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FINAL RISK ASSESSMENT WORK PLAN FOR FORMER NIKE BATTERY PR-58 NCBC DAVISVILLE RI

3/1/2014

STONE ENVIRONMENTAL INC

Prepared for:

U.S. Army Corps of Engineers

New England District

RISK ASSESSMENT WORK PLAN

Final

Former Nike Battery PR-58
North Kingstown, Rhode Island

FUDS Project Number: D01RI0029 05

CENAE Project Number: 108346

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INTRODUCTION

Stone Environmental, Inc. (Stone) team subcontractor AMEC Environment & Infrastructure, Inc. (AMEC) has prepared this Risk Assessment Work Plan for the Former Nike Battery PR-58 (the Property) in North Kingstown, RI (Figure 1) on behalf of the Army Corps of Engineers, New England District (CENAE), under Contract No. W912WJ-11-D-0001. The purpose of this Work Plan is to describe the technical approach to complete the ecological and human health risk assessments as described in the Contract Modifications 003 and 005, dated 11 July 2012 and 13 March 2013, respectively. Data collection and reporting will be executed under separate Tasks as described in the approved Remedial Investigation (RI) / Feasibility Study (FS) Sampling & Analysis Plan and Quality Assurance Project Plan (QAPP) prepared by Stone.

1.0 ECOLOGICAL RISK ASSESSMENT

A Screening Level Ecological Risk Assessment (SLERA) that assessed water bodies and wetlands associated with Hall Creek, Davol Pond and East Davol Pond (southeast of the Nike property), and wetlands located north of Perimeter Road was completed in 2011 (AECOM, 2011). The 2011 SLERA generally found negligible risk to ecological receptors but concluded additional evaluation of risk posed by chlorinated volatile organic compounds (CVOCs) was necessary due to uncertainties associated with the data obtained for Hall Creek. This section of the Work Plan describes the technical approach to integrate a new round of surface water, porewater, and sediment CVOC and metals data from Hall Creek and Davol Pond into a SLERA Update and eliminate those chemicals which pose negligible risk from further evaluation.

As explained in the RI Sampling & Analysis Plan, 12 co-located surface water, sediment, and pore water samples will be collected from Hall Creek under seasonally-low groundwater and surface water conditions. An additional co-located surface water, sediment, and pore water sample will be collected from a wetland located north of the Property. One surface water, sediment, and pore water sample will be collected from Davol Pond. All samples will be analyzed for CVOCs, and six will be analyzed for 23 target analyte list (TAL) metals following methods outlined in the QAPP. Additionally, sediment samples will be evaluated for total organic carbon (TOC). Stone Environmental, Inc. will report results to AMEC.

Consistent with the 2011 SLERA, this SLERA Update will be performed in accordance with the following key guidance documents:

- *Framework for Ecological Risk Assessment* (USEPA, 1992);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997a);
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998); and
- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001).

The SLERA Update will be organized into three major sections: 1) Problem Formulation; 2) Risk Analysis; and 3) Risk Characterization, Uncertainty, and Conclusions/Recommendations, as described below.

1.1 Screening Level Problem Formulation

Problem formulation is the initial systematic planning phase of the ecological risk assessment process. It provides the basis for the approach and methodology to be used as well as defining the specific scope and objectives of the risk evaluation. Consistent with the 2011 SLERA, the problem formulation will include the following:

- Definition of risk assessment objectives;
- Site characterization and definition of the geographic area to be considered;
- Selection of specific ecological receptors and exposure pathways;
- Selection of assessment endpoints and measures of effect;
- Selection of compounds of potential ecological concern (COPECs); and
- Development of the conceptual site model (CSM).

In accordance with the 11 July 2012 and 13 March 2013 Contract Modifications, the SLERA Update:

- will focus on CVOCs and metals in surface water, pore water, and sediment in Hall Creek and northern wetland, and
- assumes the Hall Creek CSM has not changed since the 2011 SLERA and revisions to the CSM are therefore unnecessary.

The Problem Formulation section of the SLERA Update will reference the appropriate portions of the 2011 SLERA with respect to definition of risk assessment objectives, site characterization history, selection of potential receptors and exposure pathways, and development of the CSM.

Table 1-1 summarizes the assessment and measurement endpoints proposed for the Hall Creek SLERA Update, which are consistent with the 2011 SLERA.

Table 1-1

Assessment and Measurement Endpoints for Ecological Risk Assessment

Target Communities or Receptors	Assessment Endpoints	Measurement Endpoints
Hall Creek/ northern wetland/Davol Pond	Survival, reproduction, and growth of benthic organisms	Comparison of bulk sediment analytical concentrations to freshwater sediment screening benchmarks. Comparison of porewater analytical concentrations to freshwater screening benchmarks.
	Survival, reproduction, and growth of aquatic invertebrate and fish communities	Comparison of surface water analytical concentrations to freshwater screening benchmarks

1.2 Risk Analysis

The SLERA Update will present screening tables that summarize the recent round of data. The screening tables will also compare the maximum detected concentrations of analytes in surface water, pore water, and sediment to ecological screening benchmarks in order to calculate a hazard quotient (HQ):

$$HQ = \frac{\text{Maximum Concentration}}{\text{Benchmark Value}} \qquad \text{(Equation 1)}$$

To the extent possible, the same screening benchmarks used in the 2011 SLERA have been selected for this SLERA Update. Where the 2011 SLERA did not provide benchmarks for target analytes which were not detected, surface water/porewater and sediment screening benchmarks have been selected from the scientific literature.

Surface water and pore water benchmarks (Table 1-2) have been selected from the following sources in the order presented:

1. U.S. Environmental Protection Agency (USEPA) Freshwater Ambient Water Quality Criteria (AWQC) Chronic Continuous Concentrations (CCC) (USEPA, 2013a).
2. USEPA Region 3 Freshwater Values (USEPA, 2006)
3. Oak Ridge National Laboratory (ORNL) Tier II Secondary Chronic Values (SCVs) from Suter and Tsao, 1996
4. USEPA Region 5 Surface Water Ecological Screening Levels (USEPA, 2003a)

Where a target analyte lacked a screening benchmark, surrogates have been used as noted:

- 1,2-dichloroethene was used as a surrogate for cis-1,2-dichloroethene
- 1,3-dichloropropene was used as a surrogate for cis-1,3-dichloropropene and trans-1,3-dichloropropene.
- Total xylene was used as a surrogate for o-xylene
- m-xylene was used as a surrogate for m&p-xylene

Hardness dependent criteria (cadmium, chromium, copper, lead, nickel, zinc) are based on a hardness of 100 mg/L as $CaCO_3$. Calcium, magnesium, potassium, and sodium are considered essential nutrients; therefore benchmarks are not applicable.

Sediment benchmarks (Table 1-3) have been selected from the following sources in the order presented:

1. USEPA Region 3 Freshwater Sediment Screening Values (USEPA, 2006).
2. Threshold Effects Concentrations (TECs) (MacDonald, *et al.*, 2000)
3. ORNL - SCV - Oak Ridge National Laboratory (ORNL) Tier II Secondary Chronic Values (SCVs) (Jones, Suter, & Hull, 1997)

4. Ontario Ministry of Energy and Environment (OMEE) Low-Effect Levels (LELs), assuming 1% TOC (Persaud et al.,1993)
5. USEPA Region 5 Sediment Ecological Screening levels (USEPA, 2003a)

Where a target analyte lacked a screening benchmark, surrogates have been used as noted:

- 1,2-dichloroethene was used as a surrogate for cis-1,2-dichloroethene
- 1,3-dichloropropene was used as a surrogate for cis-1,3-dichloropropene and trans-1,3-dichloropropene.
- Total xylenes was used as a surrogate for o-xylene
- m-xylene was used as a surrogate for m- & p-xylene

1.3 Screening Level Risk Characterization, Uncertainty Assessment, and Conclusions/Recommendations

The SLERA Update will conclude with a risk characterization, uncertainty analysis, and conclusions & recommendations. Analytes with an HQ of 1 or less will be eliminated from further review, and analytes with an HQ above 1 will be identified as COPECs. Major uncertainties and assumptions will also be summarized. If analytes are found to be above benchmarks during the seasonal low groundwater conditions, a quantitative ecological risk assessment may be recommended to further evaluate the potential for risks to ecological receptors.

