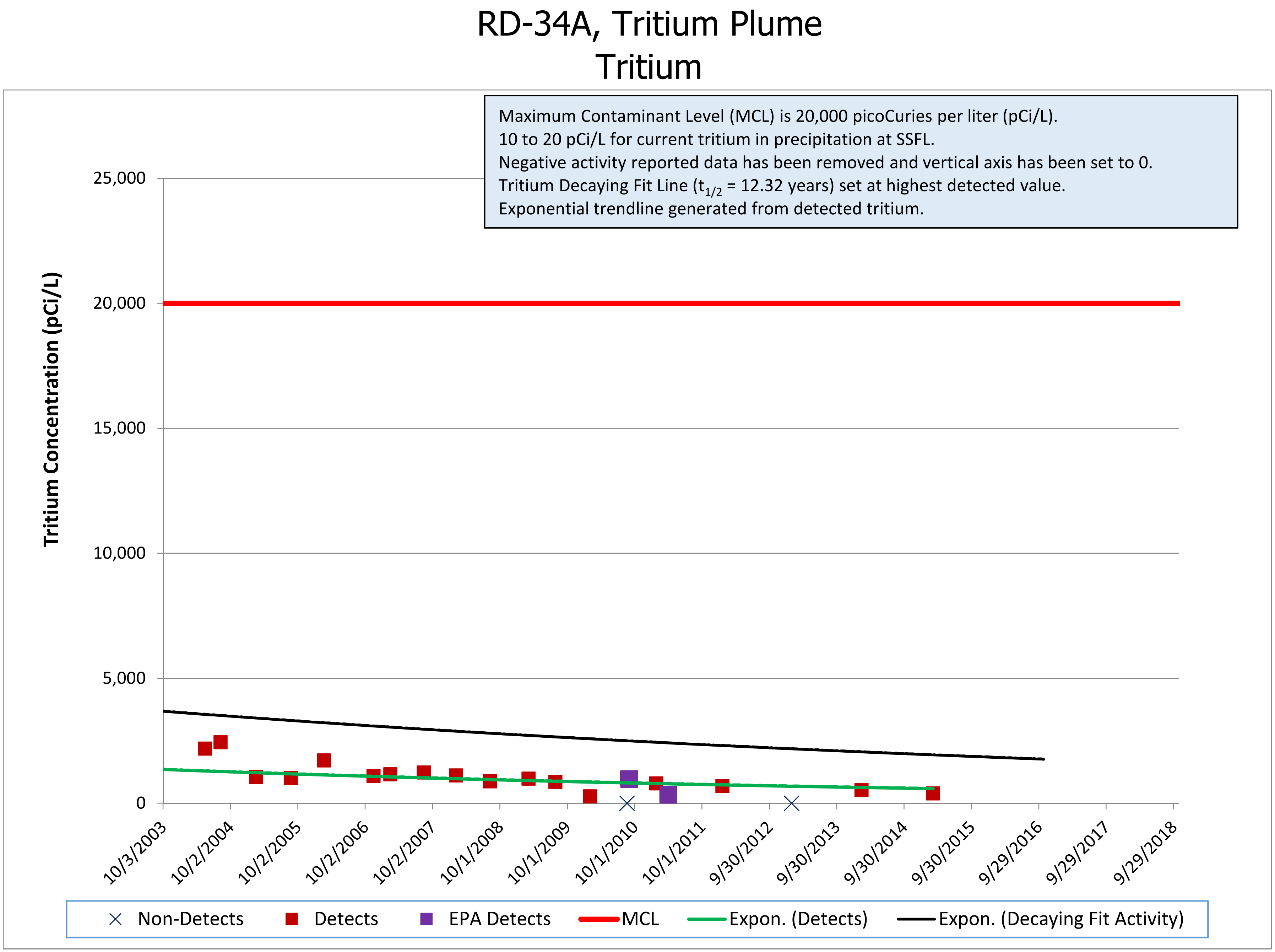
RD-21, FSDF/ESADA
Perchlorate
California Maximum Contaminant Level (MCL) 6 µg/L
FLUTe multi-level system installed 1-14-03 / removed 1-22-13
Port Depths:
Port 1 - 85 to 95 feet bgs
Port 2 - 105 to 115 feet bgs
Port 3 - 125 to 135 feet bgs
Port 4 - 145 to 155 feet bgs
Port 5 - 165 to 175 feet bgs
5
4
3
2
Perchlorate Concentration (µg/L)
0
2
4
6
8
10
12
14
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
Cal MCL


