DRAFT FINAL

Remedial Action Injection Summary Memorandum

Sites FT005, LF008, ST010, SS014, DS002, and DS004

Niagara Falls Air Reserve Station, New York

Prepared for

Air Force Civil Engineer Center

Environmental Restoration Division

Lackland Air Force Base, Texas 78236-9853

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Acronyms and Abbreviations

bgs	Below ground surface
COC	Contaminants of concern
CVOC	Chlorinated volatile organic compound
DCE	Dichloroethene
DOD	Department of Defense
DPT	Direct push technology
EA	EA Engineering, P.C. and Its Affiliate EA Science and Technology
EPA	United States Environmental Protection Agency
EVO	Emulsified vegetable oil
EZVI	Emulsified vegetable oil and zero valent iron mixture
ft	Foot/feet
HPT	Hydraulic profiling tool
IDW	Investigation-derived waste
IRP	Installation Restoration Program
Lbs	Pounds
mg/l	Milligrams per liter
ORC	Oxygen release compound
NYSDEC	New York State Department of Environmental Conservation
PBR	Performance based remediation
pH	Potential hydrogen
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
RA	Remedial action
ROI	Radius of influence
TCE	Trichloroethene
TAL	Target analyte list
TCL	Target compound list
VC	Vinyl chloride
VOC	Volatile organic compound
ZVI	Zero valent iron

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1.0 Introduction

The U.S. Department of the Air Force, Air Force Civil Engineer Center, has retained Versar, Inc. and its teaming partner EA Engineering, P.C. and its affiliate EA Science and Technology (EA) on behalf of the 914th Airlift Wing Mission Support Group/Civil Engineering-Environmental under Contract No. FA8903-09-D-8588, Task Order 0006, to perform remedial actions under a Performance Based Remediation (PBR) contract, at the Niagara Falls Air Reserve Station in Niagara Falls, New York (Figure 1-1).

As part of the PBR, Remedial Actions (RAs) were conducted at six sites (Figure 1-2) managed under the United States Department of Defense (DOD) Installation Restoration Program (IRP) and in compliance with the requirements of a New York State Department of Environmental Conservation (NYSDEC) Part 373 hazardous waste storage permit (Permit Number 9-2999-00005/00008 issued on 9 March 2010).

The primary objective of the RAs is to reduce chlorinated volatile organic compounds (CVOCs) in the overburden and the shallow bedrock groundwater at Sites FT005, LF008, ST010, DS002, and DS004 using a synergistic mixture of emulsified vegetable oil (EVO) and zero valent iron (ZVI) (EZVI). The primary objective of the RA for Site SS014 is to reduce the concentrations of volatile organic compounds (VOCs) in the overburden and shallow bedrock groundwater using an oxygen release compound (ORC).

This report provides a summary of the injections, and the initial data collected immediately before, during, and immediately after the remedial action conducted during summer 2015 including:

- Injections of EZVI at FT005 – Site 10 (Section 2)
- Injections of EZVI at LF008 – Site 3 (Section 3)
- Injections of EZVI sampling at ST010 – Site 13 (Section 4)
- ORC application at SS014 – Site 7 (Section 5)
- Injections of EZVI at DS002 – Site 8 (Section 6)
- Injections of EZVI at DS004 – Site 5 (Section 7).

Data collected as part of these injections will be used to evaluate the effectiveness of the remedial actions at each site, which will be detailed in a subsequent Injection summary report, which will follow the completion of the performance monitoring.

1.1 Overview of Field Activities

Field activities were performed in accordance with the RA Quality Assurance Project Plan (QAPP) for Sites FT005, LF008, ST010, SS014, DS002, and DS004 (EA 2015). The pre-design quantities versus the actual quantities injected at each site are presented in Table 1-1. A summary of groundwater analytical samples collected during the remedial action is presented in Table 1-2, and summary of pre- and post-injection water quality parameters are presented in Table 1-3.

TABLE 1-1

Target Quantities and Actual Quantities of Injectate

Site	Target Quantities			Actual Quantities		
	Injectate (gal)	ZVI (lbs)	EVO (lbs)	Injectate (gal)	ZVI (lbs)	EVO (lbs)
FT005 – Site 10	7,800	1,558	4,675	7,920	1,536	4,560
LF008 – Site 3	200	50	150	200	49	151
ST010 – Site 13	2,562	318	1,060	2,690	336	1,210
DS002 – Site 8	7,900	1,608	4,825	9,060	1,618	4,988
DS004 – Site 5	23,700	6,695	19,150	23,680	6,753	19,000
Total	42,162	10,229	29,860	43,550	10,292	29,909

NOTE: lbs = pounds
gal = gallons

Direct push injection points for Sites FT005, LF008, ST010, DS002, and DS004 and auger holes for Site SS014 were installed by Northeast Specialized Drilling, Inc. Low pressure injection services for delivering the EZVI into the subsurface was provided by OnMaterials, LLC. Prior to intrusive field activities, a Base Civil Engineering Work Clearance Request was obtained. In August 2015, EA retained a private utility locator firm (TREC Environmental, Inc.) to perform a detailed ground penetrating radar survey, which confirmed the locations of subsurface utilities and identified potential anomalies.

Investigative-derived waste (IDW) generated during field investigative activities included:

- Cuttings (soil) derived from ORC® backfill activities
- Groundwater purging fluids
- Expendable material (e.g., gloves, tubing, etc.).

Soil IDW was collected in a Department of Transportation approved 55-gallon drum at the point of generation. The drum was clearly labeled with its contents (i.e., drill cuttings and stored in a temporary staging area [storage shed]). Soil samples will be collected and analyzed for the Resource Conservation and Recovery Act characteristics (reactivity, cyanide, sulfide, ignitibility, and corrosivity), and toxicity characteristic leaching procedure (including VOCs, semi-volatile organic compounds, metals, pesticides, and herbicides), polychlorinated biphenyls, and pH. Following a review of analytical results, drummed IDW will be disposed of at an off-site disposal facility according to the facility requirements and with approval from the 914th Civil Engineer-Environmental Office.

Liquid IDW generated from monitoring well sampling and purging was disposed of at the Site 10 groundwater treatment system, as approved by the base IRP manager. Expendable waste materials generated during field investigative activities included used personal protective equipment, non-dedicated sampling materials (i.e., tubing), and waste paper. Expendable materials were properly disposed of as general debris/trash.

1.2 Laboratory Analysis and Data Validation

Laboratory analyses were conducted by Accutest Laboratories, a DOD Environmental Laboratory Accreditation Program and New York State Department of Health, Environmental Laboratory Accreditation Program-certified laboratory, using the most current NYSDEC Analytical Services Protocol methods, as per NYSDEC Division of Environmental Remediation-10 guidance (2010). As per NYSDEC

Analytical Services Protocol requirements, Category B laboratory data packages were obtained for data validation.

Laboratory data packages will be submitted to SGD Environmental for independent, third-party data validation. The data presented in this report are preliminary. Fully validated data will be submitted in the Injection Summary Report following one year of quarterly post injection monitoring.

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TABLE 1-2

Groundwater Sample Collection Summary

Remedial Action Injection Summary Memorandum

Niagara Falls Air Reserve Station, New York

Well Number	Sample Date	Purge/Sample Method	Sample Analyses	Field Quality Control Samples[(a)]
FT005 – Site 10				
MW10-2	9/28/15	Low-Flow	VOCs/Iron Kit	
MW10-1DA	9/28/15	Low-Flow	VOCs/Iron Kit	MS/MSD
MW10-10D	9/28/15	Low-Flow	VOCs/Iron Kit	Duplicate (MW10-FD-150928)
PW10-2	9/28/15	Low-Flow	VOCs/Iron Kit	
PZ10-7	9/28/15	Low-Flow	VOCs/Iron Kit	
LF008 - Site 3				
PZ3-3	9/4/15	Grab	Iron Kit	
PZ3-3D	9/4/15	Grab	Iron Kit	
PZ3-4	9/4/15	Grab	Iron Kit	
PZ3-4D	9/4/15	Grab	Iron Kit	
PW3-3A	9/4/15	Grab	Iron Kit	
MW3-4DA	9/4/15	Grab	Iron Kit	
ST010 - Site 13				
MW13-3	08/26/15	Low-Flow	VOCs/Iron Kit	
MW13-4	08/26/15	Low-Flow	VOCs/Iron Kit	
MW13-5A	08/26/15	Low-Flow	VOCs/Iron Kit	
MW13-5D	08/26/15	Low-Flow	VOCs/Iron Kit	
PW13-1	08/26/15	Low-Flow	VOCs/Iron Kit	
PZ13-3D	08/26/15	Low-Flow	VOCs/Iron Kit	Duplicate (PZ13-FD-15082
SS014 - Site 7				
MW7-1D	9/8/15	Grab	VOCs	MS/MSD, Duplicate (MW7-FD-150908)
DS002 - Site 8				
MW8-1	8/28/15	Low-Flow	VOCs/Iron Kit	
MW8-10D	9/1/15	Low-Flow	VOCs/Iron Kit	MS/MSD, Duplicate (MW8-FD-150901)
CH8-01	9/1/15	Low-Flow	VOCs/Iron Kit	
MW8-8	9/1/15	Low-Flow	VOCs/Iron Kit	

(a) A trip blank was collected at the beginning of the sample collection event.

(b) The grab sample was collected from the well during active pumping.

NOTES: ***PZ3-9D*** = Bold and Italicized wells were installed during the Pre-Design Investigation

QC = Quality control.

VOC = Volatile organic compound (Method 8260B).

MS/MSD = Matrix spike/matrix spike duplicate.

FD = Field duplicate.