Table 1-2 Selected Surface Water/Pore Water Screening Benchmarks (micrograms per liter)						
Analyte	**CAS#**	**AWQC [1]**	**Region III Freshwater Screening Value [2]**	**ORNL SCVs [3]**	**Region V [4]**	**Final [a]**
Acetone	67-64-1		1,500	1,500	1,700	1,500
Benzene	71-43-2		370	130	114	370
Bromobenzene	108-86-1					NA
Bromochloromethane	74-97-5					NA
Bromodichloromethane	75-27-4					NA
Bromoform	75-25-2		320	320	230	320
Bromomethane	74-83-9				16	16
2-Butanone	78-93-3		14,000	14,000	2,200	14,000
n-Butylbenzene	104-51-8					NA
sec-Butylbenzene	135-98-8					NA
tert-Butylbenzene	98-06-6					NA
Carbon Disulfide	75-15-0		0.92	0.92	15	0.92
Carbon Tetrachloride	56-23-5		13.3	9.8	240	13.3
Chlorobenzene	108-90-7		1.3	64	47	1.3
Chloroethane	75-00-3					NA
Chloroform	67-66-3		1.8	28	140	1.8
1-Chlorohexane	544-10-5					NA
Chloromethane	74-87-3					NA
2-Chlorotoluene	95-49-8					NA
4-Chlorotoluene	106-43-4					NA
Dibromochloromethane	124-48-1					NA
1,2-Dibromo-3-Chloropropane	96-12-8					NA
1,2-Dibromoethane	106-93-4					NA
Dibromomethane	74-95-3					NA
1,2-Dichlorobenzene	95-50-1		0.7	14	14	0.7
1,3-Dichlorobenzene	541-73-1		150	71	38	150
1,4-Dichlorobenzene	106-46-7		26	15	9.4	26
1,1-Dichloroethane	75-34-3		47	47	47	47
1,2-Dichloroethane	107-06-2		100	910	910	100
1,1-Dichloroethene	75-35-4		25	25	65	25
cis-1,2-Dichloroethene	156-59-2		590	590		590
trans-1,2-Dichloroethene	156-60-5		970		970	970
1,2-Dichloropropane	78-87-5				360	360
1,3-Dichloropropane	142-28-9					NA
2,2-Dichloropropane	594-20-7					NA
1,1-Dichloropropene	563-58-6					NA
cis-1,3-Dichloropropene	10061-01-5					NA
trans-1,3-Dichloropropene	10061-02-6					NA
Dichlorodifluoromethane	75-71-8					NA

Table 1-2 Selected Surface Water/Pore Water Screening Benchmarks (micrograms per liter)						
Analyte	**CAS#**	**AWQC [1]**	**Region III Freshwater Screening Value [2]**	**ORNL SCVs [3]**	**Region V [4]**	**Final [a]**
Diethyl Ether	60-29-7					NA
Di-isopropyl ether	108-20-3					NA
1,4-Dioxane - Screen	123-91-1				22,000	22,000
Ethyl tertiary-butyl ether	637-92-3					NA
Ethylbenzene	100-41-4		90	7.3	14	90
Hexachlorobutadiene	87-68-3		1.3		0.053	1.3
Hexachloroethane	67-72-1		12	12	8	12
2-Hexanone	591-78-6		99	99	99	99
Isopropylbenzene	98-82-8		2.6			2.6
4-Isopropyltoluene	99-87-6		85			85
4-Methyl-2-Pentanone	108-10-1		170	170	170	170
Methyl tert-Butyl Ether	1634-04-4		11,070			11,070
Methylene Chloride	75-09-2		98.1	2,200	940	98.1
Naphthalene	91-20-3		1.1	12	13	1.1
n-Propylbenzene	74296-31-4					NA
Styrene	100-42-5		72		32	72
Tertiary-amyl methyl ether	994-05-8					NA
1,1,1,2-Tetrachloroethane	630-20-6					NA
1,1,2,2-Tetrachloroethane	79-34-5		610	610	380	610
Tetrachloroethene	127-18-4		111	98	45	111
Tetrahydrofuran	109-99-9					NA
Toluene	108-88-3		2	9.8	253	2
1,2,3-Trichlorobenzene	87-61-6		8			8
1,2,4-Trichlorobenzene	120-82-1		24	110	30	24
1,1,1-Trichloroethane	71-55-6		11	11	76	11
1,1,2-Trichloroethane	79-00-5		1,200	1,200	500	1,200
Trichloroethene	79-01-6		21	47	47	21
Trichlorofluoromethane	75-69-4					NA
1,2,4-Trimethylbenzene	95-63-6		33			33
1,3,5-Trimethylbenzene	108-67-8		71			71
1,2,3-Trichloropropane	96-18-4					NA
Vinyl Chloride	75-01-4		930		930	930
o-Xylene	95-47-6		13			13
m- & p-Xylenes	1330-20-7		13	13	27	13
Aluminum	7429-90-5	87	87			87
Antimony	7440-36-0		30		80	30
Arsenic	7440-38-2	150	5		148	150
Barium	7440-39-3		4		220	4
Beryllium	7440-41-7		0.66		3.6	0.66

Table 1-2 Selected Surface Water/Pore Water Screening Benchmarks (micrograms per liter)						
Analyte	**CAS#**	**AWQC [1]**	**Region III Freshwater Screening Value [2]**	**ORNL SCVs [3]**	**Region V [4]**	**Final [a]**
Cadmium	7440-43-9	0.28	0.25		0.15	0.28
Calcium	7440-70-2		116,000			116,000
Chromium	7440-47-3		85		42	85
Cobalt	7440-48-4		23		24	23
Copper	7440-50-8	10.3	9		1.58	10
Iron	7439-89-6	1,000	300			1,000
Lead	7439-92-1	3.7	2.5		1.17	3.7
Magnesium	7439-95-4		82,000			82,000
Manganese	7439-96-5		120	120		120
Mercury	7439-97-6	0.91	0.026		0.0013	0.91
Nickel	7440-02-0	57	52		28.9	57
Potassium	7440-09-7		53,000			53,000
Selenium	7782-49-2	5	1		5	5
Silver	7440-22-4		3.2		0.12	3.2
Sodium	7440-23-5		680,000			680,000
Thallium	7440-28-0		0.8		10	0.8
Vanadium	7440-62-2		20		12	20
Zinc	7440-66-6	132	120		65.7	132

Notes:

[a] Final benchmarks were selected from the following sources in the order presented below:

1. U.S. Environmental Protection Agency (USEPA) Freshwater Ambient Water Quality Criteria (AWQC) Chronic Continuous Concentrations (CCC) (USEPA, 2013a).
2. USEPA Region 3 Freshwater Values (USEPA, 2006)
3. Oak Ridge National Laboratory (ORNL) Tier II Secondary Chronic Values (SCVs) from Suter and Tsao, 1996
4. USEPA Region 5 Surface Water Ecological Screening Levels (USEPA, 2003a)

Where a target analyte lacked a screening benchmark, surrogates were used as noted:

1,2-Dichloroethene was used as a surrogate for cis-1,2-dichloroethene

1,3-Dichloropropene was used as a surrogate for cis-1,3-dichloropropene and trans-1,3-dichloropropene.

Total xylenes was used as a surrogate for o-xylene

m-Xylene was used as a surrogate for m- & p-xylene

Hardness dependent criteria (cadmium, chromium, copper, lead, nickel, zinc) are based on a hardness of 100 mg/L as $CaCO_3$.

Calcium, magnesium, potassium, and sodium are considered essential nutrients; therefore benchmarks are not applicable

Table 1-3 Selected Sediment Screening Benchmarks (milligrams per kilogram)							
Analyte	**CAS#**	**Region III Freshwater Screening Value [1]**	**TEC [2]**	**ORNL SCV [3]**	**OMEE LELs [4]**	**USEPA Region V [5]**	**Final [a]**
Acetone	67-64-1			0.0087		0.0099	0.0087
Benzene	71-43-2			0.16		0.142	0.16
Bromobenzene	108-86-1						NA
Bromochloromethane	74-97-5						NA
Bromodichloromethane	75-27-4						NA
Bromoform	75-25-2	0.654		0.65		0.492	0.654
Bromomethane	74-83-9					0.0013	0.0013
2-Butanone	78-93-3			0.27		0.0424	0.27
n-Butylbenzene	104-51-8						NA
sec-Butylbenzene	135-98-8						NA
tert-Butylbenzene	98-06-6						NA
Carbon Disulfide	75-15-0	0.00085		0.00085		0.0239	0.0008
Carbon Tetrachloride	56-23-5	0.0642		0.047		1.45	0.0642
Chlorobenzene	108-90-7	0.0084		0.41		0.291	0.0084
Chloroethane	75-00-3						NA
Chloroform	67-66-3			0.022		0.121	0.022
1-Chlorohexane	544-10-5						NA
Chloromethane	74-87-3						NA
2-Chlorotoluene	95-49-8						NA
4-Chlorotoluene	106-43-4						NA
Dibromochloromethane	124-48-1						NA
1,2-Dibromo-3-Chloropropane	96-12-8						NA
1,2-Dibromoethane	106-93-4						NA
Dibromomethane	74-95-3						NA
1,2-Dichlorobenzene	95-50-1	0.0165		0.33		0.294	0.0165
1,3-Dichlorobenzene	541-73-1	4.43		1.7		1.315	4.43
1,4-Dichlorobenzene	106-46-7	0.599		0.34		0.318	0.599
Dichlorodifluoromethane	75-71-8						NA
1,1-Dichloroethane	75-34-3			0.027		0.000575	0.027
1,2-Dichloroethane	107-06-2			0.25		0.26	0.25
1,1-Dichloroethene	75-35-4	0.031		0.031		0.0194	0.031
cis-1,2-Dichloroethene	156-59-2			0.4			0.4
trans-1,2-Dichloroethene	156-60-5	1.05		0.4		0.654	1.05
1,2-Dichloropropane	78-87-5					0.333	0.333
1,3-Dichloropropane	142-28-9						NA
2,2-Dichloropropane	594-20-7						NA
1,1-Dichloropropene	563-58-6						NA
cis-1,3-Dichloropropene	10061-01-5						NA