RD-54A, FSDF/ESADA
Perchlorate
California Maximum Contaminant Level (MCL) 6 µg/L
FLUTe multi-level system installed 1-25-03 / removed 1-25-13
Port Depths:
Port 1 - 150.5 to 160.5 feet bgs
Port 2 - 170.5 to 180.5 feet bgs
Port 3 - 190.50 to 200.5 feet bgs
Port 4 - 210.5 to 220.5 feet bgs
Port 5 - 230.5 to 240.5 feet bgs
Port 6 - 250.5 to 260.5 feet bgs
Port 7 - 270.5 to 278 feet bgs
Perchlorate Concentration (µg/L)
60
50
40
30
20
10
0
3
4
5
6
2
7
1
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
Cal MCL

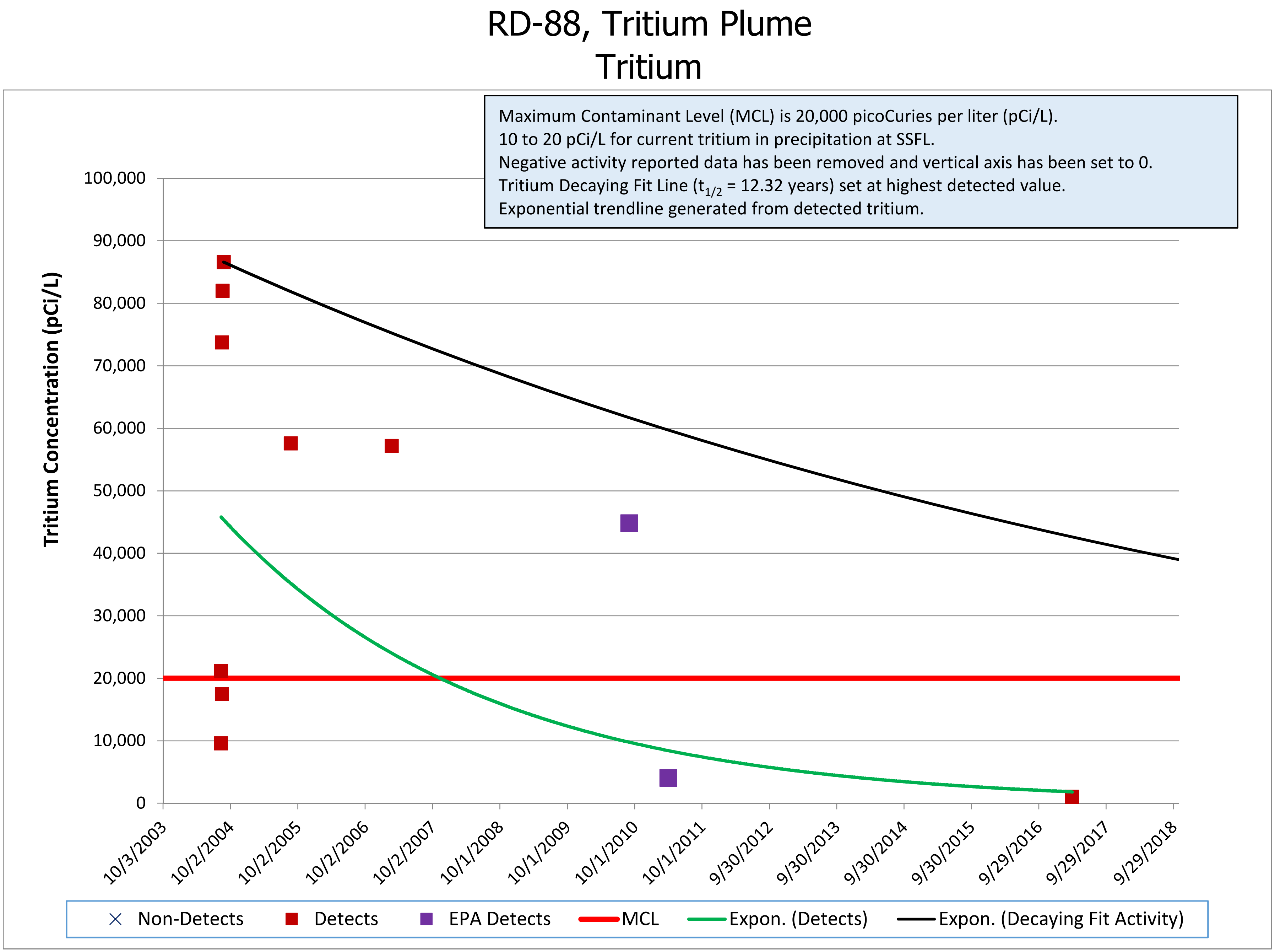
RS-18, FSDF/ESADA
Perchlorate

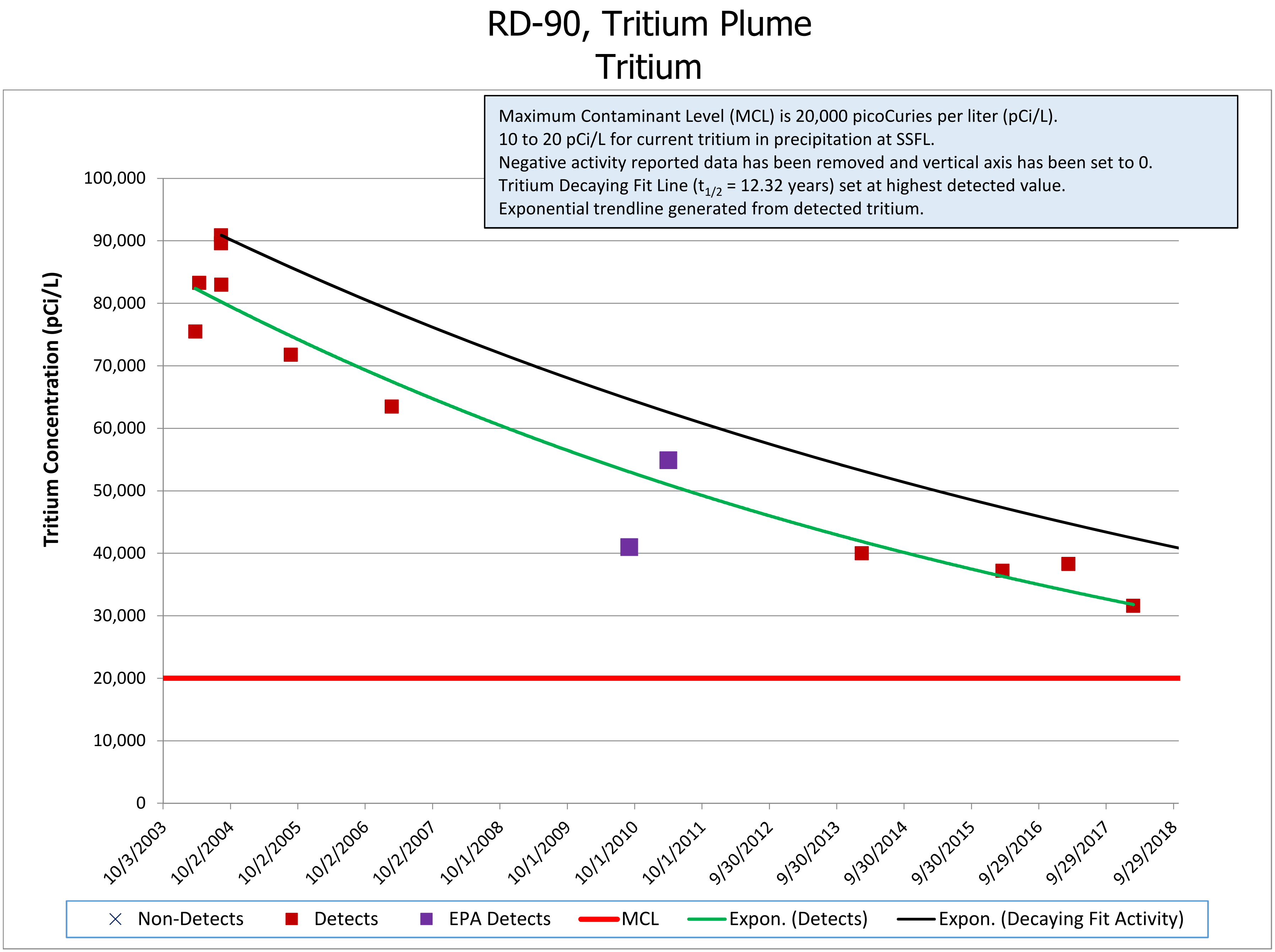



RS-54, FSDF/ESADA
Perchlorate
California Maximum Contaminant Level (MCL) 6 µg/L
Perchlorate Concentration (µg/L)
14
12
10
8
6
4
2
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003
8/1/2004
12/14/2005
4/28/2007
9/9/2008
1/22/2010
6/6/2011
10/18/2012
3/2/2014
7/15/2015
11/26/2016
4/10/2018
Non-Detects
Detects (Estimated)
Detects
Cal MCL