TABLE 1-2

Groundwater Sample Collection Summary

Remedial Action Injection Summary Memorandum

Niagara Falls Air Reserve Station, New York

Well Number	Sample Date	Purge/Sample Method	Sample Analyses	Field Quality Control Samples[a]
DS004 - Site 5				
MW5-5D	9/02/15	Low Flow	VOCs/Iron Kit	MS/MSD, Duplicate (MW5-FD-150902)
RW5-1	9/02/15	Low Flow	VOCs/Iron Kit	
RW5-2	9/02/15	Low Flow	VOCs/Iron Kit	
RW5-4	9/02/15	Low Flow	VOCs/Iron Kit	

TABLE 1-3

Groundwater Geochemical Parameter Summary

Remedial Action Injection Summary Memorandum

Niagara Falls Air Reserve Station, New York

Location ID	Date Sampled	Temp (°C)	pH (s.u.)	ORP (mV)	Conductivity (µS/cm)	Turbidity (NTU)	D.O. (mg/L)	Total Iron (ppm)	Ferrous (Fe^{2+}) (ppm)
FT005 - Site 10									
Pre-Injection									
MW10-1DA	9/28/2015	16.97	7.10	-102	1.850	1.2	1.89	0.6	0
MW10-10D[2]	*9/28/2015*	na	na	na	na	na	na	na	na
MW10-2[2]	*9/28/2015*	na	na	na	na	na	na	na	na
PW10-2	9/28/2015	14.2	7.40	-130	0.898	10	7.51	0	0.4
Post-Injection									
MW10-1DA[1]	9/30/2015	14.24	7.34	-159	1.720	>800	10.54	0.6	0
MW10-10D[1]	9/30/2015	14.24	7.49	-193	0.982	>1000	5.25	na	na
MW10-2[1]	9/30/2015	14.16	7.72	-136	0.759	>1000	6.14	na	na
PW10-2[1]	10/27/2015	14.4	7.09	-190	1.550	63.8	1.20	na	na
LF008 - Site 3									
Pre-Injection									
PZ3-4D	9/4/2015	19.6	7.11	-122	0.816	98.3	1.34	45	7
PZ3-3	9/4/2015	21.43	7.05	-114	2.290	241	2.20	37.5	20
PZ3-3D	9/4/2015	17.57	7.30	-151	2.170	533	1.45	30	7.5
PW3-3A	9/4/2015	14.69	7.36	-57	1.840	0	0.70	11	5
MW3-4DA	9/4/2015	22.24	7.57	15	1.800	10.9	4.58	3	0
Post-Injection									
PW3-3A[1]	*9/30/2015*	*15.72*	*7.01*	*50*	*0.757*	*>1000*	*2.57*	*na*	*na*
PZ3-3D	9/30/2015	15.96	7.46	-117	1.780	417	1.44	0	0
PZ3-3	9/30/2015	15.78	7.21	-30	1.900	68	4.08	0	0
PZ3-4	9/30/2015	15.91	7.21	-153	0.956	68.9	2.32	0	0
MW3-4DA	9/30/2015	14.97	7.38	9	1.710	0	3.26	0	0
ST010 - Site 13									
Pre-Injection									
MW13-5A	8/25/2015	19.86	10.84	-14	4.090	8	7.48	2	0
PZ13-3D	8/26/2015	17.18	7.20	-157	3.940	47.1	0.83	>10	>10
MW13-4[2]	8/26/2015	16.61	7.29	86	6.280	212	13.74	*na*	*na*
MW13-5D	8/26/2015	17.39	6.96	99	3.940	18.8	6.92	0	0
MW13-3	8/26/2015	17.25	7.05	190	4.140	>800	4.56	10	1
PW13-1	8/26/2015	16.61	6.93	-103	3.120	2.9	0.56	10	1
Pre-Injection									
MW13-5A[1]	9/4/2015	16.2	7.4	103	1.547	>1000	1.5	135	90
PZ13-3D[1]	9/4/2015	15.8	7.6	-142	2.795	>1000	1.67	45	30
MW13-4[2]	9/4/2015	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
MW13-5D[1]	9/4/2015	16.42	6.87	76	1.623	25.9	2.49	3	1
MW13-3	9/4/2015	16.48	7.18	92	2.687	>1000	4.78	3	2
PW13-1	9/4/2015	17.56	7.21	-152	4.056	3.7	1.24	*7*	15
SS014 - Site 7									
Pre-ORC Application									
MW7-1D[2,3]	*9/8/2015*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
Post-ORC Application									
MW7-1D[2,3]	*9/30/2015*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
DS002 - Site 8									
Pre-Injection									
MW8-1	8/28/2015	18.06	6.77	-119	2.010	20.9	0.56	0.2	0.7
CH8-01	9/1/2015	14.89	7.19	-192	3.530	>800	0.48	1	1
MW8-08	9/1/2015	16.93	7.02	85	3.200	0	0.70	0	0
MW8-10D	9/1/2015	17.19	6.93	-112	2.780	12.2	0.32	1.5	0.8
Post-Injection									
MW8-8	9/30/2015	15.54	7.00	-152	3.020	620	1.54	7..5	2
MW8-10D	9/30/2015	14.69	6.73	-62	2.060	971	3.65	*7*	5
MW8-1[1]	*9/30/2015*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
CH8-01[1]	*9/30/2015*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
DS004 - Site 5									
Pre-Injection									
MW5-5D	9/2/2015	15.9	7.00	-352	1.720	0	0.66	0	0
RW5-2	9/2/2015	16.56	8.86	-181	1.150	0	1.43	3	3
RW5-1	9/2/2015	16.6	6.68	-230	1.550	8	0.69	0.4	0.4
RW5-4	9/3/2015	18.19	7.06	-169	1.960	0.1	0.69	2	2
Post - Injection									
MW5-5D	9/30/2015	13.84	7.20	-113	0.187	25.4	3.25	5	2
RW5-2	9/30/2015	14	7.20	-101	0.190	30.1	2.51	5	3
RW5-1	9/30/2015	14.14	7.24	-76	1.230	0	1.64	15	10
RW5-4[1]	*9/30/2015*	*13.98*	*7.51*	*-120*	*0.177*	*>1000*	*2.31*	*6*	*2*

1. Monitoring wells were filled with EZVI injectate and accurate groundwater geochemical readings were not obtained due to groundwater probe fouling and iron test kit incompatibility.

2. Monitoring wells would not recharge to allow for low flow sampling. The wells were sampled with bailer for VOCs.

3. Iron is not applicable to Site 7 monitoring parameters

Note: °C = degrees Celsius NTU Nephelometric Turbidity Units

s.u. = standard units D.O. = dissolved oxygen

mV = millivolts mg/L = milligrams per liter

µS/cm = micro Siemens per centimeter ppm = parts per million

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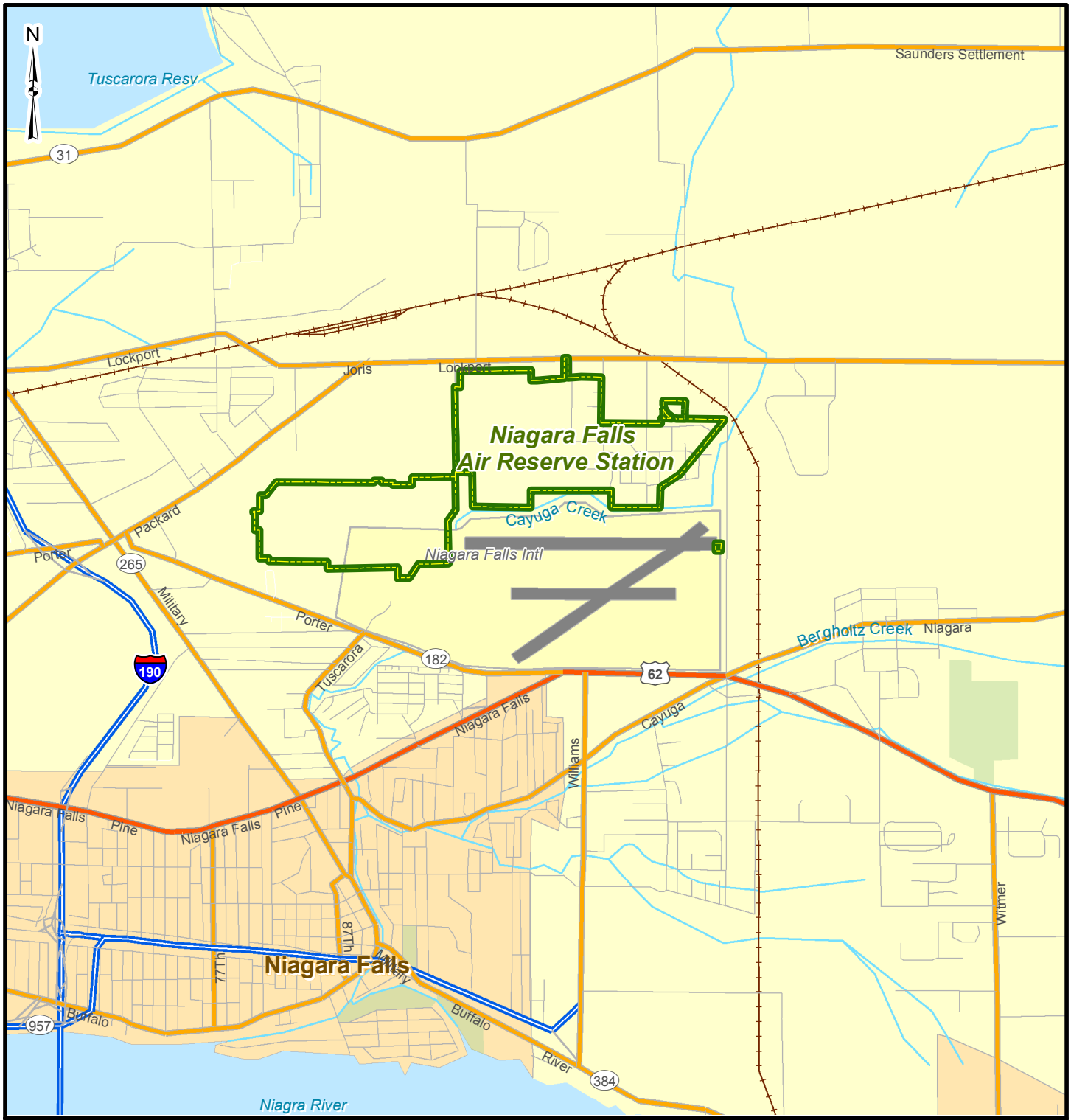

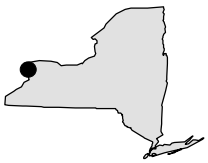

Legend

NFARS Boundary

0 1 2

Miles

EA®	Remedial Action Injection Summary Memorandum Sites FT005, LF008, ST010, SS014, DS002, and DS004 Niagara Falls Air Reserve Station Niagara Falls, New York					FIGURE 1-1 Location of Niagara Falls Air Reserve Station	
PROJECT MGR: BY	DESIGNED BY: FD	CREATED BY: FD	CHECKED BY: BY	SCALE: AS SHOWN	DATE: DECEMBER 2015	PROJECT NO: 6265401	FILE NO: G:\Projects\Federal\DOD\ 6265401_AFCEC_NFARS