Table 1-3 Selected Sediment Screening Benchmarks (milligrams per kilogram)							
Analyte	**CAS#**	**Region III Freshwater Screening Value [1]**	**TEC [2]**	**ORNL SCV [3]**	**OMEE LELs [4]**	**USEPA Region V [5]**	**Final [a]**
trans-1,3-Dichloropropene	10061-02-6						NA
Ethylbenzene	100-41-4	1.1		0.089		0.175	1.1
Hexachlorobutadiene	87-68-3					0.0265	0.0265
2-Hexanone	591-78-6			0.022		0.0582	0.022
Isopropylbenzene	98-82-8	0.086					0.086
4-Isopropyltoluene	99-87-6						NA
4-Methyl-2-Pentanone	108-10-1			0.033		0.0251	0.033
Methyl tert-Butyl Ether	1634-04-4						NA
Methylene Chloride	75-09-2			0.37		0.159	0.37
Naphthalene	91-20-3	0.176	0.03275	0.24		0.176	0.176
n-Propylbenzene	74296-31-4						NA
Styrene	100-42-5	0.559				0.254	0.559
1,1,1,2-Tetrachloroethane	630-20-6						NA
1,1,2,2-Tetrachloroethane	79-34-5	1.36		1.4		0.85	1.36
Tetrachloroethene	127-18-4	0.468		0.41		0.99	0.468
Toluene	108-88-3			0.05		1.22	0.05
1,2,3-Trichlorobenzene	87-61-6	0.858					0.858
1,2,4-Trichlorobenzene	120-82-1	2.1		9.6		5.062	2.1
1,1,1-Trichloroethane	71-55-6	0.0302		0.03		0.213	0.0302
1,1,2-Trichloroethane	79-00-5	1.24		1.2		0.518	1.24
Trichloroethene	79-01-6	0.0969		0.22		0.112	0.0969
Trichlorofluoromethane	75-69-4						NA
1,2,4-Trimethylbenzene	95-63-6						NA
1,3,5-Trimethylbenzene	108-67-8						NA
Vinyl Chloride	75-01-4					0.202	0.202
m- & p-Xylenes	1330-20-7			0.16		0.433	0.16
o-Xylene[5]	95-47-6						NA
Aluminum	7429-90-5						NA
Antimony	7440-36-0	2					2
Arsenic	7440-38-2	9.8	12.1			9.79	9.8
Barium	7440-39-3						NA
Beryllium	7440-41-7						NA
Cadmium	7440-43-9	0.99	0.592		0.6	0.99	0.99
Calcium	7440-70-2						NA
Chromium	7440-47-3	43.4	56		26		43.4
Cobalt	7440-48-4.					50	50
Copper	7440-50-8	31.6	28		16	31.6	31.6
Iron	7439-89-6	20,000			20,000		20,000
Lead	7439-92-1	35.8	34.2		31	35.8	35.8

Table 1-3 Selected Sediment Screening Benchmarks (milligrams per kilogram)							
Analyte	**CAS#**	**Region III Freshwater Screening Value [1]**	**TEC [2]**	**ORNL SCV [3]**	**OMEE LELs [4]**	**USEPA Region V [5]**	**Final [a]**
Magnesium	7439-95-4						NA
Manganese	7439-96-5	460	1673		460		460
Mercury	7439-97-6	0.18			0.2	0.174	0.18
Nickel	7440-02-0	22.7	39.6		16	22.7	22.7
Potassium	7440-09-7						NA
Selenium	7782-49-2	2					2
Silver	7440-22-4	1				0.5	1
Sodium	7646-69-7						NA
Thallium	7440-28-0						NA
Vanadium	7440-62-2						NA
Zinc	7440-66-6	121	159		120	121	121

Notes:

[a] Final benchmarks were selected from the following sources in the order presented:

1. USEPA Region 3 Freshwater Sediment Screening Values (USEPA, 2006).
2. Threshold Effects Concentrations (TECs) (MacDonald, *et al.*, 2000)
3. ORNL - SCV - Oak Ridge National Laboratory (ORNL) Tier II Secondary Chronic Values (SCVs) (Jones, Suter, & Hull, 1997)
4. Ontario Ministry of Energy and Environment (OMEE) Low-Effect Levels (LELs), assuming 1% TOC (Persaud et al.,1993)
5. USEPA Region 5 Sediment Ecological Screening levels (USEPA, 2003a)

Where a target analyte lacked a screening benchmark, surrogates were used as noted:

1,2-Dichloroethene was used as a surrogate for cis-1,2-dichloroethene
1,3-Dichloropropene was used as a surrogate for cis-1,3-dichloropropene and trans-1,3-dichloropropene.
Total xylenes was used as a surrogate for o-xylene
m-Xylene was used as a surrogate for m- & p-xylene

2.0 HUMAN HEALTH RISK ASSESSMENT SCOPE OF WORK

A Human Health Risk Assessment (HHRA) was prepared for the former Nike Battery PR-58 Property in 2011 (AECOM, 2011) and addressed risk to the following four exposure areas:

1) Onsite – Southwest ¼ of the Nike Project,
2) Onsite – Rest of Nike Project,
3) Offsite Residential – Drinking Water Well Area, and
4) Offsite Residential – North of Perimeter Road Area located on or surrounding the Property.

This revised HHRA is being prepared to address additional exposure scenarios that were not addressed in the 2011 HHRA and to update the original risk assessment with more recent screening levels and toxicity information. Refer to Figure 2 for a figure depicting the exposure areas evaluated in the 2011 HHRA.

The revised HHRA will be conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements and the Contract Modifications dated 11 July 2012 and 13 March 2013, respectively. As explained in the RI Work Plan, Stone Environmental has proposed to collect additional groundwater and soil data at select locations to further supplement the existing RI dataset. The exposure point concentrations used in the revised HHRA will be based on the groundwater and soil data used in the 2011 HHRA, and will incorporate the newly collected groundwater and soil data, when appropriate.

Per the Addendum to the *Performance Work Statement* (*PWS*), dated January 29, 2013, a January 22, 2013 e-mail correspondence, and AMEC's understanding of the available analytical data, the HHRA will address the following exposure areas (which include two new areas) and exposure scenarios:

- Recreational Area minus Source Area (reconfigured Southwest ¼ of the Nike Project):
  - Child and a teenage recreator exposed to surface soil and irrigation water, and;
  - Construction worker exposed to surface and subsurface soils.
- Rest of Nike Property minus Source Area (reconfigured Rest of Nike Property):
  - Hypothetical future resident (child and adult) exposed to surface and subsurface soils, potable groundwater[1] (ingestion as drinking water, dermal contact during bathing/showering, and inhalation of volatiles during bathing/showering), and indoor air;
  - Daycare children exposed to surface soil and inhalation of indoor air;
  - Construction worker exposed to surface and subsurface soil;

[1] The Rest of Nike Property is located within a GB groundwater area; groundwater classified as GB may not be suitable for drinking without treatment. However, groundwater on the Rest of Nike Property minus Source Area will be evaluated for potable groundwater use to assess need for restriction on groundwater use.

  - Indoor worker exposed to indoor air and surface soil; and,
  - Outdoor worker exposed to surface soil.
- Source Area:
  - Outdoor worker exposed to surface and subsurface soil;
  - Indoor worker exposed to indoor air (screening level evaluation only); and,
  - A comparison of soil data against the USEPA Leaching-based soil screening levels (SSLs) (screening level evaluation only).
- Area East and South of Property – DPW Property (the land south of the Nike Property Area):
  - Indoor worker exposed to indoor air (from groundwater) - new scenario for area of impacted shallow groundwater; and,
  - A qualitative comparison[2] of groundwater concentrations in the Area East and South of Property with respect to those on the Property.
- Area East and South of Property – (the land east of the Nike Project Area):
  - Indoor worker exposed to indoor air (volatilization from groundwater) – new scenario for area of impacted shallow groundwater.
  - A qualitative comparison[2] of groundwater concentrations in the Area East and South of Property with respect to those on the Property.
- Offsite Residential Drinking Water Wells area:
  - Resident and daycare child exposed to indoor air (volatilization from groundwater). (Update).
  - Ingestion of drinking water, dermal contact during bathing/showering, and inhalation of volatiles during bathing/showering - update
- Offsite Residential – North of Perimeter Road (two areas)
  - Resident and daycare child exposed to indoor air (volatilization from groundwater). (Update).Ingestion of drinking water, dermal contact during bathing/showering, and inhalation of volatiles during bathing/showering - update

Refer to Figure 1 for a depiction of the exposure areas to be evaluated in the HHRA. The HHRA will be performed consistent with USEPA risk assessment guidance (USEPA, 1989). It is noted

[2] Groundwater concentrations in the Area East and South of the Property will be compared to concentrations identified on the Property. The qualitative evaluation will discuss how the risks would be expected to differ (if at all) in the Area East and South of the Property from those identified in the quantitative risk calculations for the Property itself. The qualitative evaluation will be conducted for this area that is not currently used as a drinking water source and that is not expected to be a drinking water source in the future. The qualitative assessment does not include any comparison of site groundwater data to background conditions.

that the Rhode Island Remediation Regulations (RIDEM, 2011) allow for the development of Method 3 Remedial Objectives (with approval from RIDEM where governed by RIDEM regulations), which are based on a site-specific risk assessment following USEPA guidance. Therefore, the HHRA will also be generally consistent with RIDEM's Method 3 Remedial Objectives guidance. In accordance with USEPA guidance, the HHRA will include the following four steps:

- Data Evaluation
- Exposure Assessment
- Dose-Response Assessment
- Risk Characterization

2.1 Data Evaluation

This step of the HHRA involves compiling and summarizing the data for the revised HHRA, and selecting chemicals of potential concern (COPCs), which will be evaluated quantitatively. As discussed later in this section, the revised HHRA will include the soil data collected between 1987 to 2010, which were included in the 2011 HHRA (AECOM, 2011). The data that were presented in the 2011 HHRA were collected, validated, and accepted according to a project-specific QAPP. Therefore the data selected from previous studies will meet the data quality requirements for the revised HHRA. The following new data will also be included in this revised HHRA.

Soil:

Additional Source characterization data will be collected in 2013. These data will be collected in accordance with Section 7.0 of the Final RI/FS Supplemental Work Plan (SWP). Only data that meet the data quality requirements in accordance with the project-specific QAPP will be used in the revised HHRA.