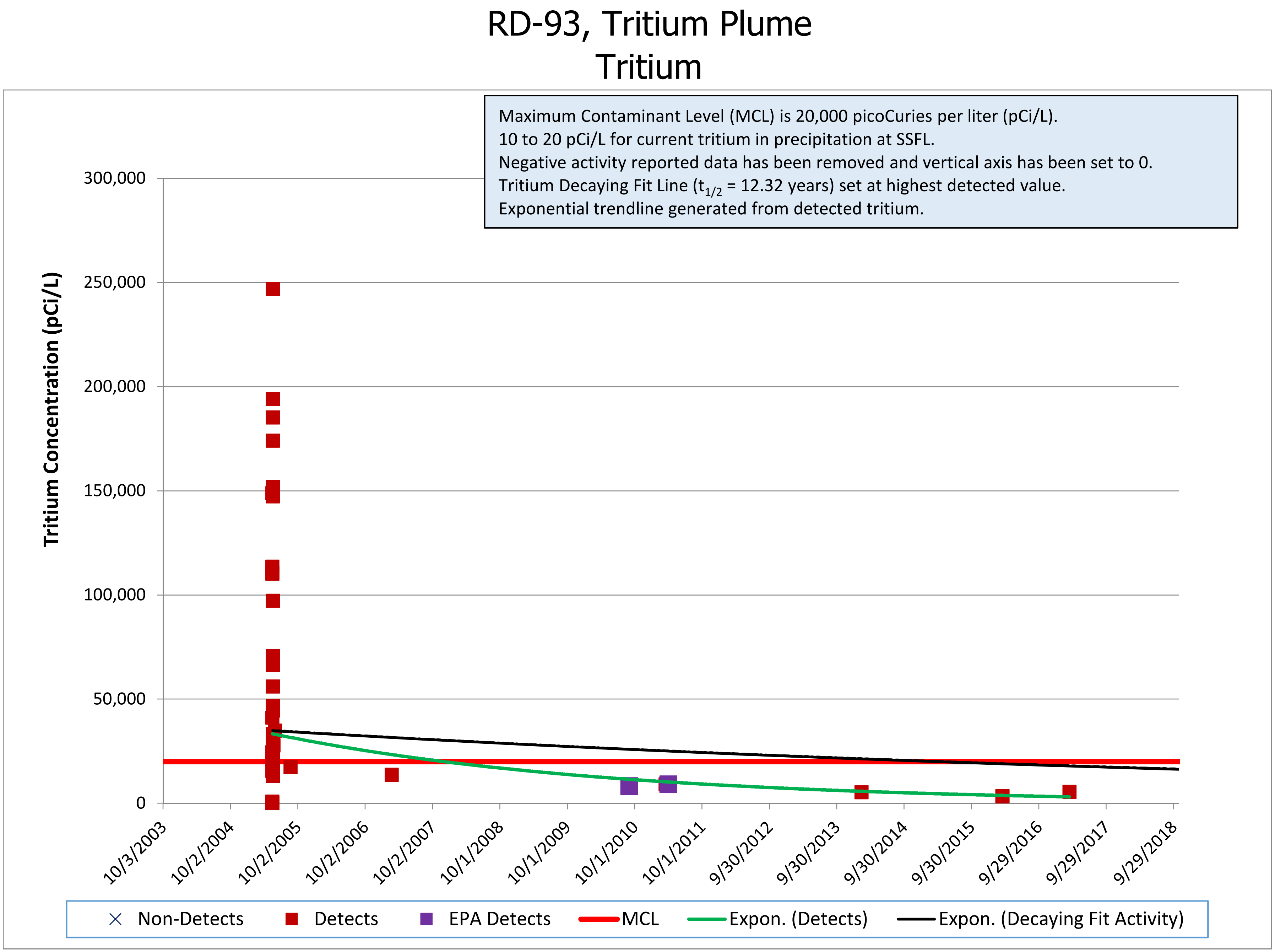


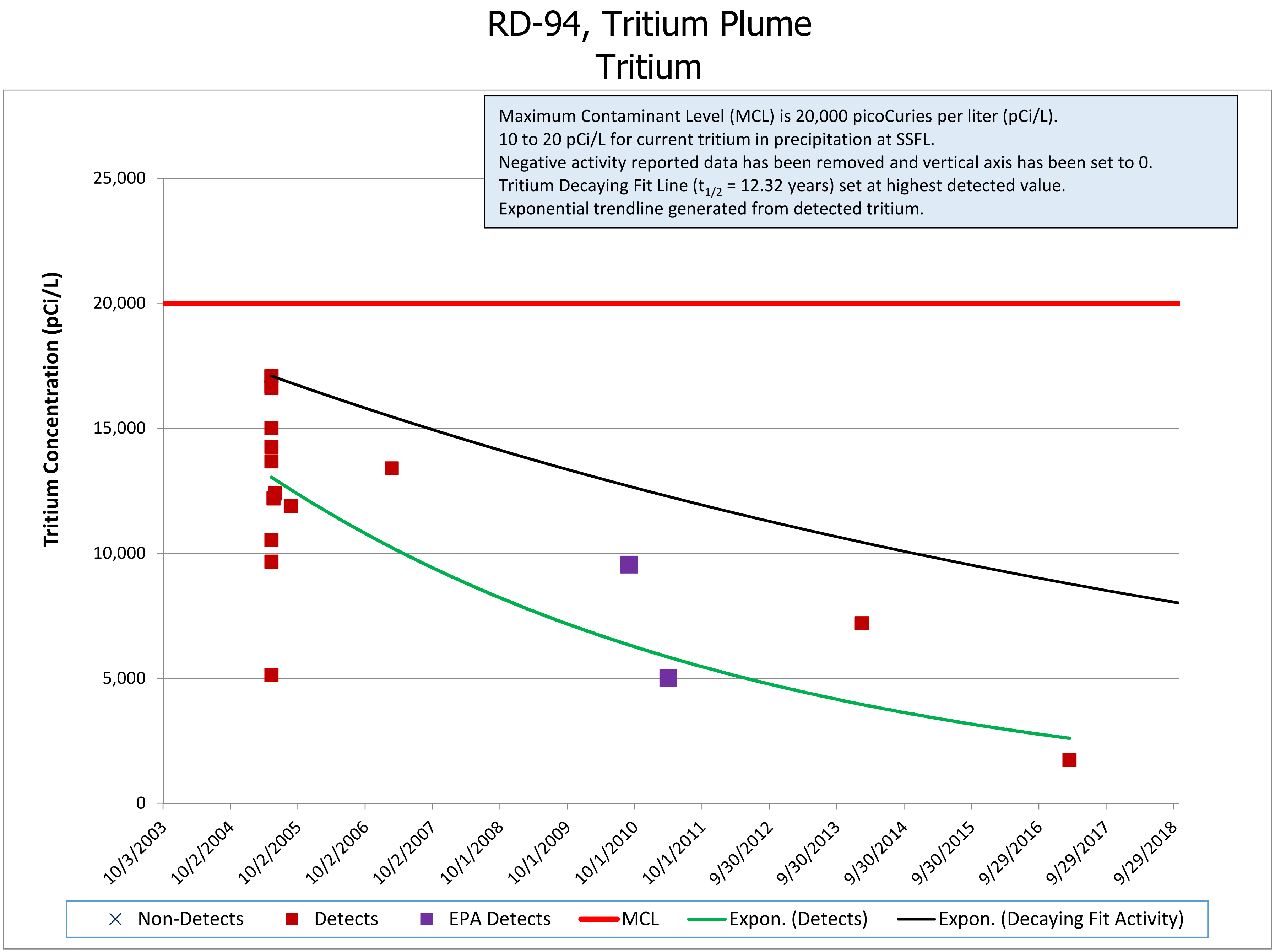
RD-34A, Tritium Plume
Tritium
Maximum Contaminant Level (MCL) is 20,000 picoCuries per liter (pCi/L).
10 to 20 pCi/L for current tritium in precipitation at SSFL.
Negative activity reported data has been removed and vertical axis has been set to 0.
Tritium Decaying Fit Line (t1/2 = 12.32 years) set at highest detected value.
Exponential trendline generated from detected tritium.
Tritium Concentration (pCi/L)
25,000
20,000
15,000
10,000
5,000
0
10/3/2003
10/2/2004
10/2/2005
10/2/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
9/30/2015
9/29/2016
9/29/2017
9/29/2018
Non-Detects
Detects
EPA Detects
MCL
Expon. (Detects)
Expon. (Decaying Fit Activity)