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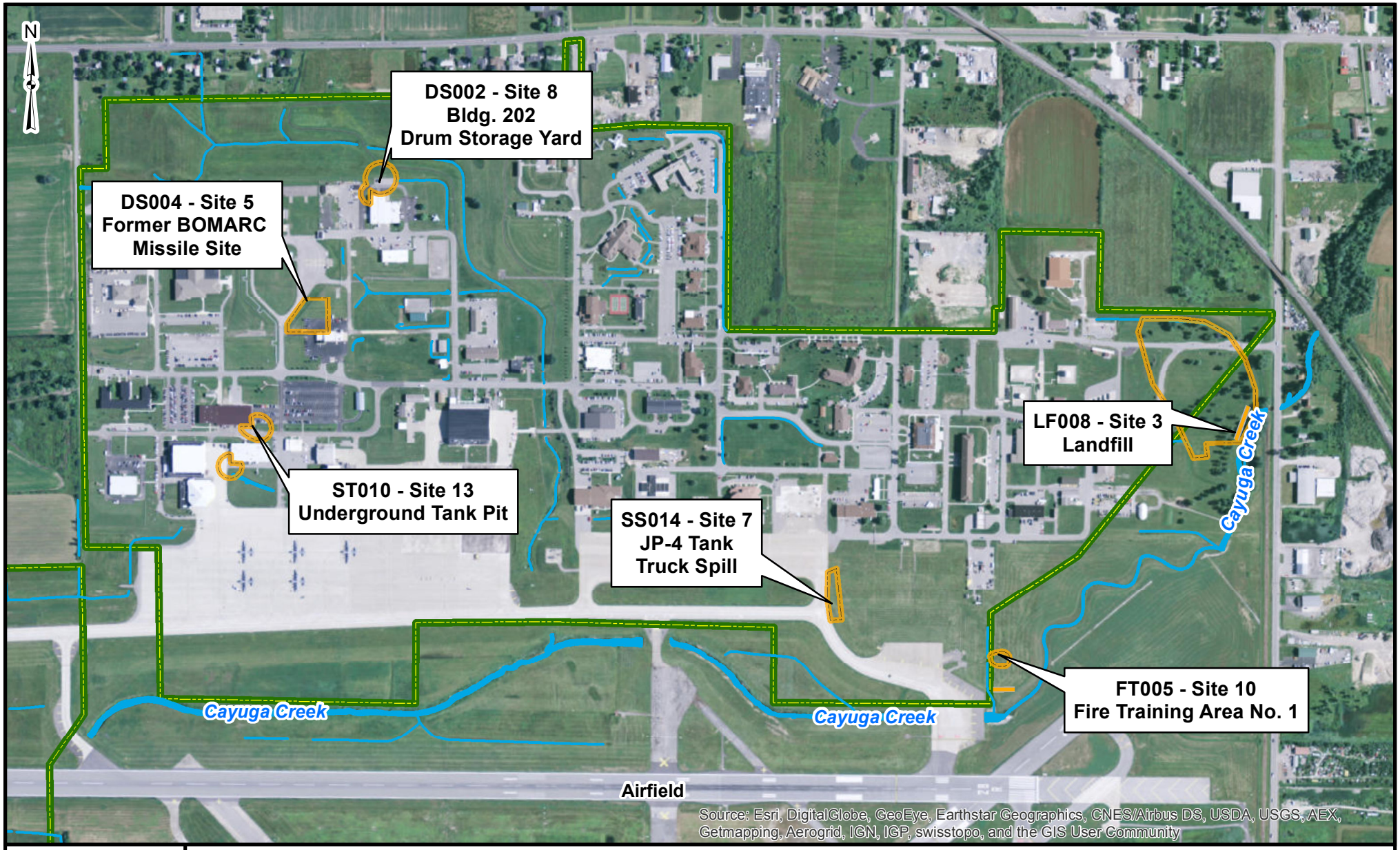

Installation Boundary
Site Source Area
Surface Water Pathway
Groundwater Collection Trench

0 1,500
Feet

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 1-2
Remedial Action Sites
Location Map

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
BY	HW	HW	FD	AS SHOWN	DECEMBER 2015	6265401	G:\Projects\Federal\DOD\6265401_AFCEC

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2.0 Site FT005 – Site 10 Injection Summary

2.1 Introduction

Injection activities were completed at the site from 28-30 September 2015. Injection activities were conducted as described in the RA QAPP with the exception of the termination of the pumping system at Site 10. The pumping system was shut down immediately prior to beginning the injections on 28 September 2015 rather than one month prior as presented in the QAPP. This decision was based on discussions with the injection subcontractor who indicated that the distribution of the EZVI mixture into the subsurface would be greatly enhanced if the water table were depressed due to continued pumping. Following system shut-down, injection activities commenced with a focus on delivering the EZVI to the former source areas described in the RA QAPP (EA 2015). Site tasks for the injection activities included collection of pre-injection groundwater sampling in performance monitoring points, injection point grid layout and direct push technology (DPT) injection point installation, injectate mixing and application, followed by post injection sampling.

2.2 Injection Point Installation Injectate Application

2.2.1 Injection Point Installation

During 28-30 September 2015, 24 DPT points were installed at the former fire training pit at Site 10. The injection grid was roughly 100 feet (ft) by 50 ft area oriented roughly northeast-southwest with DPT points spaced approximately 7.5 ft apart (Figure 2-1). DPT points were pushed to refusal at the bedrock/overburden interface. The typical depth of the injection points was 8 to 9 ft below ground surface (bgs).

2.2.2 Injectate Mixing and Delivery

The ZVI was mixed with EVO in a mixing tank and pumped to individual totes prior to pumping into each injection point. Each point received a mixture containing approximately 64 pounds (lbs) of ZVI and 190 lbs of EVO. The amendments were mixed with approximately 300 gallons of pre-treated water. This pre-treatment step occurred in a separate tote where potable water was treated with larger scale ZVI powder to remove any dissolved oxygen, and to drop the initial ORP prior to mixing with the ZVI amendments. This step was used to optimize the ZVI amendment prior to injection. Overall, Site 10 received 1,536 lbs of ZVI and 4,560 lbs of EVO with a total injectate volume of 7,800 gallons of water.

2.2.3 Performance Well Sampling and Geochemical parameters

Baseline groundwater samples and geochemical parameters were collected from four performance monitoring points (MW10-2[1], MW10-1DA, MW10-10D, and PW10-2) to allow comparison of the pre-treatment conditions to post injection conditions. Groundwater samples collected prior to the injections were submitted for Site 10 contaminants of concern (COCs) in order to evaluate the effectiveness of the remedial action. Site 10 COCs include trichloroethene (TCE), *cis* 1.2 dichloroethene (DCE) and vinyl chloride (VC). Site 10 VOC samples were collected using low flow techniques, and were only collected from performance monitoring wells prior to starting the EZVI injection work. Groundwater samples were submitted for laboratory analysis including target compound list (TCL) VOCs EPA Method 8260C.

[1] MW10-2 was dry during pre-injection sampling.

Geochemical parameters were measured in the field as described in the RA QAPP (EA 2015) both prior to, as wells as following, EZVI injection work in order to evaluate the distribution of the EZVI in the subsurface. Geochemical parameters including pH, dissolved oxygen, ORP, specific conductance temperature, were measured using a Horiba 22 with a low flow cell. Total dissolved iron and dissolved ferrous (Fe2+) were also measured in the field using CHEMetrics iron test kits. Grab samples of water were collected for iron testing when groundwater parameters had stabilized indicating formation water.

2.3 Injection Observations and Post Injection Results

2.3.1 Monitoring Well Observations

During the injection work at Site 10, water levels were periodically checked in several of the wells adjacent to injection points in the injection grid. This was done in order to evaluate the progress of the injection and to monitor for the potential of daylighting injectate through monitoring wells to the surface. Water level increases in adjacent wells, as well as the EZVI injectate, was observed in all performance monitoring wells within the injection grid (MW10-10D, PW10-2, MW10-1DA, and MW10-2[2]) during the injection work. Injectate continued to be observed in the performance monitoring wells following the completion of the injection work.

2.3.2 Pre- and Post-Injection Geochemical Results

Groundwater sampling at Site 10 included a collection of:

- Low flow geochemical sampling parameters from three performance monitoring wells (MW10-10D, W10-1DA, and MW10-2) and from pumping well PW10-2
- Grab samples for total dissolved and ferrous iron (Fe^{2+}) from three performance monitoring wells (MW10-10D, MW10-1DA, and MW10-2) and from pumping well PW10-2
- Grab samples for CVOCs were collected for pre-injection baseline samples only.

Groundwater sample locations are shown on Figure 2-2. Pre-Injection and post-Injection iron test result are provided in Table 2-1.

TABLE 2-1

Pre- and Post-Injection Iron Results (FT005—Site 10)

Performance Monitoring Well	Pre Injection		Post Injection	
	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)
MW10-10D	0	0	NA[(b)]	NA[(b)]
PW10-2	0.6	0	45	45
MW10-1DA	0.6	0	NA[(b)]	NA[(b)]
MW10-2	NA[(a)]	NA[(a)]	NA[(b)]	NA[(b)]

(a) Well was dry and was not sampled prior to the injection

(b) Injectate observed in well and was not sampled and tested for iron

NOTE: mg/l = milligrams per liter

[2] Injectate was observed in MW10-2, which was dry prior to injections.

2.3.3 Pre- and Post-Injection Results Discussion

Water levels were monitored in wells adjacent to the injection points primarily monitor for potential daylighting. The increase in water levels in MW10-10D, PW10-1DA, and MW10-10DA as the injections were ongoing indicated that injectate was successfully injected into the subsurface. Water levels and injectate were observed in each of the performance wells at a maximum distance of 10 ft away from injection points while the injections were ongoing. Following the completion of the injections, injectate remained in performance monitoring wells (MW10-10D, PW10-2, MW10-1DA, and MW10-2).

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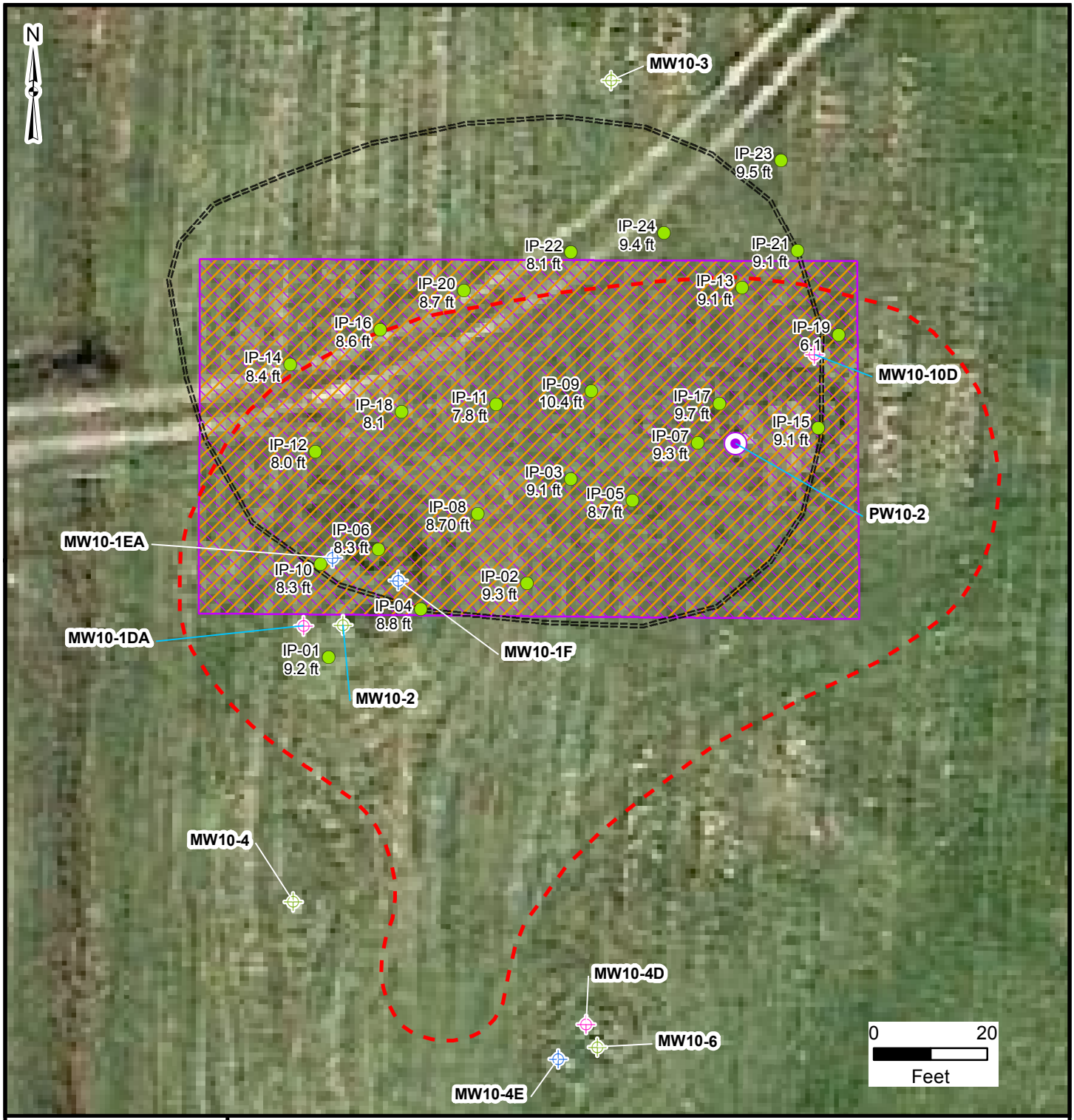