Groundwater

The most recent data collected between 2007 and 2010 will be used, and where appropriate, the new (2013) round of groundwater sampling data will be used in the HHRA. Both the 2007 to 2010 sampling program and the 2013 sampling program were designed to meet data quality objectives (DQOs) for the HHRA, therefore the data will meet the data quality requirements for the HHRA. The 2013 data will be reviewed to determine their suitability for inclusion in the HHRA. Reasons the data may not be appropriate for use include anomalous results, field conditions that indicate that the results are not representative, and other circumstances that when professional judgment is applied, it is determined that the results are not representative of site conditions. Any groundwater analytical results that are excluded from the HHRA will be tabulated and a description of the reason for the exclusion will be provided in the table as well. This table will be included as part of the HHRA.

Indoor Air

Laboratory analytical results for indoor air samples collected in January 2011 from the existing building on the DPW property will be used in the HHRA. All eight of the collected indoor air samples will be used in the HHRA and the analytical results will be presented in a table as part of the HHRA. Data Compilation

Soil

Soil data collected from 1987 to 2013 are available. All of the soil data that were used in the 2011 HHRA will be used in the revised HHRA (this consisted of data within the SW corner of the Nike Property and the Rest of Nike Area). Based on the exposure scenarios identified in the HHRA (discussed in the Exposure Assessment section), the soil samples will be divided into two different depth intervals (surficial soil including samples from 0-2 and 0-1 feet (ft) bgs and combined surface and subsurface including samples collected within the 0-10 ft bgs interval).

Groundwater

The most recent data collected between 2007 and 2010 will be used, and where appropriate, the new (2013) round of groundwater sampling data will be used in the HHRA. Additional groundwater data have been collected in 2009, 2010, and will be collected in 2013 (for a total of 53 wells). This revised HHRA will incorporate the new data, and replace previous data, where appropriate. Therefore, the 2007, 2008, 2009, 2010, and 2013 data will be considered for the HHRA.

Indoor Air

A total of eight indoor air samples were collected from the existing building on the DPW property. These samples were collected in January 2011. All eight of the samples will be considered in the HHRA with respect to the indoor air evaluation for the Area East and South of Property – DPW Property.

2.1.1 Summary Statistics

Summary statistics will be complied for each medium and data set, by chemical including: minimum and maximum detected concentrations, frequency of detection, range of reporting limits for non-detects, and arithmetic mean concentrations. The following guidance documents will be used to develop the summary statistics:

- Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual, Part A (USEPA, 1989).
- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Solid Waste and Emergency Response (OSWER) 9285.6-10. December 2002 (USEPA, 2002a).

The steps used to summarize the data by medium are discussed here. The additional steps used to identify exposure point concentrations (EPCs) are presented in the Exposure Assessment. The steps used to summarize the data by area and medium are as follows:

Treatment of Field Duplicates: For sample locations in which a duplicate sample has also been collected, duplicates will be resolved as follows:

1) where both the sample and the duplicate are not detected, the resulting value is the average of the detection limits;
2) where both the sample and the duplicate are detected, the resulting value is the average of the detected results; and
3) where one of the pair is reported as not detected and the other is detected, the detected concentration is used.

The selected value for each compound/medium/area combination will be used in the calculation of summary statistics (including maximum detection and frequency of detection).

Frequency of Detection: The frequency of detection is reported as the number of detects and the total number of samples analyzed for a specific chemical.

Minimum Detected Concentration: This is the minimum detected concentration for each chemical/medium combination.

Maximum Detected Concentration: This is the maximum detected concentration for each chemical/medium combination.

Mean Concentration: This is the arithmetic mean concentration for each chemical/medium combination considering ½ the reporting limit for non-detects.

2.1.2 Selection of Chemicals of Potential Concern (COPC)

COPCs are a subset of the complete list of chemicals detected in site media that are carried through the quantitative risk assessment process. Selection of COPCs focuses the analysis on the most likely risk "drivers." As stated in USEPA guidance (USEPA, 1995):

> "Most risk assessments are dominated by a few compounds and a few routes of exposure. Inclusion of all detected compounds at a site in the risk assessment has minimal influence on the total risk. Moreover, quantitative risk calculations using data from environmental media that may contain compounds present at concentrations too low to adversely affect public health have no effect on the overall risk estimate for the site. The use of a toxicity screen allows the risk assessment to focus on the compounds and media that may make significant contributions to overall risk."

Several factors are typically considered in selecting COPCs for a site, including essential nutrient status, and toxicity.

Essential Nutrient Status

Chemicals that are considered essential nutrients (calcium, magnesium, sodium, potassium, and phosphorous) will not be included as COPCs.

Toxicity

Screening on the basis of toxicity is done by comparing site concentrations to risk-based screening levels.

Soil

For each soil data set (surface and combined surface and subsurface), maximum detected concentrations will be compared to a screening level that is based on the USEPA Regional Screening Levels (RSLs) for residential soil (USEPA, 2013b or more recent publication). Consistent with USEPA Region I guidance, the screening value used in the COPC selection will be the lower of the concentration identified for cancer risk of 1×10^{-6} and the concentration identified with a non-cancer HQ of 0.1 to account for cumulative effects.

Groundwater

For each groundwater data set being evaluated for potable use and/or dermal contact (Recreational Area, Rest of Nike Area and Source Area), maximum detected concentrations will be compared to screening levels based on USEPA RSLs for tapwater (USEPA, 2013b or more recent publication). Consistent with USEPA Region I guidance, the screening value used in the COPC selection will be the lower of the concentration identified for cancer risk of 1×10^{-6} and the concentration identified with a non-cancer HQ of 0.1 to account for cumulative effects.

Indoor Air

For the indoor air data set being evaluated for inhalation of indoor air, maximum detected concentrations will be compared to the USEPA RSLs for a commercial worker exposed to indoor air scenario. Consistent with USEPA Region I guidance, the screening value used in the COPC selection will be the lower of the concentration identified for cancer risk of 1×10^{-6} and the concentration identified with a non-cancer HQ of 0.1 to account for cumulative effects.

2.2 Exposure Assessment

The purpose of the exposure assessment is to estimate the magnitude and frequency of potential human exposure to COPCs present in media of interest at each exposure area. The first step in the exposure assessment process is determining potential receptors (i.e., people who may contact the impacted environmental media of interest). Potential exposure scenarios identifying appropriate environmental media and exposure pathways for current and potential future site uses are then developed. This risk assessment considers potential exposure to soil and groundwater onsite, and groundwater offsite.

Based on current and potential future land use, the HHRA will consider the following receptors and exposure pathways:

- Resident – exposure to potable groundwater, including ingestion, dermal contact and inhalation of volatiles during showering. It will be assumed that the resident could be exposed to vapors in indoor air arising from groundwater. It will also be assumed that residents are also exposed to vadose zone soil (0-10 ft) through dermal contact and incidental ingestion and inhalation of airborne particles in outdoor air. Both child and adult residents will be evaluated.
- Construction Worker – exposure to vadose zone soil (0-10 ft) through dermal contact and incidental ingestion, and inhalation of airborne particles in outdoor air.

- Recreational Child/Teenager – exposure to surface soil (0-2 ft) through dermal contact and incidental ingestion; and inhalation of airborne particles in outdoor air. The recreational child/teenager will also be evaluated for dermal contact with irrigation water.
- Daycare Child – exposure to surface soil (0-2 ft) through dermal contact and incidental ingestion; and inhalation of airborne particles in outdoor air. It will also be assumed that a daycare child could be exposed to vapors in indoor air arising from groundwater.
- Indoor Worker – exposure to vapors in indoor air arising from groundwater. It will also be assumed that the indoor worker is exposed to surface soil (0-2 ft) through dermal contact, incidental ingestion, and inhalation of airborne particles in outdoor air.
- Outdoor Worker – exposure to surface soil (0-2 ft) through dermal contact, incidental ingestion, and inhalation of airborne particles in outdoor air.

Tables 2-1 through 2-6 at the end of this section show proposed exposure assumptions for each of these receptors. The assumptions were developed using USEPA guidance documents (as referenced in the tables) and site-specific information. Table 2-7 shows the calculation of soil adherence factors used to evaluate dermal soil exposure for the Adult/child Resident, Construction Worker, Child/Teenage Recreator, Daycare Child, and Outdoor Worker.

For each receptor, the exposure dose will be estimated for each chemical via each exposure pathway by which the receptor is assumed to be exposed. Exposure dose equations combine the estimates of chemical concentration in the environmental medium of interest with assumptions regarding the type and magnitude of each receptor's potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of COPC taken into the receptor and is expressed in units of milligrams of COPC per kilogram of body weight per day (mg/kg-day). The chemical concentrations that go into the exposure dose equations are called exposure point concentrations (EPC).

Soil

Soil EPCs will be developed for each soil data set (surface and combined surface and subsurface) for three of the seven exposure areas (Recreational Area minus Source Area; Rest of Nike Property minus Source Area; and the Source Area). The remaining four exposure areas are off-site areas where the soil exposure pathways have been evaluated by other parties (Area East and South of Property – DPW Property and Area East and South of Property) or are not complete pathways (Offsite Residential Drinking Water Wells and Offsite Residential – North of Perimeter Road). The EPCs for each COPC will be defined as the upper confidence limit (UCL) on the arithmetic mean concentration, or the maximum concentration, whichever is lower (USEPA, 2002a). USEPA's ProUCL Version 5.0 software USEPA, 2013c) will be used to calculate UCLs. The full reporting limits will be input into ProUCL and the mode that allows the program to select appropriate values for non-detects will be used. The ProUCL recommended UCLs (95%, 97.5%, 99%) will be used as EPCs unless they are greater than the maximum detected concentration. Based on information presented in the ProUCL guidance

(USEPA, 2013c) regarding minimum sample size and frequency of detection, UCLs will be calculated where at least 10 samples and at least 5 detects are available. Where too few samples or detects are available, the maximum detected concentration will be used. ProUCL version 5.0 recommends 10 to 15 or more distinct results for the most accurate and reliable UCL calculation. When fewer than 10 detects are present in the dataset, the calculations will be reviewed individually to determine appropriate UCLs. Where these standards were not met, the maximum detected concentration will be used as the EPC.