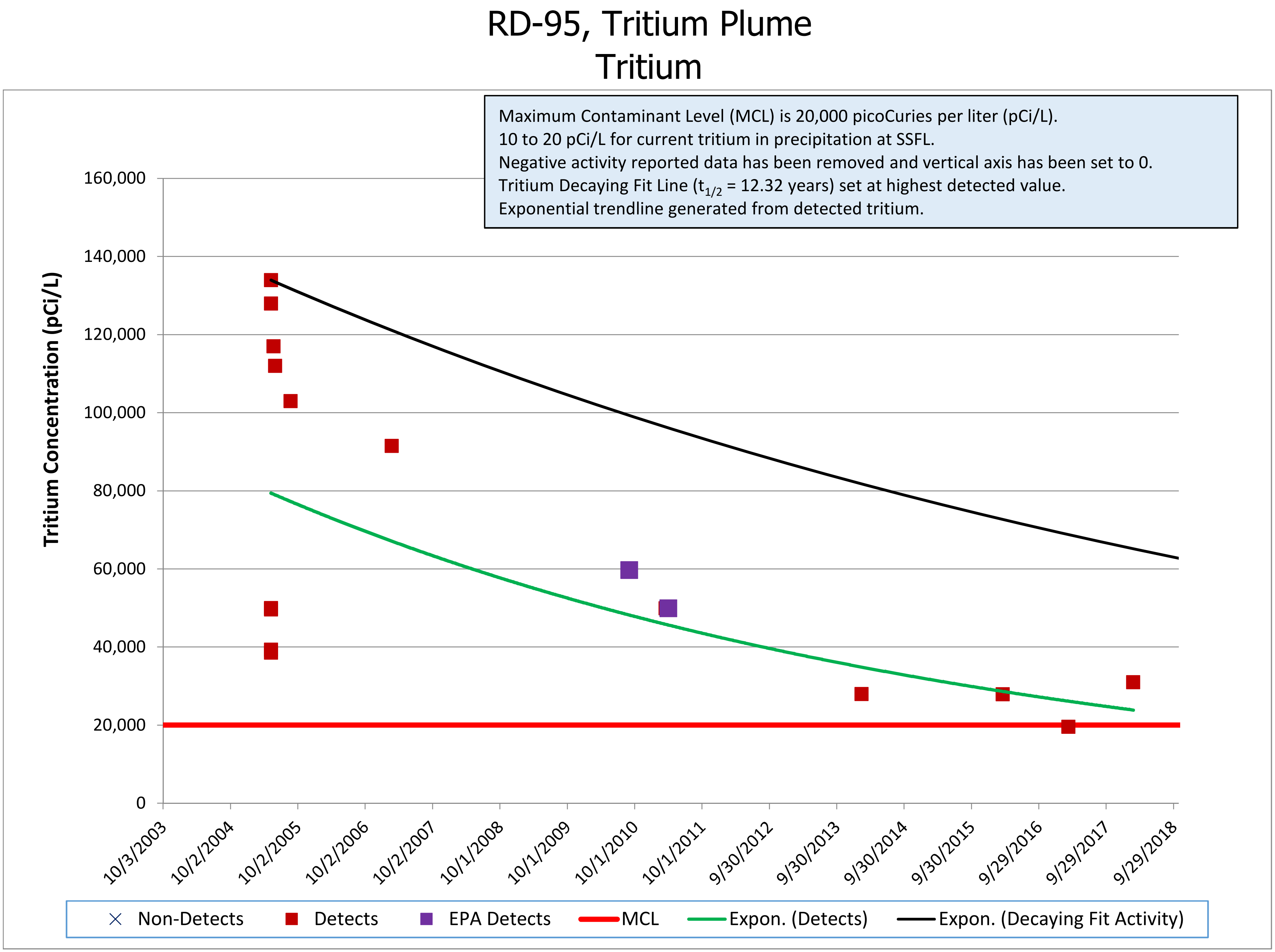

RD-88, Tritium Plume
Tritium
Maximum Contaminant Level (MCL) is 20,000 picoCuries per liter (pCi/L).
10 to 20 pCi/L for current tritium in precipitation at SSFL.
Negative activity reported data has been removed and vertical axis has been set to 0.
Tritium Decaying Fit Line ($t_{1/2}$ = 12.32 years) set at highest detected value.
Exponential trendline generated from detected tritium.
Tritium Concentration (pCi/L)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
10/3/2003
10/2/2004
10/2/2005
10/2/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
9/30/2015
9/29/2016
9/29/2017
9/29/2018
Non-Detects
Detects
EPA Detects
MCL
Expon. (Detects)
Expon. (Decaying Fit Activity)



RD-90, Tritium Plume
Tritium
Maximum Contaminant Level (MCL) is 20,000 picoCuries per liter (pCi/L).
10 to 20 pCi/L for current tritium in precipitation at SSFL.
Negative activity reported data has been removed and vertical axis has been set to 0.
Tritium Decaying Fit Line ($t_{1/2}$ = 12.32 years) set at highest detected value.
Exponential trendline generated from detected tritium.
Tritium Concentration (pCi/L)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
10/3/2003
10/2/2004
10/2/2005
10/2/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
9/30/2015
9/29/2016
9/29/2017
9/29/2018
Non-Detects
Detects
EPA Detects
MCL
Expon. (Detects)
Expon. (Decaying Fit Activity)


RD-93, Tritium Plume
Tritium
Maximum Contaminant Level (MCL) is 20,000 picoCuries per liter (pCi/L).
10 to 20 pCi/L for current tritium in precipitation at SSFL.
Negative activity reported data has been removed and vertical axis has been set to 0.
Tritium Decaying Fit Line ($t_{1/2}$ = 12.32 years) set at highest detected value.
Exponential trendline generated from detected tritium.
Tritium Concentration (pCi/L)
300,000
250,000
200,000
150,000
100,000
50,000
0
10/3/2003
10/2/2004
10/2/2005
10/2/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
9/30/2015
9/29/2016
9/29/2017
9/29/2018
Non-Detects
Detects
EPA Detects
MCL
Expon. (Detects)
Expon. (Decaying Fit Activity)