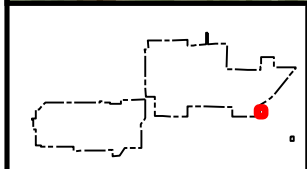

Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
Deep Bedrock Well
Overburden Injection Point
Proposed Injection Zone
Overburden Plume Boundary (Total CVOCs >100 µg/L)
Pumping System
Former Fire Training Pit

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 2-1
FT005 - Site 10
Injection Point Locations

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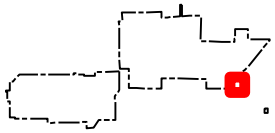

Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
Deep Bedrock Well
Pumping System
Former Fire Training Pit
Groundwater Collection Trench
Proposed Injection Zone
MWX-X Performance Monitoring Well

0 100
Feet

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 2-2
FT005 - Site 10
Performance Monitoring Locations

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3.0 Site LF008 – Site 3 Injection Summary

3.1 Introduction

Injection activities were completed at the site on 4 September 2015. Injection activities were conducted as described in the RA QAPP (EA 2015). Injection activities commenced with a focus on delivering the synergistic mixture of EZVI into the existing extraction trench through the "clean-out" at the north end of the trench to create a treatment curtain for shallow groundwater. Site tasks for the injection activities included collection of pre-injection groundwater sampling in performance monitoring points, injectate mixing and application to the trench, followed by post-injection sampling.

3.2 Injectate Application

3.2.1 Injectate Mixing and Delivery

The ZVI was mixed with EVO in a mixing tank and pumped to a tote prior to pumping the trench pipe clean-out. The trench received approximately 50 lbs of ZVI and 150 lbs of EVO. The amendments were mixed with approximately 200 gallons of pre-treated water. This pre-treatment step occurred in a separate tote where potable water was treated with larger scale ZVI powder to remove any dissolved oxygen and to drop the initial ORP prior to mixing with the ZVI amendments. This step was used to optimize the ZVI amendment prior to injection.

3.2.2 Performance Well Sampling and Geochemical parameters

Baseline groundwater samples and geochemical parameters were collected from seven performance monitoring points (MW3-4DA, PW3-3A, PZ3-3, PZ3-3D, and PZ3-4, PZ3-4 D) to allow comparison of the pre-treatment conditions to post injection conditions. Groundwater samples will be submitted for Site 3 COCs in order to evaluate the effectiveness of the remedial action. Site 3 COCs include TCE, *cis* 1.2 DEC, and VC. Site 3 VOC samples were collected using low flow techniques, and were only collected from performance monitoring wells prior to starting the EZVI injection work.

Groundwater samples were submitted for laboratory analysis including TCL VOCs by EPA Method 8260C. Groundwater analytical results will be reported in the Injection Summary Report, following completion of the one year of performance monitoring.

Geochemical parameters were measured in the field as described in the RA QAPP (EA 2015) both prior to, as wells as following EZVI injection work, in order to evaluate the distribution of the EZVI in the subsurface. Geochemical parameters including pH, dissolved oxygen, ORP, specific conductance, temperature, were measured using a Horiba 22 with a low-flow cell. Total dissolved iron and dissolved ferrous (Fe2+) were also measured in the field using CHEMetrics iron test kits. Grab samples of water were collected for iron testing when groundwater parameters had stabilized indicating formation water.

3.3 Injection Observations and Post Injection Results

3.3.1 Monitoring Well Observations

During the injection work at Site 3, water levels were periodically checked in PW3-3A. This was done in order to evaluate the progress of the injection and to monitor for the potential for overfilling the trench, and overflowing the pumping well at the south end of the trench. Water level increases were observed in PW3-3A as the injectate was being pumped into the north end of the trench. The injection work was ceased when injectate was observed in PW3-3A.

3.3.2 Pre- and Post-Injection Geochemical Results

Groundwater sampling at Site 3 included the collection of:

- Low flow geochemical sampling parameters from three performance monitoring wells (MW3-4DA, PZ3-3, PZ3-3D, PZ3-4, PZ3-4D) and from pumping well PW3-3A
- Grab samples for total dissolved and ferrous iron (Fe^{2+}) from three performance monitoring wells (MW3-4DA, PZ3-3, PZ3-3D, PZ3-4, PZ3-4D) and from pumping well PW3-3A
- Grab samples for CVOCs were collected for pre-injection baseline samples only.

Groundwater sample locations are shown on Figure 3-1. Pre- and post-Injection iron test result are provided in Table 3-1.

TABLE 3-1

Pre- and Post-Injection Iron Results (LF008—Site 3)

Performance Monitoring Well	Pre-Injection		Post-Injection	
	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)
MW3-4DA	3	0	0	0
PZ3-3	37.5	20	30	18
PZ3-3D	30	7.5	25	4
PZ3-4	NA[(a)]	NA[(a)]	0	0
PZ3-4D	45	7.5	40	6
PW3-3A	11.25	5	NA[(b)]	NA[(b)]

(a) Well was dry and was not sampled prior to the injection

(b) Injectate in well was not sampled and tested for iron

NOTE: mg/l = milligrams per liter

3.3.3 Pre- and Post-Injection Results Discussion

Based on the iron results prior to placing the EVO/ZVI injectate into the trench, reducing conditions already exist in the groundwater at Site 3. Furthermore, as indicated by the presence of ferrous iron, the reducing conditions are strong enough to allow for the natural presence if ferrous iron in the groundwater, making the use of ferrous iron concentrations as an indicator of ZVI oxidation inconclusive. The intent was to create a treatment curtain using the existing trench. Therefore, visual changes in PW3-3A are the singular method for evaluating successful application of the injectate to the trench. Groundwater geochemical changes are also not expected to occur immediately following the injection because groundwater flow will take time to affect the performance monitoring points downgradient from the collection trench. Therefore, the increase in water level in PW3-3A and the observation of injectate in the pumping well following the injection indicated that injectate was successfully distributed into the trench.

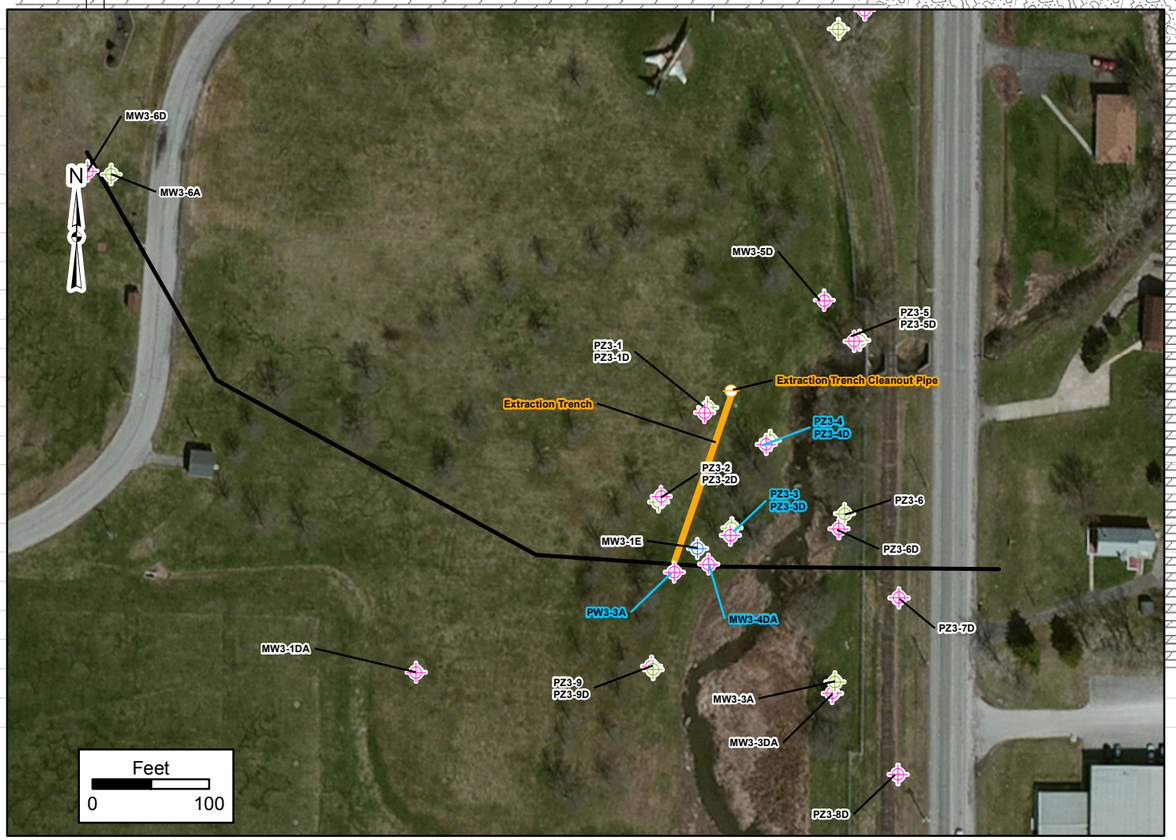
Northwest

Southeast

Elevation (feet above mean sea level)

610
600
590
580
570
560
550
540
Ft AMSL

MW3-6D
MW3-6A
596.39
596.24
Landfill
PZ3-2D
PZ3-2
PW3-3A
Extraction Trench
588.75
588.57
588.68
MW3-1E
MW3-4DA
590.29
589.82
PZ3-3
PZ3-3D
587.94
586.76
Cayuga Creek
PZ3-6D
PZ3-6
587.91
Railroad
PZ3-7D
589.77
Road



Legend

- Fill (Disturbed Soil, Gravel)
- Lacustrine Deposits (Silt and Clay)
- Till (Unsorted Silty Clay With Sand to Boulders)
- Lockport Dolomite
- Monitoring Well
- Screened Interval
- Groundwater Elevation June 2013
- Groundwater Flow Direction
- MWX-X Performance Monitoring Well

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 3-1
LF008 - Site 3
Geologic Cross Section and Performance Monitoring Locations

Feet
0
1 inch = 70 feet
150

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4.0 Site ST010 – Site 13 Injection Summary

4.1 Introduction

Injection activities were completed at the site from 26-27 August 2015. Injection activities were conducted as described in the RA QAPP (EA 2015). The pumping system at PW13-1 was shut down for its normal, quarterly "off" cycle on 22 July 2015, and will remain off for at least one year following the injection in order to evaluate the effectiveness of the remedial action. Injection activities commenced with a focus on delivering the synergistic mixture of EVO and ZVI to the former source areas described in the RA QAPP (EA 2015). Site tasks for the injection activities included collection of pre-injection groundwater sampling in performance monitoring points, injection point grid layout and DPT injection point installation, injectate mixing and application, followed by post injection sampling.