Groundwater

For groundwater, it is assumed that a receptor could be continuously exposed to the well with the highest concentrations, therefore UCLs will not be calculated for each groundwater data set, and maximum concentrations will be used as EPCs. For some well locations, samples were collected at 3 depths (S, D and R) ranging from shallow to deeper points. The results from the shallowest available sample will be used as EPCs for the volatilization pathway, since the shallow samples provide a better representation of the volatile concentrations that could migrate into an onsite building. Groundwater EPCs will be developed for all six exposure areas. For the two areas south and east of the Property, the indoor air pathway will be evaluated for the footprint of trichloroethene (TCE) and 1,1,2,2-tetrachloroethane (TeCA) contamination (depicted on Figure 4-10 of the *Draft RI Report* (The Johnson Company, 2011)), as these are the areas likely to have a potential for exposure to indoor air and would provide a conservative evaluation, without dilution, for areas beyond the plume.

Indoor Air

For the exposure pathway involving volatilization from groundwater to indoor air, screening evaluations and risk calculations will be conducted using USEPA's Vapor Intrusion Screening Level (VISL) Calculator (USEPA, 2012). Per USEPA 2012, the VISL calculator provides generally recommended screening-level concentrations for groundwater, soil gas, and indoor air. It also allows for forward calculation of risk using site-specific parameters. The VISL calculator is based on the generic CSM described in the USEPA's Subsurface Vapor Intrusion Guidance (USEPA, 2002b) and utilizes attenuation factors based on the analysis of exposure to indoor air data in the USEPA's Vapor Intrusion Database: Preliminary Evaluation of Attenuation Factors (USEPA, 2008). The Tri-Services Environmental Risk Assessment Workgroup, Department of Defense (DoD) Vapor Intrusion Handbook, January 2009 embraces the USEPA 2002 approach. If revised USEPA guidance is published prior to the HHRA production, the updated guidance will be used in the evaluation. For the showering pathway, concentrations of volatiles in the shower will be calculated using a model developed by Foster and Chrostowski (1987).

For the Area East and South of Property – DPW Property, the existing data set for indoor air (a total of eight samples collected in 2011) will be used to calculate risk. Risks will be calculated for a commercial worker scenario using a scaling approach. EPCs will be calculated as the average of the indoor air dataset. The cancer and noncancer components of the USEPA RSLs for commercial indoor air will be used as the scaling factors. Risk will be calculated by dividing the EPCs for each COPC by the cancer component of the USEPA RSLs and multiplying the resulting quotient by 1×10^{-6} for commercial indoor air for cancer risk and by the noncancer

component (concentration at HQ of 1) of the USEPA RSLs for commercial indoor air for the HQs.

2.3 Dose-Response Assessment

The purpose of the dose-response assessment is to identify the types of adverse health effects a chemical may potentially cause, and to define the relationship between the dose of a chemical and the likelihood or magnitude of an adverse effect (response) (USEPA, 1989). Adverse effects are classified by USEPA as potentially carcinogenic or non-carcinogenic (i.e., potential effects other than cancer). Dose-response values for potentially carcinogenic effects are called Cancer Slope Factors (CSFs), and those for non-carcinogenic effects are called Reference Doses (RfDs). Dose-response relationships are defined by USEPA for oral and inhalation exposure. Oral toxicity values are also used to assess dermal exposures, with appropriate adjustments. Combining the results of the dose-response assessment with information on the magnitude of potential human exposure provides an estimate of potential risk.

USEPA's guidance regarding the hierarchy of sources of human health dose-response values in HHRA will be followed in selecting dose-response values (USEPA, 2003b). The following hierarchy of sources for dose-response values [taken from USEPA, 2003b]. *Human Health Toxicity Values in Superfund Risk Assessments* (OSWER No. 9285.753, December 2003] will be used in identifying dose-response values for this HHRA:

Tier 1 - IRIS (http://www.epa.gov/iris/). In accordance with USEPA guidance, the main source of dose-response values is IRIS, which is a database established by USEPA containing all validated data on many toxic substances found at hazardous waste sites. The most current version of this database at the time of the HHRA preparation will be used to identify the CSFs, Unit Risks (URs), RfDs, and Reference Concentrations (RfCs) applied in this risk assessment.

Tier 2 - National Center for Environmental Assessment (NCEA) provisional peer reviewed toxicity values (PPRTVs) (http://hhpprtv.ornl.gov/). NCEA's PPRTVs are developed by the Superfund Technical Support Center (STSC) for the USEPA Superfund program. STSC's reassessment of USEPA Health Effects Assessment Summary Tables (HEAST) toxicity values, as well as development of PPRTVs in response to Regional or Headquarters Superfund program requests, are consistent with Agency practices on toxicity value development, use the most recent scientific literature, and are supported by both internal and external peer review, providing a high level of confidence in the use of these values in the Superfund Program. The PPRTVs that will be used in this HHRA will be obtained from the USEPA-recommended website.

Tier 3 - Other Toxicity Values:

- California Environmental Protection Agency (CALEPA) toxicity values (CALEPA, 2013). CALEPA develops toxicity values for both cancer and non-cancer effects. CALEPA toxicity values were obtained from the CALEPA website at http://www.oehha.ca.gov/risk/chemicalDB//index.asp. The most current version of this database at the time of the HHRA preparation will be used to identify appropriate toxicity criteria.

- Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) (ATSDR, 2013) address non-cancer effects only, and are available on the ATSDR website at http://www.atsdr.cdc.gov/mrls.html. MRL values for intermediate exposure were used as subchronic RfD and RfC values, and MRL values for chronic exposures were used as chronic RfD and RfC values. The most current version of this database at the time of the HHRA preparation will be used to identify appropriate toxicity criteria.
- Toxicity values remaining in current versions of HEAST.

2.4 Risk Characterization

The risk characterization for this project will include a screening level evaluation (for soil in the source area and for exposure to indoor air in the source area and offsite drinking water well area), a comparison of groundwater concentrations in the two exposure areas east and south of the Property, and a traditional risk assessment. For the traditional risk assessment, two general types of health risk are characterized for each potential exposure pathway considered: potential carcinogenic risk and potential non-carcinogenic risk. The following sections describe the risk characterization approach:

2.4.1 Carcinogenic Risk Characterization

The purpose of carcinogenic risk characterization is to estimate the upper-bound likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of exposure to a chemical in environmental media at the site. This likelihood is a function of the dose of a chemical and CSF for that chemical. The Excess Lifetime Cancer Risk (ELCR) is the likelihood over and above the background cancer rate. The risk value is expressed as a probability (e.g., 10^{-6}, or one in one million). The relationship between the ELCR and the lifetime average daily dose (LADD) of a chemical may be expressed as:

$$ELCR = 1-e^{-(CSF \times LADD)}$$

When the product of the CSF and the LADD is much greater than 1, the ELCR approaches 1 (i.e., 100 percent probability). When the product is less than 0.01 (one chance in 100), the equation can be closely approximated by:

$$ELCR = LADD\ (mg/kg\text{-}day) \times CSF\ (mg/kg\text{-}day)^{-1}$$

The product of the CSF and the LADD is unitless, and provides an upper-bound estimate of the potential carcinogenic risk associated with a receptor's exposure to that chemical via that pathway.

The potential carcinogenic risk for each exposure pathway is calculated for each receptor. In current regulatory risk assessment, it is assumed that cancer risks are additive. Risk from different exposure pathways are summed to estimate the total site potential cancer risk for each receptor. The sum of the cancer risk estimates for each receptor will be compared to the USEPA's target risk range of 1×10^{-4} to 1×10^{-6}. Cancer risk estimates will also be compared to

the RIDEM target risk levels: carcinogenic risk 1×10^{-6} for each carcinogen, 1×10^{-5} cumulative risk.

2.4.2 Noncarcinogenic Risk Characterization

The potential for exposure to a chemical to result in adverse non-carcinogenic health effects is estimated for each receptor by comparing the chronic average daily dose (CADD) for each COPC with the RfD for that COPC. The resulting ratio, which is unitless, is known as the HQ for that chemical. The HQ is calculated using the following equation:

$$HQ = \frac{CADD(mg/kg-day)}{RfD(mg/kg-day)}$$

The target HQ is defined as an HQ of less than or equal to one (USEPA, 1989). When the HQ is less than or equal to 1, the RfD has not been exceeded, and no adverse non-carcinogenic effects are expected. If the HQ is greater than 1, there may be a potential for adverse non-carcinogenic health effects to occur; however, the magnitude of the HQ cannot be directly equated to a probability or effect level.

The total Hazard Index (HI) is calculated for each exposure pathway by summing the HQs for each individual chemical. The total site HI is calculated for each potential receptor by summing the HIs for each pathway associated with the receptor. Where the total site HI is greater than 1 for any receptor, a more detailed evaluation of potential non-carcinogenic effects based on specific health or target endpoints (e.g., liver effects, neurotoxicity) is performed (USEPA, 1989). The target HI is 1 on a per target endpoint basis. RIDEM's non-carcinogenic target levels are non-carcinogenic risk HI < 1 for each chemical and cumulative HI < 1 for any target organ system.

2.4.3 Screening Level Evaluation

As described above, for the source area and exposure pathway involving volatilization from groundwater to indoor air, a screening level evaluation will be conducted using USEPA's VISL Calculator (USEPA, 2012). The residential scenario was selected for the VISL. For the screening level evaluation, maximum detected groundwater concentrations will be compared to calculated groundwater concentrations protective of human health (i.e., the lower of the groundwater concentrations predicted to pose an excess lifetime cancer risk of 1×10^{-6} or a HI of 1) for a residential scenario.