RD-94, Tritium Plume
Tritium
Maximum Contaminant Level (MCL) is 20,000 picoCuries per liter (pCi/L).
10 to 20 pCi/L for current tritium in precipitation at SSFL.
Negative activity reported data has been removed and vertical axis has been set to 0.
Tritium Decaying Fit Line ($t_{1/2}$ = 12.32 years) set at highest detected value.
Exponential trendline generated from detected tritium.
Tritium Concentration (pCi/L)
25,000
20,000
15,000
10,000
5,000
0
10/3/2003
10/2/2004
10/2/2005
10/2/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
9/30/2015
9/29/2016
9/29/2017
9/29/2018
Non-Detects
Detects
EPA Detects
MCL
Expon. (Detects)
Expon. (Decaying Fit Activity)



RD-95, Tritium Plume
Tritium
Maximum Contaminant Level (MCL) is 20,000 picoCuries per liter (pCi/L).
10 to 20 pCi/L for current tritium in precipitation at SSFL.
Negative activity reported data has been removed and vertical axis has been set to 0.
Tritium Decaying Fit Line ($t_{1/2}$ = 12.32 years) set at highest detected value.
Exponential trendline generated from detected tritium.
Tritium Concentration (pCi/L)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
10/3/2003
10/2/2004
10/2/2005
10/2/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
9/30/2015
9/29/2016
9/29/2017
9/29/2018
Non-Detects
Detects
EPA Detects
MCL
Expon. (Detects)
Expon. (Decaying Fit Activity)

Appendix B

Data Validation Qualifier Definitions

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Inorganic Data Validation Qualifiers

Flag	Definition
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting quality control criteria. The analyte may or may not be present in the sample.

Organic Data Validation Qualifiers

Flag	Definition
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting quality control criteria. The analyte may or may not be present in the sample.
NJ	Presumptively present at an estimated quantity (use with Tentatively Identified Compounds (TICs) only). A TIC is a compound not specified on the Target Compound List (TCL). A mass spectral library search is used to identify the compound.

Radiochemical Data Validation Qualifiers

Flag	Definition
	The analysis was performed, and radioactivity was detected (e.g., the radioanalytical result is statistically positive at the 95% confidence interval and is above its MDC). **NOTE:** *The radionuclide is considered to be present in the sample.*
U	The analysis was performed, but no radioactivity was detected (i.e., the radioanalytical result was not statistically positive at the 95% confidence interval and/or the result was below its MDC). The "U" qualifier flag is also applicable to any result reported as zero (0) (± an associated uncertainty). **NOTE:** *The radionuclide is not considered to be present in the sample.*
UJ	The analysis was performed, but the result is highly questionable due to analytical and/or laboratory quality control anomalies. The use of such a result is strongly discouraged. Analytical and quality control anomalies include such items as: significant blank contamination, known photopeak interferences and/or photopeak resolution problems, known matrix interferences, unacceptable laboratory control sample recoveries, serious instrument calibration problems, improper sample preservation, etc. The "UJ" qualifier flag could designate a possible false positive result in the case of a result that is statistically positive at the 95% confidence level. The "UJ" qualifier flag could indicate the result is considered an estimated non-detect (a non-detect that may be due to loss of analyte from lack of sample preservation, holding time exceedances, etc.). The specific use of the "UJ" flag is included by the validator in the text of the validation report. **NOTE:** *The radionuclide may or may not be present in the sample and the result is considered highly questionable.*
J	The analysis was performed, and radioactivity was detected (i.e., the radionuclide result is statistically positive at the 95% confidence interval and is above its MDC). However, the result is questionable due to analytical and/or laboratory quality control anomalies/ irregularities and should therefore be used only as an estimated (approximated) quantity. Analytical and/or quality control anomalies include such items as: laboratory duplicate imprecision, unsatisfactory analytical yields, insufficient laboratory control sample recoveries, unacceptable PE sample results, instrument calibration problems, improper sample preservation, etc. **NOTE:** *The radionuclide is considered to be present in the sample; however, the result may not be an accurate representation of the amount of activity actually present in the sample.*
R	The analysis result is unusable and was rejected due to severe analytical and/or quality control problems. **NOTE:** *The radionuclide may or may not be present, and the result is known to be inaccurate or imprecise.*