4.2 Injection Point Installation Injectate Application

4.2.1 Injection Point Installation

During 26-27 August 2015, a total of 8 DPT were installed at Site 13. Three points were installed as part of an initial pilot test to evaluate radius of influence (ROI) for all the injections at the Base. These points were centered on existing monitoring wells MW13-5A and PZ13-3D at a 120 degree radial spacing from each other and at distances of 12.5 ft, 10 ft, and 7 ft from the well cluster. Five more injection points were completed in a second injection zone located in the area of the former underground storage tank. These points were arraigned in a zig zag pattern within an injection grid measuring approximately 50 ft by 25 ft oriented roughly east-west. DPT points spaced approximately 18 to 20 ft apart (Figure 4-1). DPT points in both injection locations were pushed to refusal at the bedrock/overburden interface. The typical depth of the injection points was between 8-9 ft bgs.

4.2.2 Injectate Mixing and Delivery

The EZVI was mixed with EVO in a mixing tank and pumped to individual totes prior to pumping into each injection point. Each point received approximately 64 lbs of ZVI and 190 lbs of EVO. The amendments were mixed with approximately 300 gallons of pre-treated water. This pre-treatment step occurred in a separate tote where potable water was treated with larger scale ZVI powder to remove any dissolved oxygen and to drop the initial ORP prior to mixing with the ZVI amendments. This step was used to optimize the ZVI amendment prior to injection. Overall, Site 13 received 336 lbs of ZVI and 1,210 lbs of EVO with a total injectate volume of 2,690 gallons of water.

4.2.3 Performance Well Sampling and Geochemical parameters

Baseline groundwater samples and geochemical parameters were collected from six performance monitoring points including three overburden monitoring wells (MW13-3, MW13-4, MW13-5A), two shallow bedrock monitoring wells/piezometers (MW13-5D, PZ13-3D), and one pumping well (PW13-1) (Figure 4-2). Groundwater samples will be submitted for Site 13 COCs in order to evaluate the effectiveness of the remedial action. Site 13 COCs include TCE, *cis* 1.2 DCE, and VC. Site 13 VOC samples were collected using low flow techniques, and were only collected from performance monitoring wells prior to starting the ZVI/EVO injection work.

Groundwater samples were submitted for laboratory analysis including TCL VOCs by EPA Method 8260C. Groundwater analytical results will be reported in the Injection Summary Report, following completion of the one year of performance monitoring.

Geochemical parameters were measured in the field as described in the RA QAPP (EA 2015) both prior to, as wells as following, EVO/ZVI injection work in order to evaluate the distribution of the EVO/ZVI in the subsurface. Geochemical parameters including pH, dissolved oxygen, ORP, specific conductance, temperature, were measured using a Horiba 22 with a low-flow cell. Total dissolved iron and dissolved ferrous (Fe2+) were also measured in the field using CHEMetrics iron test kits. Grab samples of water were collected for iron testing when groundwater parameters had stabilized indicating formation water.

4.3 Injection Observations and Post Injection Results

4.3.1 Monitoring Well Observations

During the injection work at Site 13, water levels were periodically checked in several of the wells adjacent to injection points in the injection grid. This was done in order to evaluate the progress of the injection and to monitor for the potential of daylighting injectate through monitoring wells to the surface. Water level increases as well as the EZVI injectate was observed in all performance monitoring wells within the pilot injection area, and the injection grid during the injection work. Injectate was also observed in the performance monitoring wells following the completion of the injection work.

4.3.2 Pre- and Post-Injection Geochemical Results

Groundwater sampling at Site 13 included collection of:

- Low flow geochemical sampling parameters from five performance monitoring wells (MW13-3, MW13-4, MW13-5A, MW13-5D, PZ13-3D) and one pumping well (PW13-1)
- Grab samples for total dissolved and ferrous iron (Fe^{2+}) from five performance monitoring wells (MW13-3, MW13-4, MW13-5A, MW13-5D, PZ13-3D) and one pumping well (PW13-1)
- Grab samples for CVOCs were collected for pre-injection baseline samples only.

Groundwater sample locations are shown on Figure 4-2. Pre- and post-injection iron test result are provided in Table 4-1.

TABLE 4-1

Pre- and Post-Injection Iron Results (ST010—Site 13)

Performance Monitoring Well	Pre Injection		Post Injection	
	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)
MW13-3	10	1	3	2
MW13-4	NA[(a)]	NA[(a)]	NA[(b)]	NA[(b)]
MW13-5A	2	0	135	90
MW13-5D	0	0	3	1
PZ13-3D	10	10	45	30
PW13-1	10	1	NA[(b)]	NA[(b)]

(a) Well only had enough water to sample for VOCs

(b) Injectate in well was not sampled and tested for iron

NOTE: mg/l = milligrams per liter

4.3.3 Pre- and Post-injection Results Discussion

Water levels were monitored in wells adjacent to the injection points primarily monitor for potential daylighting. The increase in water levels in PZ13-3D, MW13-5A and MW13-3 as the injections were ongoing indicated that injectate was successfully injected into the subsurface. Water levels and injectate were observed in each of the performance wells at a maximum distance of 10 ft away from injection points while the injections were ongoing. Following the completion of the injections, injectate remained in performance monitoring wells PZ13-3D, MW13-5A and MW13-3.

Total iron and ferrous iron (Fe^{2+}) both increased three-fold in each of the performance monitoring points with the exception of MW13-4 (Table 2-2). Monitoring well MW13-4 is in the overburden, and was dry at the time of the injections, but contained injectate following the injections. For each of the remaining performance monitoring point, a three-fold or larger increase in the dissolved iron content indicates a successful injection of ZVI, and that the iron powder is dissolving as well as reducing to ferrous iron.

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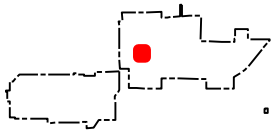

Site_13_Injections
Proposed Injection Zone
Pumping Well
Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
Deep Bedrock Well
Approximate Location of Former Underground Storage Tank Pit
Approximate CVOC Plume Boundary

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
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FIGURE 4-1
Injection Point Locations

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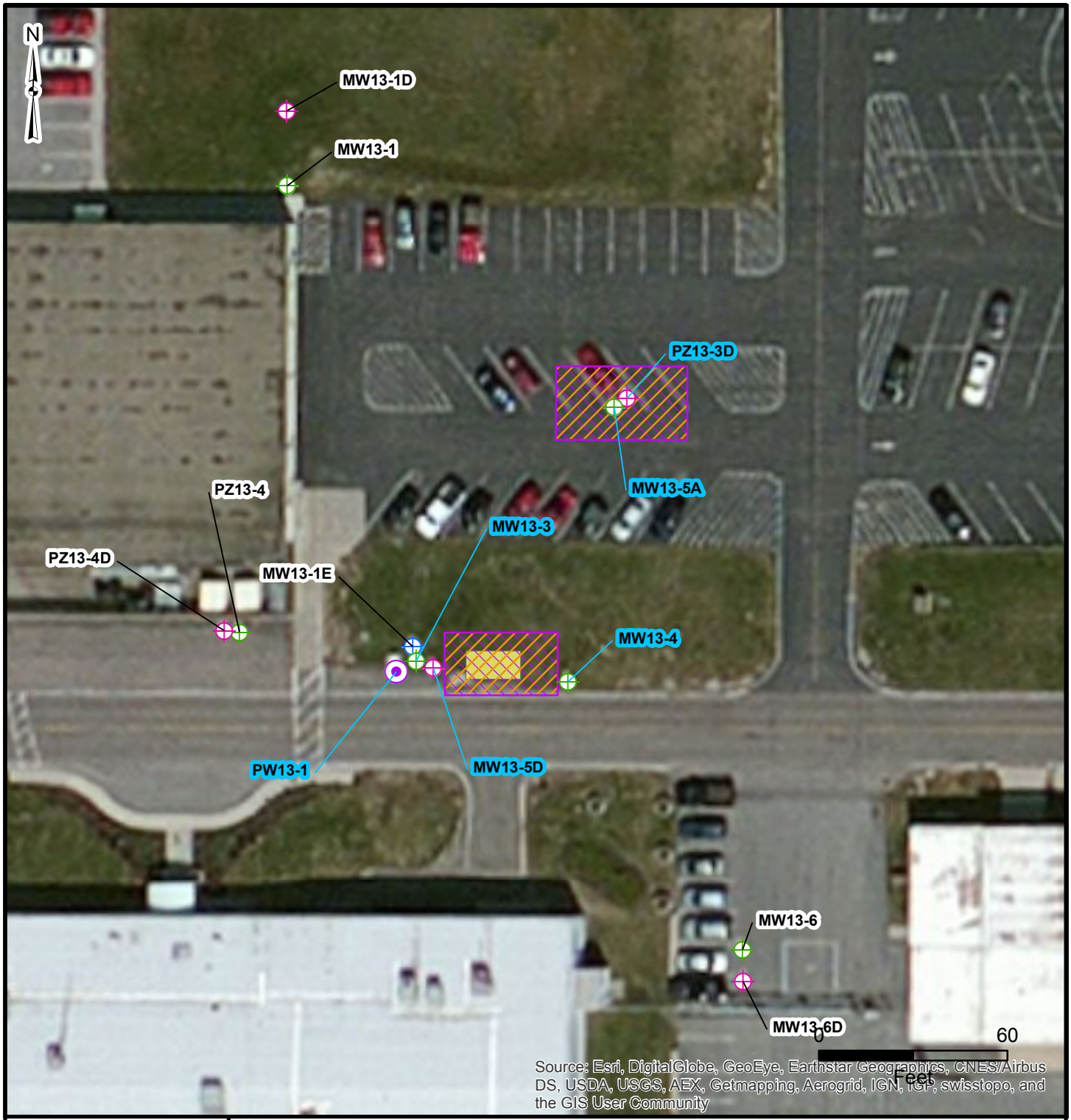

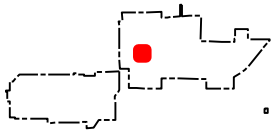

Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
Deep Bedrock Well
Pumping Well
Approximate Location of Former Underground Storage Tank Pit
Approximate CVOC Plume Boundary
Proposed Injection Zone
MWX-X Performance Monitoring Well

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 4-2
ST010 - Site 13
Performance Monitoring Locations

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5.0 Site SS014 – Site 7 Injection Summary

5.1 Introduction

The ORC® auger backfill activities were completed at the site from 8-9 September 2015. These activities were conducted as described in the RA QAPP. Auger backfill activities commenced with a focus on delivering the ORC® adjacent to the former source area of the JP-4 tanker truck spill described in the RA QAPP (EA 2015). Site tasks for the injection activities included collection of pre-injection groundwater sampling in the performance monitoring point, 2 ¼-inch auger boring installation, injectate mixing and application through the auger string, followed by post-injection sampling.