The maximum detected soil concentrations from the source area data set will be compared to the risk-based USEPA Leaching Based SSLs presented in USEPA, 2013b. Analytes that exceed these concentrations in soil will have the potential to leach to groundwater and lead to groundwater concentrations in excess of the USEPA Tapwater RSLs.

2.4.4 Area East and South of Property Comparison

A qualitative evaluation of potable use of groundwater in the two exposure areas East and South of the Property will be performed. This evaluation will compare groundwater concentrations for COPCs in the Area East and South of the Property to corresponding groundwater concentrations on the Property. The qualitative evaluation will discuss how the hypothetical drinking water

risks would be expected to be no greater in the Area East and South of the Property from those identified in the quantitative risk calculations (ingestion, dermal contact, and inhalation during showering/bathing) for the Property itself. The Area East and South of the Property is not currently used as a source of drinking water and is not expected to be a source of drinking water in the future. The qualitative assessment will indicate that, due to natural attenuation (primarily dispersion), the risks would be expected to be no greater than those calculated for groundwater at the Property

2.4. Determination of Risk Drivers and Comparison to Standards

The Risk Characterization section of the RI Report will discuss the chemicals that are risk drivers in each medium. If calculated risks are above the USEPA cancer risk range and/or HI values are above 1, risk-based preliminary remediation goals will be developed for Chemicals of Concern (COCs), as part of the RI Report, after the risk assessment has been completed. As appropriate, exposure point concentrations in groundwater will be compared to Maximum Contaminant Levels (MCLs) (USEPA, 2011b). Exposure point concentrations in both soil and groundwater will be compared to RIDEM Method 1 remediation objectives for soil and groundwater (RIDEM, 2004). This comparison provides a useful risk management tool.

2.4.6 Uncertainty Analysis

The Risk Characterization will include an Uncertainty Analysis. Regulatory risk assessment methodology requires that conservative assumptions be made throughout the risk assessment to ensure that public health is protected. The assumptions that introduce the greatest amount of uncertainty in this risk assessment will be discussed in this section. They will be discussed in qualitative terms, because for most of the assumptions there is not enough information to assign a numerical value to the uncertainty that can be factored into the calculation of risk. Uncertainties involved in the Data Evaluation include assumptions regarding the decision of which sampling points to include as exposure point concentrations, and selecting COPCs on the basis of screening. In the Exposure Assessment, uncertainties exist in the selection of receptors and assumptions concerning rates of ingestion, frequency and duration of exposure, and bioavailability of the chemicals in the medium. Typically, when limited information is available to establish these assumptions, a health-protective estimate of potential exposure is employed. In the Dose-Response Assessment, there are uncertainties involved in animal to human extrapolations, high to low dose extrapolations, and the specific models used to develop dose-response values. The Risk Characterization includes uncertainties in the evaluation of potential exposure to multiple chemicals, the combination of upper-bound exposure estimates with upper-bound toxicity estimates, and the risk to sensitive populations. The uncertainties involved in the different HHRA steps will be discussed.

Table 2-1

Summary of Potential Exposure Assumptions - Resident

Parameter		Resident			
		Adult		Child (0 to 6 yrs)	
Parameters Used in the Exposure to Indoor Air from Groundwater Pathway					
	Exposure Time (hr/day)	16.4	(a)	18	(a)
	Exposure Frequency (days/year)	350	(b)	350	(b)
	Exposure Duration (yr)	24	(b)	6	(b)
	Body Weight (kg)	70	(b)	15	(b)
Parameters Used in the Drinking Water Pathway					
	Exposure Frequency (days/year)	350	(b)	350	(b)
	Exposure Duration (yr)	24	(b)	6	(b)
	Water Ingestion Rate (l/event)	2	(b)	1	(b)
	Body Weight (kg)	70	(b)	15	(b)
Parameters Used in the Showering/Bathing Pathway					
	Exposure Time (hr/event)	0.17	(c)	0.33	(c)
	Exposure Frequency (days/year)	350	(b)	350	(b)
	Exposure Duration (yr)	24	(b)	6	(b)
	Skin Contacting Medium (cm^2)	18,150	(d)	6,557	(d)
	Body Weight (kg)	70	(b)	15	(b)
Parameters Used in the Outdoor Air Inhalation Pathway					
	Exposure Time (hr/day)	2	(e)	5.6	(e)
	Exposure Frequency (days/year)	350	(b)	350	(b)
	Exposure Duration (yr)	24	(b)	6	(b)
	Body Weight (kg)	70	(b)	15	(b)
Parameters Used in the Surface Soil Pathway					
	Exposure Frequency (days/year)	350	(b)	350	(b)
	Exposure Duration (yr)	24	(b)	6	(b)
	Ingestion Rate (mg/day)	100	(b)	200	(b)
	Exposed Skin Surface Area (cm^2)	5,700	(f,g)	2,800	(f,g)
	Adherence Factor (mg/cm^2)	0.07	(g.h)	0.2	(g,h)
	Body Weight (kg)	70	(b)	15	(b)

Notes:

(a) – USEPA, 1997b. Exposure Factors Handbook. Values for time spent indoors listed in Table 1-2 (weighted average of weekends/weekdays for children, and residential value for adults).

(b) - USEPA, 1991. Standard Default Exposure Factors.

(c) - USEPA, 1997b. Exposure Factors Handbook. Recommended value for time spent showering for adults and bathing for children (Table 15-176). The adult time is the average (10 minutes per day) and the child time is the median (20 minutes per day).

(d) - USEPA, 1997b. Exposure Factors Handbook. Represents average 50th percentile surface area for males and females of entire body.

(e) - USEPA, 1997b. Exposure Factors Handbook. Values for time spent outdoors listed in Table 1-2 (weighted average of weekends/weekdays for children, and residential value for adults).

(f) - USEPA, 1997b. Exposure Factors Handbook. Adult surface area represents average 50th percentile surface

Table 2-1 Summary of Potential Exposure Assumptions - Resident		
Parameter	Resident	
	Adult	Child (0 to 6 yrs)

area for males and females of hands, forearms, lower legs, and head. Child surface area represents average 50th percentile surface area for males and females of hands, feet, forearms, lower legs, and head.

(g) - USEPA, 2004. Risk Assessment Guidance for Superfund, Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-5, Reasonable Maximum Exposure (RME) recommended residential value.

(h) - USEPA, 1997b and USEPA, 2004. See Table 1-7 for calculation.

Table 2-2 Summary of Potential Exposure Assumptions - Construction Worker			
Parameter		Construction/Utility Worker	
Parameters Used in the Outdoor Air Inhalation Pathway			
	Exposure Time (hr/day)	8	(a)
	Exposure Frequency (days/year)	40	(b)
	Exposure Duration (yr)	1	(c)
	Body Weight (kg)	70	(d)
Parameters Used in the Soil Pathway			
	Exposure Frequency (days/year)	40	(b)
	Exposure Duration (yr)	1	(c)
	Soil Ingestion Rate (mg/day)	330	(e)
	Exposed Skin Surface Area (cm^2)	3,300	(f,g)
	Adherence Factor (mg/cm^2)	0.3	(h,i)
	Body Weight (kg)	70	(d)

Notes:

(a) - USEPA, 1997b. Exposure Factors Handbook (EFH). 50th percentile time spent at work, males and females, all ages. EFH Table 15-68.

(b) - Exposure frequency is equivalent to 5 days per week for 2 months.

(c) - Construction activities are assumed to occur within a 1 year period.

(d) - USEPA, 1991. Standard Default Exposure Factors.

(e) - USEPA, 2002c. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Exhibit 4-1.

(f) - USEPA, 1997b. Exposure Factors Handbook. Represents 50th percentile values for males and females based on hands, forearms, and face listed in EFH Tables 6-2 and 6-3. See Table 6 for calculation.

(g) - USEPA, 2004. Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-5.

(h) - USEPA, 1997b and USEPA, 2004e. See Table 8-10 for calculation.

(i) - USEPA, 2004. Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-3.

Table 2-3
Summary of Potential Exposure Assumptions - Recreational Teenager

Parameter		Recreational			
		Child (0 to 6 yrs)		Teenager (7 to 18 yrs)	
Parameters Used in the Outdoor Air Inhalation Pathway					
	Exposure Time (hr/day)	2	(a)	2	(a)
	Exposure Frequency (days/year)	52	(b)	52	(b)
	Exposure Duration (yr)	6	(c)	11	(c)
	Body Weight (kg)	15	(d)	47	(e)
Parameters Used in the Surface Soil Pathway					
	Exposure Frequency (days/year)	52	(b)	52	(b)
	Exposure Duration (yr)	6	(c)	11	(c)
	Soil Ingestion Rate (mg/day)	200	(d)	100	(d)
	Surface Area Exposed (cm^2/day)	2,400	(f)	4,500	(g)
	Adherence Factor (mg/cm^2)	0.2	(h)	0.03	(h)
	Body Weight (kg)	15	(f)	47	(e)
Parameters Used in the Irrigation Well Exposure Pathway					
	Exposure Time (hr/event)	2	(a)	2	(a)
	Exposure Frequency (days/year)	26	(b)	26	(b)
	Exposure Duration (yr)	6	(c)	11	(c)
	Skin Contacting Medium (cm^2)	2,400	(f)	4,500	(g)
	Body Weight (kg)	15	(f)	47	(e)

Notes:

(a) - The recreational teen is assumed to be onsite for two hours.

(b) - 2 days per week for 26 weeks (6 months) of the year.

(c) - Child is assumed to range in age from 0 to 6 years; teenager is assumed to range in age from 7 to 18.

(d) - USEPA, 1991. Standard Default Exposure Factors.

(e) - USEPA, 1997b. Exposure Factors Handbook. Body weight is the average of males and females aged 7 to 18 listed in EFH Table 7-3

(f) – USEPA, 2011. Exposure Factors Handbook. Average surface area of head, hands, forearms, and lower legs of males and females aged 0 to 6.

(g) - USEPA, 1997b. Exposure Factors Handbook. Average surface area of head, hands, forearms and lower legs of males and females aged 7 to 18 listed in EFH Tables 6-6 to 6-8. See Table 6 for calculation.

(h) - USEPA, 1997b and USEPA, 2004. See Table 1-7 for calculation.

Table 2-4 Summary of Potential Exposure Assumptions – Day Care Child			
Parameter		**Day Care Child (0 to 6 yrs)**	
Parameters Used in the Exposure to Indoor Air from Groundwater Pathway			
	Exposure Time (hr/day)	9	(a)
	Exposure Frequency (days/year)	250	(b)
	Exposure Duration (yr)	6	(b)
	Body Weight (kg)	15	(b)
Parameters Used in the Outdoor Air Inhalation Pathway			
	Exposure Time (hr/day)	2	(c)
	Exposure Frequency (days/year)	250	(b)
	Exposure Duration (yr)	6	(b)
	Body Weight (kg)	15	(b)
Parameters Used in the Surface Soil Pathway			
	Exposure Frequency (days/year)	250	(b)
	Exposure Duration (yr)	6	(b)
	Ingestion Rate (mg/day)	200	(b)
	Exposed Skin Surface Area (cm^2)	2,800	(d,e)
	Adherence Factor (mg/cm^2)	0.2	(e,f)
	Body Weight (kg)	15	(b)

Notes:

(a) - Assumes child is at day care for an 8 hour work day plus commute time.

(b) - USEPA, 1991. Standard Default Exposure Factors. Assumes child is present at day care during work days, so occupational exposure frequency is used.

(c) - Assumes that child is outdoors for an average of 2 hours per day.

(d) - USEPA, 1997b. Exposure Factors Handbook. Child surface area represents average 50th percentile surface area for males and females of hands, feet, forearms, lower legs, and head.

(e) - USEPA, 2004. Risk Assessment Guidance for Superfund, Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-5, RME recommended residential value.

(f) - USEPA, 1997b and USEPA, 2004. See Table 8-10 for calculation.

Table 2-5 Summary of Potential Exposure Assumptions – Indoor Worker			
Parameter		**Indoor Worker**	
Parameters Used in the Exposure to Indoor Air from Groundwater Pathway			
	Exposure Time (hr/day)	8	(a)
	Exposure Frequency (days/year)	250	(b)
	Exposure Duration (yr)	25	(b)
	Body Weight (kg)	70	(b)
Parameters Used in the Surface Soil Pathway			
	Exposure Frequency (days/year)	250	(b)
	Exposure Duration (yr)	25	(b)
	Ingestion Rate (mg/day)	50	(b)
	Exposed Skin Surface Area (cm^2)	3,300	(c)
	Adherence Factor (mg/cm^2)	0.07	(c)
	Body Weight (kg)	15	(b)

Notes:

(a) - USEPA, 1997b. Exposure Factors Handbook. 50th percentile time spent at work, males and females, all ages. EFH Table 15-68.

(b) - USEPA, 1991. Standard Default Exposure Factors. Commercial/industrial scenario.

(c) - USEPA, 2004. Risk Assessment Guidance for Superfund, Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-5, recommended value.

(d) - USEPA, 1997b and USEPA, 2004. See Table 1-9 for calculation.

Table 2-6 Summary of Potential Exposure Assumptions – Outdoor Worker			
Parameter		**Outdoor Worker**	
Parameters Used in the Outdoor Air Inhalation Pathway			
	Exposure Time (hr/day)	8	(a)
	Exposure Frequency (days/year)	40	(b)
	Exposure Duration (yr)	25	(c)
	Body Weight (kg)	70	(b)
Parameters Used in the Soil Pathway			
	Exposure Frequency (days/year)	40	(b)
	Exposure Duration (yr)	25	(c)
	Soil Ingestion Rate (mg/day)	330	(d)
	Exposed Skin Surface Area (cm^2)	3,300	(e,f)
	Adherence Factor (mg/cm^2)	0.3	(g,h)
	Body Weight (kg)	70	(e)

Notes:

(a) - USEPA, 1997b. Exposure Factors Handbook. 50th percentile time spent at work, males and females, all ages. EFH Table 15-68.

(b) - Exposure frequency is equivalent to 5 days per week for 2 months.

(c) - USEPA, 1991. Standard Default Exposure Factors. Commercial/industrial scenario.

(d) - USEPA, 2002c. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Exhibit 4-1.

(e) - USEPA, 1997b. Exposure Factors Handbook. Represents 50th percentile values for males and females based on hands, forearms, and face listed in EFH Tables 6-2 and 6-3. See Table 6 for calculation.

(f) - USEPA, 2004. Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-5.

(g) - USEPA, 1997b and USEPA, 2004. See Table 8-10 for calculation.

(h) - USEPA, 2004. Supplemental Guidance for Dermal Risk Assessment. Exhibit 3-3. Landscaper used.

Table 2-7 Soil Adherence Factors			
	Adult Resident		
	Surface Area	Soil Loading	Total Soil
	50th percentile (a)	Gardeners	Mass
Body Part	(cm^2)	(mg/cm^2) (b)	(mg)
Hands	904	0.19	171.67
Forearms	1,173	0.052	61
Lower legs	2,370	0.033	78.21
Face (⅓ head)	402	0.052	20.89
Head	1,205	--	--
Total (c)	4,845	--	331.87
Total (d)	5,649		
Area-Weighted Soil Adherence factor (mg/cm^2) = Soil mass/Surface area =			0.07

Notes:

(a) - Data from USEPA (1997b). Tables 6-2, 6-3. Average of 50th percentile values for men and women (45% arm used as proxy for female forearm).

(b) - Data from USEPA (2004) Exhibit C-2. Geometric mean of gardeners Nos. 1 and 2.

(c) - In accordance with (USEPA, 2004) ⅓ of head surface area used in derivation of adherence factor because adherence data are for face only.

(d) - Full surface area of the head is assumed to be available for soil contact.

Table 2-7 (Continued) Soil Adherence Factors			
	Child Resident, Recreator, and Day Care Child (0 to 6 years old)		
	Surface Area	Soil Loading	Total Soil
	50th percentile (a)	Children Playing in Wet Soil	Mass
Body Part	(cm^2)	(mg/cm^2) (b)	(mg)
Hands	358	0.656	234.84
Forearms	393	0.015	5.90
Lower legs	650	0.026	16.90
Feet	451	--	--
Face (⅓ head)	326	0.004	1.30
Head	977	--	--
Total (c)	1,727	--	258.94
Total (d)	2,829		
Area-Weighted Soil Adherence factor (mg/cm^2) = Soil mass/Surface area =			0.15

Notes:

(a) - Data from USEPA (1997b), presented in USEPA, 2004. Based on average of boys (Table 6-6) and girls (Table 6-7) total body surface area (6,557 cm^2), and mean percentages of total surface area for individual body parts (Table 6-8). Forearm assumed to be 0.45 arm, and lower leg assumed to be 0.4 leg, in accordance with USEPA, 2004, Risk Assessment Guidance for Superfund, Supplemental Guidance for Dermal Risk Assessment.

(b) - Data from USEPA (2004) Exhibit C-2. Geometric mean of Children playing in wet soil.

(c) - In accordance with USEPA (2004) ⅓ of head surface area used in derivation of adherence factor because adherence data are for face only. Total for adherence calculation also does not include feet, as no soil loading data are available.

(d) - Full surface area of the head is assumed to be available for soil contact. Total for surface area exposed also includes feet.

Table 2-7 (Continued) Soil Adherence Factors			
	Construction Worker		
	Surface Area	Soil Loading	Total Soil
	50th percentile	Construction Workers	Mass
Body Part	(cm^2) (a)	(mg/cm^2) (b)	(mg)
Head	1,205	0.071	85.56
Hands	904	0.518	468.01
Forearms	1,173	0.215	252.20
Total	3,282		805.76
Area-Weighted Soil Adherence factor (mg/cm^2) = Soil mass/Surface area =			0.25

Notes:

(a) - Data from USEPA (1997b), Tables 6-2, 6-3. Average of 50th percentile values for men and women (45% arm used as proxy for female forearm).

(b) - Data from USEPA (2004) Exhibit C-2. 95th Percentile of Construction Workers

Table 2-7 (Concluded) Soil Adherence Factors			
	Recreational Teenager - Soil (7 to 18 years)		
	Surface Area	Soil Loading	Total Soil
	50th percentile (a)	Soccer No. 1	Mass
Body Part	(cm^2)	(mg/cm^2) (b)	(mg)
Hands	540	0.110	59.4
Forearms	601	0.011	6.61
Lower legs	1240	0.031	38.44
Head	942	0.012	11.304
Total	3323	--	115.755
Area-Weighted Soil Adherence factor (mg/cm^2) = Soil mass/Surface area =			0.03

Notes:

(a) - Data from USEPA (1997b). Based on average of boys (EFH Table 6-6) and girls (EFH Table 6-7) total body surface area, and mean percentages of total surface area for individual body parts EFH Table 6-8). 45% arm used as proxy for lower arm, and 40% leg used as proxy for lower leg (USEPA, 2004a).

(b) - Data from USEPA (2004), Supplemental Guidance for Dermal Risk Assessment. Exhibit C-2. Geometric mean for Soccer Players No. 1.