5.2 ORC® Application

5.2.1 ORC® Auger Backfill

Eleven (11) borings spaced 12-ft apart were advanced to refusal using 2¼-inch hollow stem augers (Figure 5-1). Approximately 25 to 30 pounds of solid (lbs) ORC® was mixed with 5 to 6 gallons of water and poured down the auger upon reaching terminal depth at bedrock refusal. The augers were then backed out of the boring, allowing the ORC® to remain in place at the targeted depth. The following table details the total depth of each boring, the ORC® dosing, and water applied per location.

TABLE 5-1

ORC® Injection Summary (SS014—Site 7)

Injection Point ID	Boring Depth (ft bgs)	ORC® Dosing (lbs)	Water (gallons)
SITE07-IP-01	5.0	30	6
SITE07-IP-02	4.8	30	6
SITE07-IP-03	6.8	30	6
SITE07-IP-04	6.2	30	6
SITE07-IP-05	5.4	30	6
SITE07-IP-06	5.1	30	6
SITE07-IP-07	4.8	25	5
SITE07-IP-08	4.7	25	5
SITE07-IP-09	6.2	30	6
SITE07-IP-10	5.0	30	6
SITE07-IP-11	5.2	30	6

5.2.2 Pre- and Post-Injection Geochemical Results

Groundwater sampling at Site 7 included the collection of:

- Low flow grab samples for CVOCs were collected for pre-injection baseline samples only from one performance monitoring well (MW7-1D).

The performance monitoring point for the groundwater sample is shown on Figure 5-2. Geochemical parameters for pre- and post-injection sampling were not obtained due to the low water table at the time of sampling. Only enough water was available for the baseline COC sample. Following sampling, the well did not recharge prior to commencing the ORC® backfill work adjacent to the boring.

Groundwater samples were submitted for laboratory analysis including TCL VOCs by EPA Method 8260C. Groundwater analytical results will be reported in the Injection Summary Report, following completion of the one year of performance monitoring.

Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
ORC Backfill Location
ORC Treatmement Zone
MWX-X Performance Monitoring Well

0 50
Feet

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 5-1
SS014-Site 7
ORC Backfill Locations and
Performance Monitoring Points

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6.0 Site DS002 – Site 8 Injection Summary

6.1 Introduction

Injection activities were completed Site 8 from 28 August – 3 September 2015. Injection activities were conducted as described in the RA QAPP (EA 2015). Injection activities commenced with a focus on delivering the synergistic mixture of EZVI to the former source areas described in the RA QAPP (EA 2015). The EZVI mixture was also delivered to one bedrock core hole in an effort to treat residual CVOCs in the impacted groundwater at Site 8. Site tasks for the injection activities included collection of pre-injection groundwater sampling in performance monitoring points, injection point grid layout and DPT injection point installation, injectate mixing and application, followed by post injection sampling.

6.2 Injection Point Installation Injectate Application

6.2.1 Injection Point Installation

During 28 August – 3 September 2015, 32 DPT points were installed through the overburden to the bedrock contact in two separate 50-ft by 50-ft grids. DPT points were spaced approximately 15 ft apart in each grid (Figure 6-1). These points were centered on existing monitoring wells MW8-1E and MW8-1 in the northeastern grid and existing monitoring wells MW8-8 and MW8-10D in the southwestern grid. The expected ROI for the injection points was estimated at approximately 7.5 to 10 ft as determined during the pilot test at Site 13. Therefore, the injection points were spaced at approximately 15 to 20 ft apart. The typical depth of the injection points was between 12-16 ft bgs.

Injectate was also applied to the bedrock through CH8-01 in order to mitigate groundwater contamination in the shallow bedrock. The fracture zones were identified in the pre-design investigation and selected based on CVOC concentrations and fracture locations. Two separate depths were selected and isolated via packer in the core hole, and 50 gallons were injected into each of the two zones.

6.2.2 Injectate Mixing and Delivery

The ZVI was mixed with EVO in a mixing tank and pumped to individual totes prior to pumping into each injection point. Each overburden point received approximately 49 lbs of ZVI and 151 lbs of EVO. The amendments were mixed with approximately 250 gallons of pre-treated water. This pre-treatment step occurred in a separate tote where potable water was treated with larger scale ZVI powder to remove any dissolved oxygen and to drop the initial ORP prior to mixing with the ZVI amendments. This step was used to optimize the ZVI amendment prior to injection. Overall, the overburden points at Site 8 received 1568 lbs of ZVI and 4,838 lbs of EVO with a total injectate volume of 8,690 gallons of injectate.

The EZVI was also injected into the shallow bedrock core hole CH8-01. Two 4-ft fracture zones were selected based on CVOC concentrations and core log descriptions collected during the pre-design investigation. The fractured bedrock in both of these zones was targeted for low pressure injection using a 4-ft section of polyvinyl chloride (PVC) screen separated by inflated packers at the top and bottom of the selected zone. Fifty gallons of injectate was injected into each of the two zones at low pressures through a 10 slot PVC screen fixed in place with a packer assemble. A total of 100 gallons of EZVI injectate was applied to the shallow bedrock.

6.2.3 Performance Well Sampling and Geochemical parameters

Baseline groundwater samples and geochemical parameters were collected from four performance monitoring points including two overburden monitoring wells (MW8-1 and MW8-8), and two shallow bedrock monitoring wells (CH8-01, MW8-10D) (Figure 6-2). Groundwater samples will be submitted

for Site 8 COCs in order to evaluate the effectiveness of the remedial action. Site 8 COCs include TCE, *cis* 1.2 DCE, and VC. Site 8 VOC samples were collected using low flow techniques, and were only collected from performance monitoring wells prior to starting the EZVI injection work.

Groundwater samples were submitted for laboratory analysis including TCL VOCs by EPA Method 8260C. Groundwater analytical results will be reported in the Injection Summary Report, following completion of the one year of performance monitoring.

Geochemical parameters were measured in the field as described in the RA QAPP (EA 2015) both prior to, as wells as following, EZVI injection work in order to evaluate the distribution of the EVO/ZVI in the subsurface. Geochemical parameters including pH, dissolved oxygen, ORP, specific conductance, temperature, were measured using a Horiba 22 with a low-flow cell. Total dissolved iron and dissolved ferrous (Fe2+) were also measured in the field using CHEMetrics iron test kits. Grab samples of water were collected for iron testing when groundwater parameters had stabilized indicating formation water.

6.3 Injection Observations and Post Injection Results

6.3.1 Monitoring Well Observations

During the injection work at Site 8, water levels were periodically checked in several of the wells adjacent to injection points in the injection grid. This was done in order to evaluate the progress of the injection, and to monitor for the potential of daylighting injectate through monitoring wells to the surface. Water level increases as well as the EZVI injectate was observed in two overburden performance monitoring wells within the injection grids (MW8-1 and MW8-8) during the injection work. Injectate was also observed in all four of the performance monitoring wells following the completion of the injection work.

6.3.2 Pre- and Post-Injection Geochemical Results

Groundwater sampling at Site 8 included the collection of:

- Low flow geochemical sampling parameters from four performance monitoring wells (MW8-1, MW8-8, MW8-10D, and CH8-01)
- Grab samples for total dissolved and ferrous iron (Fe^{2+}) from four performance monitoring wells (MW8-1, MW8-8, MW8-10D, and CH8-01)
- Grab samples for CVOCs were collected for pre-injection baseline samples only.

Groundwater sample locations are shown on Figure 6-2. Pre- and post-injection iron test result are provided in Table 6-1.

TABLE 6-1

Pre- and Post-Injection Iron Results (DS002—Site 8)

Performance Monitoring Well	Pre Injection		Post Injection	
	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)
MW8-1	0.2	0.7	20	5
CH8-01	1	1	45	7.5
MW8-08	0	0	7.5	2
MW8-10D	1.5	0.8	7	5

(a) Well was dry and was not sampled prior to the injection

(b) Injectate in well was not sampled and tested for iron

NOTE: mg/l = milligrams per liter

6.3.3 Pre- and Post-Injection Results Discussion

Water levels were monitored in wells adjacent to the injection points primarily monitor for potential daylighting. The increase in water levels in MW8-1 and MW8-8 and MW13-3 as the injections were ongoing indicated that injectate was successfully injected into the subsurface. Water levels and injectate were observed in each of the performance wells at a distance of up to 10 ft away from injection points while the injections were ongoing. Following the completion of the injections, injectate was observed in all four of the performance monitoring wells (MW8-1, MW8-8, MW8-10D, and CH8-01).

Total iron and ferrous iron (Fe^{2+}) doubled in MW8-8 and increased five times in MW8-10D (Table 2-2). Post iron test kits and geochemical parameters were not collected in MW8-1 and CH8-01 because injectate was observed within the wells indicating a successful injection of EZVI.

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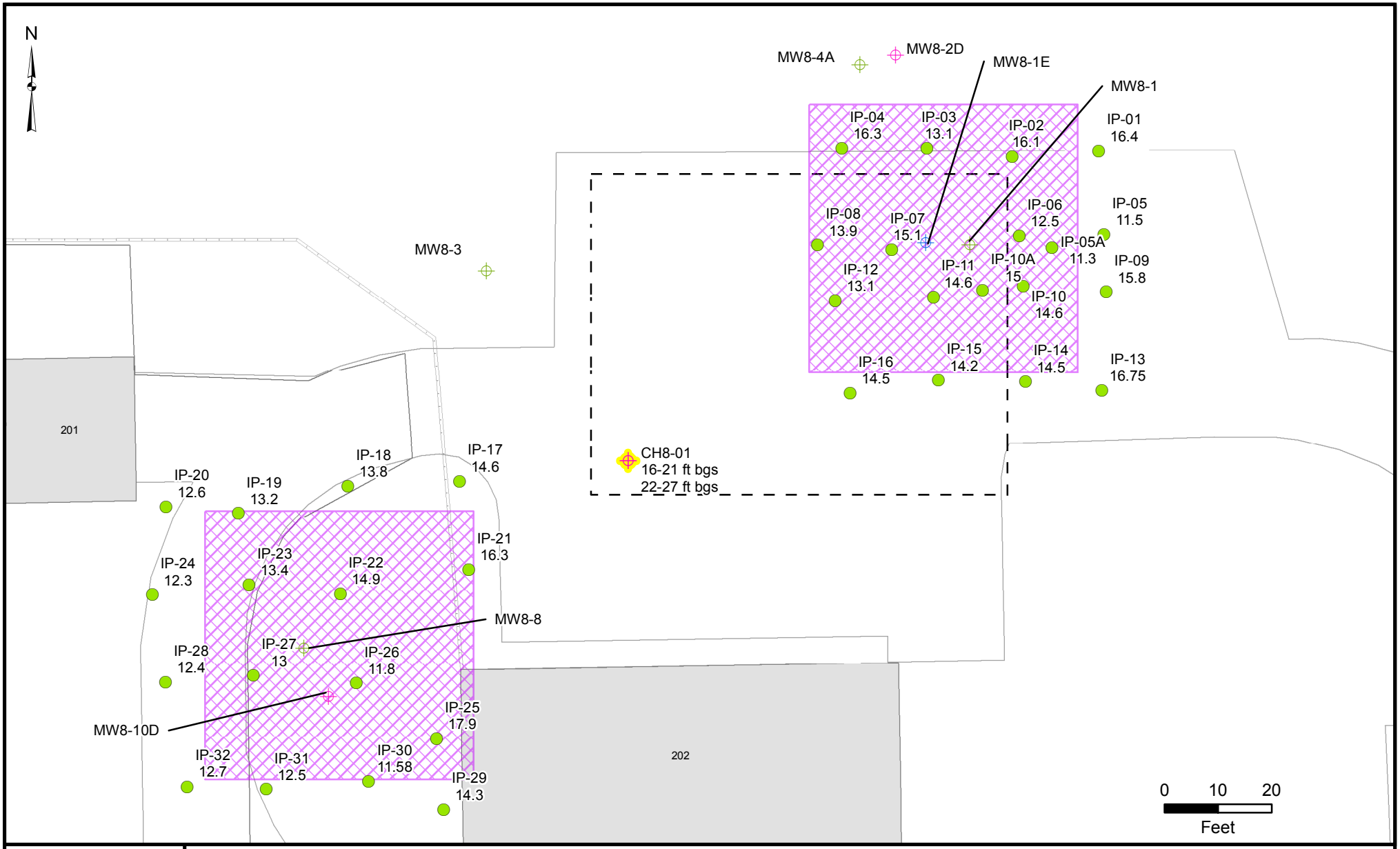

Remedial Action Quality Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 6-1
DS002 - Site 8
Injection Point Location

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
BY	HW	RP	BY	AS SHOWN	DECEMBER 2015	6265401	G:\Projects\Federal\DOD\6265401_AFCEC

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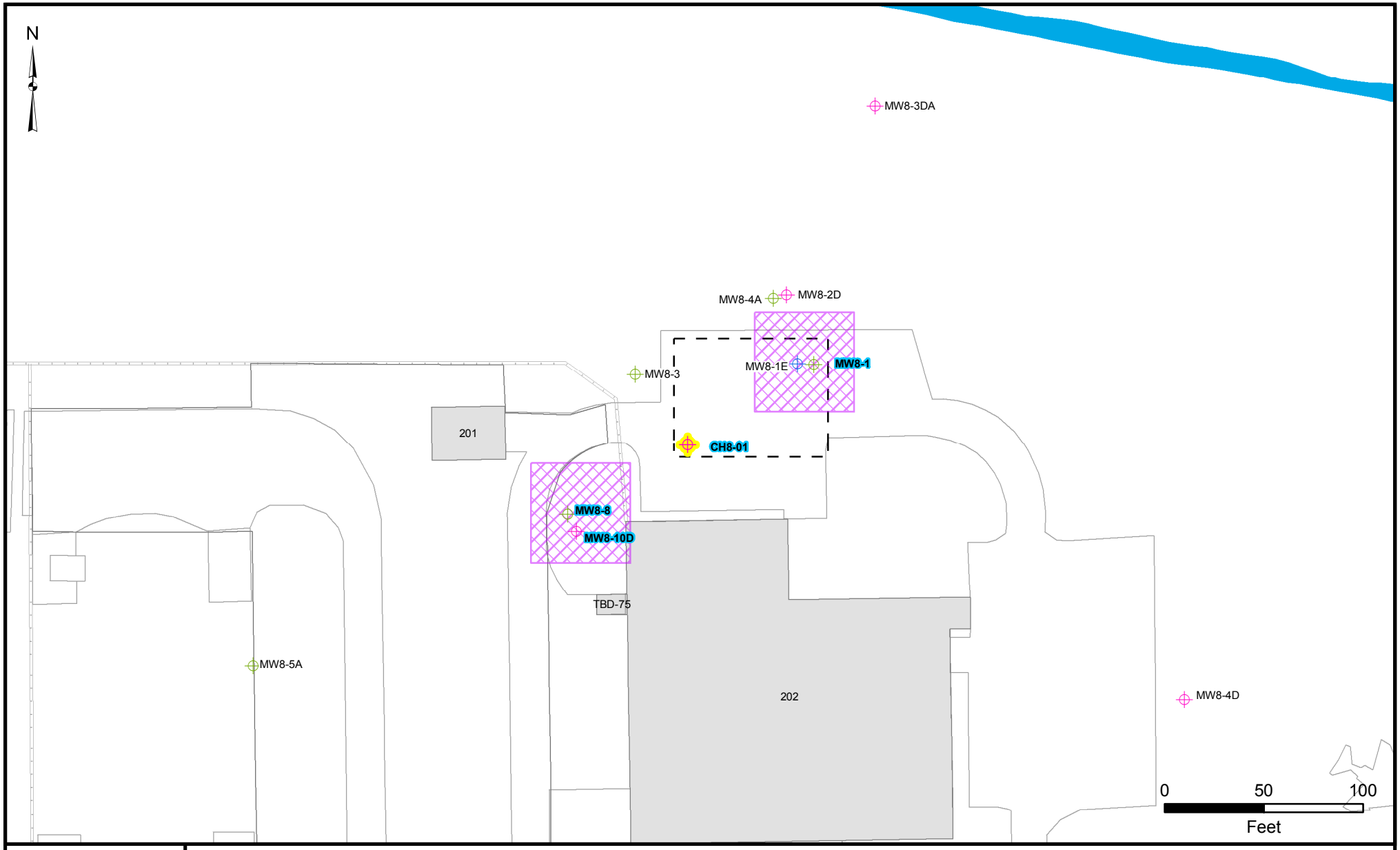

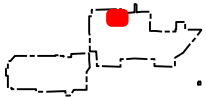

Drum Storage Yard
Proposed Injection Zones
Bedrock Injection Point
Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
Deep Bedrock Well
MWX-X Performance Monitoring Well

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 6-2
DS002 - Site 8
Performance Monitoring Locations

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
BY	HW	RP	FD	AS SHOWN	DECEMBER 2015	6265401	G:\Projects\Federal\DOD\6265401_AFCEC

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7.0 Site DS004 – Site 5 Injection Summary

7.1 Introduction

Injection activities were completed Site 5 from 14-24 September 2015. Injection activities were conducted as described in the RA QAPP (EA 2015). Injection activities commenced with a focus on delivering the synergistic mixture of EZVI to the former source areas described in the RA QAPP (EA 2015). The EZVI mixture was also delivered to four bedrock core holes in an effort to treat residual CVOCs in the impacted groundwater at Site 5. Site tasks for the injection activities included collection of pre-injection groundwater sampling in performance monitoring points, injection point grid layout and DPT injection point installation, injectate mixing and application, followed by post injection sampling.

7.2 Injection Point Installation Injectate Application

7.2.1 Injection Point Installation

During 14-24 September 2015, 69 DPT points were installed through the overburden to the bedrock contact in two separate 50-ft by 50-ft grids and one larger grid measuring approximately 60 ft by 100 ft. DPT points were spaced approximately 15 ft apart in each grid (Figure 6-1). These points were centered on existing monitoring wells RW5-1 northeastern grid, existing monitoring wells RW5-2 in the larger easternmost grid and RW5-5 in the southern grid. The expected ROI for the injection points was estimated at approximately 7.5 to 10 ft as determined during the pilot test at Site 13. Therefore, the injection points were spaced at approximately 15 to 20 ft apart. The typical depth of the injection points was between 12-16 ft bgs.

The shallow bedrock treatment area, located at areas around MW5-5D, is comprised of four open bedrock holes (CH5-01 through CH5-04) with a vertical extent from top of bedrock—13-16 ft bgs to 30 ft bgs. The injectate was pressure injected into two different 4-ft sections of fractured bedrock in each of the core holes. The fracture zones were identified in the pre-design investigation and selected based on CVOC concentrations and fracture locations.

7.2.2 Injectate Mixing and Delivery

The ZVI was mixed with EVO in a mixing tank and pumped to individual totes prior to pumping into each injection point. Each overburden point received approximately 49 lbs of ZVI and 151 lbs of EVO. The amendments were mixed with approximately 250 gallons of pre-treated water. This pre-treatment step occurred in a separate tote where potable water was treated with larger scale ZVI powder to remove any dissolved oxygen and to drop the initial ORP prior to mixing with the ZVI amendments. This step was used to optimize the ZVI amendment prior to injection. Overall, the overburden points at Site 8 received 1568 lbs of ZVI and 4,838 lbs of EVO with a total injectate volume of 8,690 gallons of injectate.

The EZVI mixture was also injected into the shallow bedrock in four core holes (CH5-01 through CH5-04). Two 4-ft fracture zones were selected in each of the core holes based on CVOC concentrations and core log descriptions collected during the pre-design investigation. The fractured bedrock in these zones was targeted for low pressure injection using a 4-ft section of PVC screen separated by inflated packers at the top and bottom of the selected zone. Fifty gallons of injectate was injected into each of the two zones at low pressures through a 10-slot PVC screen fixed in place with a packer assemble. A total of 100 gallons of EZVI injectate was applied to the shallow bedrock at each location (CH5-01 through CH5-04) for a total of 400 gallons of EZVI applied in the bedrock.

7.2.3 Performance Well Sampling and Geochemical parameters

Baseline groundwater samples and geochemical parameters were collected from four performance monitoring points including three overburden monitoring wells (MW5-5D, RW5-1 and RW5-2), and one shallow bedrock monitoring well (RW5-4) (Figure 7-2). Groundwater samples will be submitted for Site 5 COCs in order to evaluate the effectiveness of the remedial action. Site 5 COCs include TCE, *cis* 1.2 DCE, and VC. Site 5 VOC samples were collected using low flow techniques, and were only collected from performance monitoring wells prior to starting the EZVI injection work.

Groundwater samples were submitted for laboratory analysis including TCL VOCs by EPA Method 8260C. Groundwater analytical results will be reported in the Injection Summary Report, following completion of the one year of performance monitoring.

Geochemical parameters were measured in the field as described in the RA QAPP (EA 2015) both prior to as wells as following EZVI injection work in order to evaluate the distribution of the EZVI in the subsurface. Geochemical parameters including pH, dissolved oxygen, ORP, specific conductance, temperature, were measured using a Horiba 22 with a low-flow cell. Total dissolved iron and dissolved ferrous (Fe2+) were also measured in the field using CHEMetrics iron test kits. Grab samples of water were collected for iron testing when groundwater parameters had stabilized indicating formation water.

7.3 Injection Observations and Post Injection Results

7.3.1 Monitoring Well Observations

During the injection work at Site 5, water levels were periodically checked in several of the wells adjacent to injection points in the injection grid. This was done in order to evaluate the progress of the injection, and to monitor for the potential of daylighting injectate through monitoring wells to the surface. Water level increases, as well as visual evidence of the EZVI injectate, was observed in five overburden wells with the injection grids during the injection work. These wells include three of the overburden performance monitoring wells (RW5-1, RW5-2, RW5-4), as well as two other overburden monitoring wells, not included on the list of performance monitoring wells (MW5-6 and RW5-3). Injectate remained in all five of the overburden monitoring wells following the completion of the injection work.

7.3.2 Pre- and Post-Injection Geochemical Results

Groundwater sampling at Site 5 included the collection of:

- Low flow geochemical sampling parameters from four performance monitoring wells (RW5-1, RW5-2, RW5-4, and MW5-8)
- Grab samples for total dissolved and ferrous iron (Fe^{2+}) from 4 performance monitoring wells (RW5-1, RW5-2, RW5-4, and MW5-8)
- Grab samples for CVOCs were collected for pre-injection baseline samples only.

Groundwater sample locations are shown on Figure 7-2. Pre-and post-injection iron test result are provided in Table 7-1.

TABLE 7-1

Pre- and Post-Injection Iron Results (DS004—Site 5)

Performance Monitoring Well	Pre Injection		Post Injection	
	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)	Total Iron Fe (mg/l)	Ferrous Iron Fe^{2+} (mg/l)
RW5-1	0.4	0.4	15	10
RW5-2	3	3	5	3
RW5-4	2	2	6	2
MW5-5D	0	0	5	2

(a) Well was dry and was not sampled prior to the injection

(b) Injectate in well was not sampled and tested for iron

NOTE: mg/l = milligrams per liter

7.3.3 Pre- and Post-Injection Results Discussion

Water levels were monitored in wells adjacent to the injection points primarily monitor for potential daylighting. The increase in water levels in RW5-1, RW5-2, RW5-3, RW5-4, and MW5-6 as the injections were ongoing indicated that injectate was successfully injected into the subsurface. Water levels and injectate were observed in each of the performance wells at a maximum distance of 10 ft away from injection points while the injections were ongoing. Following the completion of the injections, injectate remained in performance monitoring wells (RW5-1, RW5-2, RW5-4, and MW5-8).

Total iron and ferrous iron (Fe^{2+}) increased in all four performance monitoring wells (Table 7-1). Geochemical parameters were not collected from the injectate because these readings would not represent the geochemical conditions of the groundwater. Furthermore, the EVO based injectate was coating the probes on the meter and were preventing accurate readings.

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N

IP-55
18.3 ft

IP-54
19 ft

IP-53
16.3 ft

IP-52
17 ft

IP-51
16.9 ft

IP-50
18.7 ft

IP-49
15.9 ft

IP-47
15.9 ft

IP-45
17.1 ft

IP-46
17.8 ft

IP-44
15.2 ft

IP-43
16.3 ft

IP-42
16.25 ft

IP-40
14.9 ft

IP-39
15.5 ft

IP-38
15.33 ft

IP-37
13.5 ft

IP-41
9 ft

RW5-1

IP-36
18.9 ft

CH5-01
18-20.5 ft bgs
24-26.5 ft bgs

IP-35
14.66 ft

MW5-6

IP-34
16.16 ft

MW5-1E

IP-33
12.7 ft

CH5-02
17-19.5 ft bgs
23-25.5 ft bgs

IP-32
13.8 ft

MW5-5D

RW5-3

CH5-03
19-21.5 ft bgs
23-25.5 ft bgs

CH5-04
20-22.5 ft bgs
24-26.5 ft bgs

IP-05
16.3 ft

IP-04
16 ft

IP-03
8.6 ft

IP-02
16.5 ft

IP-01
16 ft

IP-07
14.6 ft

IP-08
15 ft

IP-06
14.3 ft

IP-09
15.4 ft

IP-10
15.3 ft

IP-11
13 ft

IP-12
13.3 ft

IP-15
13.75 ft

IP-14
13.5 ft

IP-13
13.45 ft

RW5-2

IP-19
14.45 ft

IP-18
14.5 ft

IP-17
16.3 ft

IP-16
15.80 ft

IP-20
13.3 ft

IP-23
15.8 ft

IP-22
16.0 ft

IP-25
15.16 ft

IP-27
15.4 ft

IP-26
15.25 ft

IP-24
14.8 ft

IP-29
15.3 ft

IP-28
14.9 ft

IP-31
15.16 ft

IP-30
15.25 ft

IP-59
14.66 ft

IP-58
16.3 ft

IP-56
12 ft

IP-62
15 ft

IP-57
11.1 ft

IP-61
17.5 ft

IP-60
14.3 ft

IP-63
15 ft

RW5-4

IP-64
16.8 ft

IP-65
13.9 ft

IP-67
11.2 ft

IP-66
14.1 ft

IP-71
12.9 ft

IP-70
13.3 ft

IP-69
13.9 ft

IP-68
13.8 ft

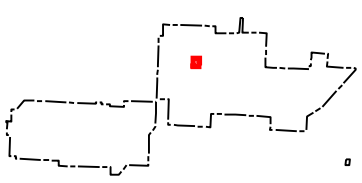
920

VOC Concentration (µg/L)

100-1,000

>1,000

IP-XX = Injection Point ID
XX ft bgs = feet below ground surface



Legend

Former BOMARC Launcher Shelter

Former BOMARC Sump

Overburden Well/Piezometer

Shallow Bedrock Well/Piezometer

Deep Bedrock Well

Drainage Ditch

Overburden Injection Point

Bedrock Injection Point

0 40

Feet

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 7-1
DS004 - Site 5
Injection Point Locations

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
BY	ALK	ALK	MH	AS SHOWN	DECEMBER 2015	6265401	G:\Projects\Federal\DOD\6265401_AFCEC_NFARS\

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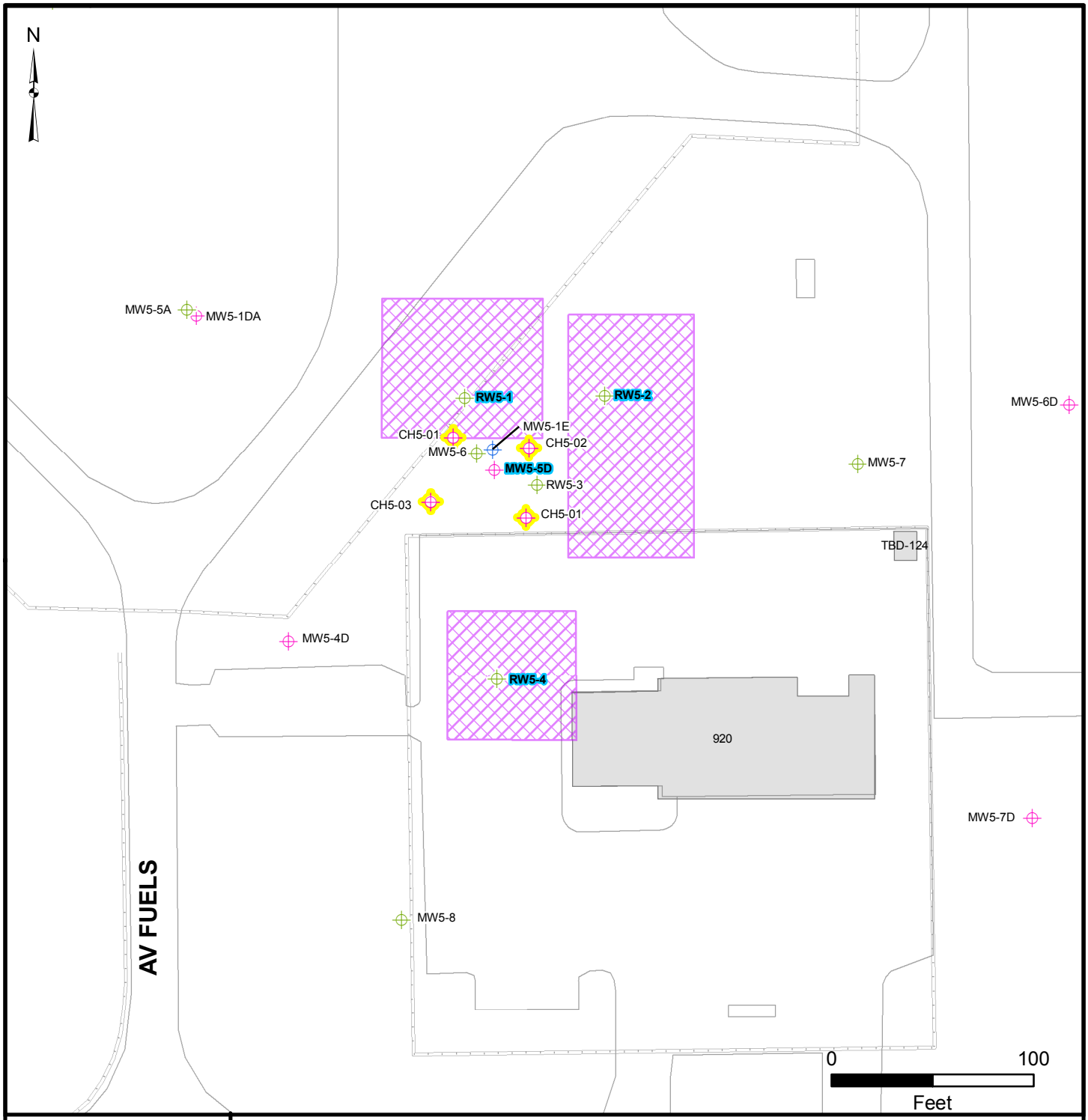

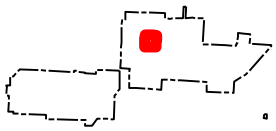

Overburden Well/Piezometer
Shallow Bedrock Well/Piezometer
Deep Bedrock Well
Proposed Injection Zones
Bedrock Injection Point
MWX-X Performance Monitoring Well

Remedial Action Injection Summary Memorandum
Sites FT005, LF008, ST010, SS014, DS002, and DS004
Niagara Falls Air Reserve Station
Niagara Falls, New York

FIGURE 7-2
DS004 - Site 5
Performance Monitoring Locations

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BY	RP	FD	BY	AS SHOWN	DECEMBER 2015	6265401	G:\Projects\Federal\DOD\6265401_AFCEC_NFARS\

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8.0 References

EA. 2015. Remedial Action Quality Assurance Project Plan Sites FT005, LF008, ST010, SS014, DS002, and DS004 Niagara Falls Air Reserve Station. Niagara Falls, New York. August.

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