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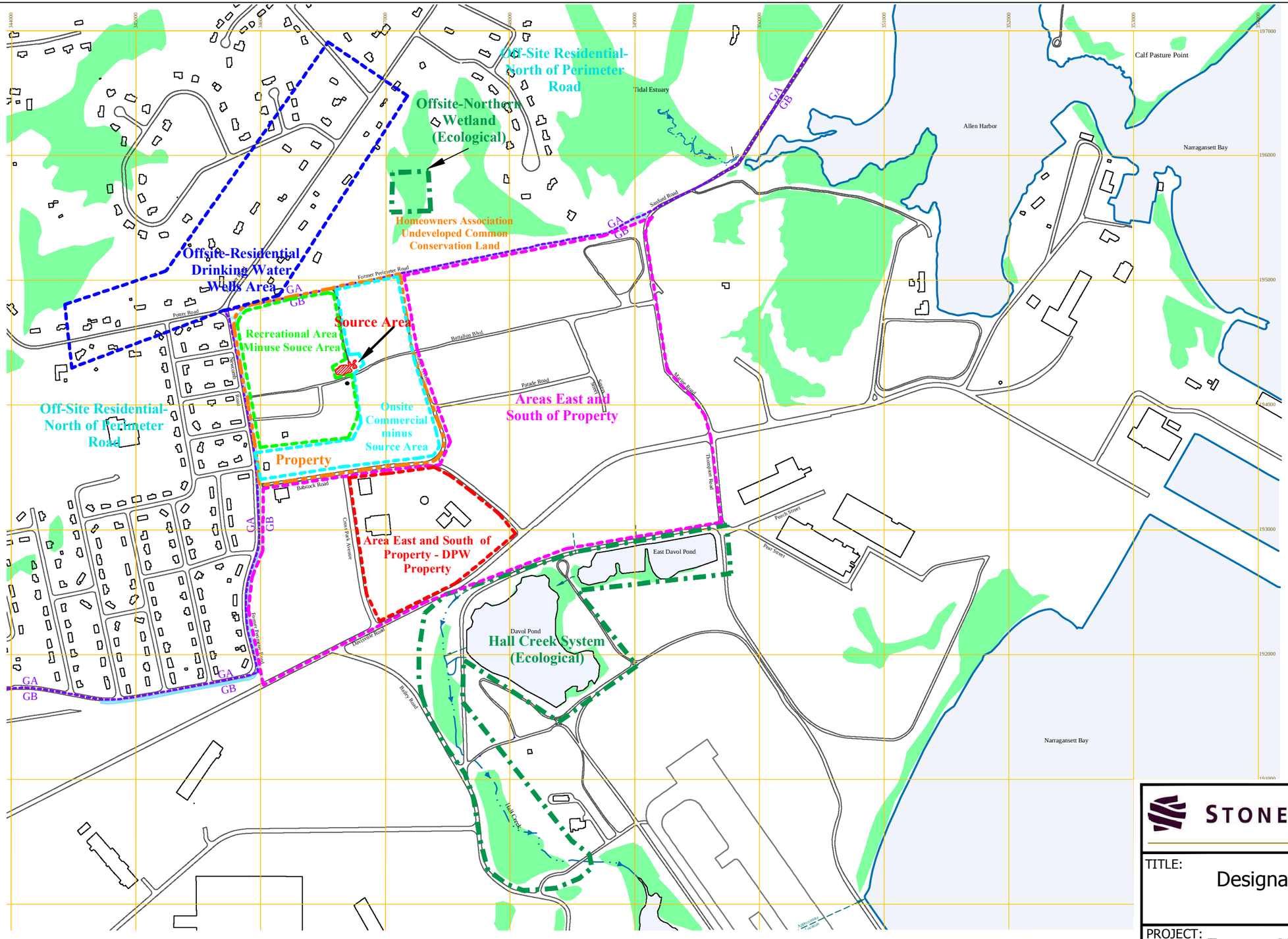

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Data Provided Electronically by the Quonset Point Development Company, NikeSite.dwg and bikepath.dwg, April 2011 (QDC, 2011)

LEGEND

- Offsite ECO Surface Water & Wetlands
- Drinking Water Wells
- Recreational Area Minus Source Area
- NIKE Battery Property
- Areas East and South of Property
- Area East and South of Property - DPW Property
- Onsite Commercial Minus Source Area
- Source Area
- GA/GB — Rhode Island Department of Environmental Management GA/GB Groundwater Classification Boundary
- Culvert with Flow Direction
- Creek with Flow Direction
- Wetland
- Water Body
- Building
- Bike Path

True North

800 0 400 800 1600 2400

Scale in Feet

STONE ENVIRONMENTAL INC

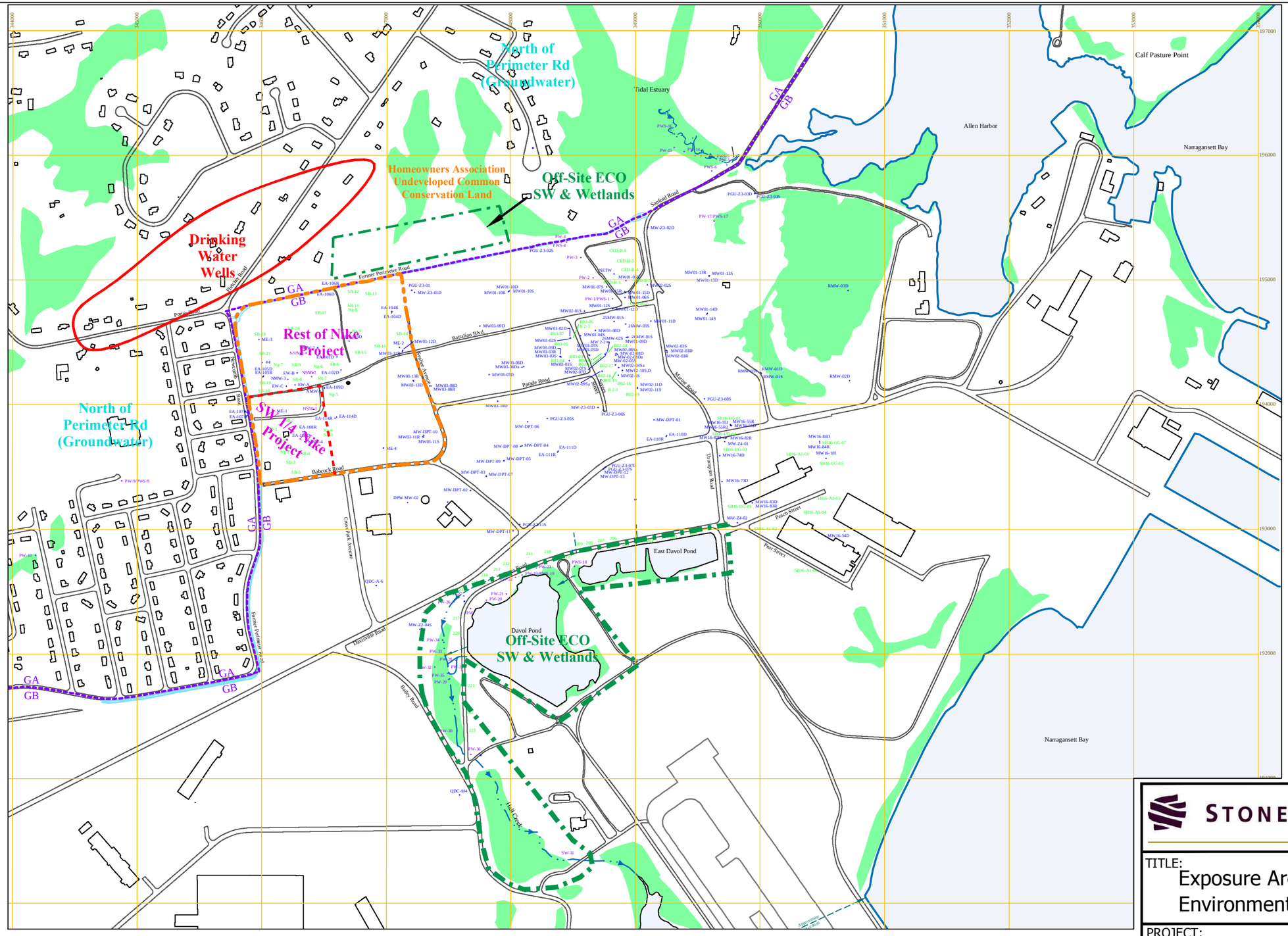
TITLE: Designated Exposure Areas For Risk Assessment

PROJECT: Former Nike Battery PR-58

FIGURE NO.: 1

DATE: 5/17/13 DRAWN BY: DJL CHECKED BY: JS

O:\Proj\101R2305-R USACE NAE HTRW SB Contract\03_Nike\PR-58RIFS\Data\Autocad\Risk Assessment Maps



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Scale in Feet

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Data Provided Electronically by the Quonset Point Development Company, NikeSite.dwg and bikepath.dwg, April 2011 (QDC, 2011)

LEGEND

- Offsite ECO Surface Water & Wetlands
- Drinking Water Wells
- NIKE Battery Property
- Southwest (SW) 1/4 Nike Project
- GA/GB — Rhode Island Department of Environmental Management GA/GB Groundwater Classification Boundary
- Culvert with Flow Direction
- Creek with Flow Direction
- Wetland
- Water Body
- Building
- Bike Path

STONE ENVIRONMENTAL INC

TITLE: Exposure Area Map - 2011 Screening Level Environmental Risk Assessment

PROJECT: Former Nike Battery PR-58

FIGURE NO.: 2

DATE: 9/16/13 DRAWN BY: SAH CHECKED BY: DRAFT

O:\Proj-101\R2305-R USACE NAE HTRW SB Contract\03_Nike\PR-58\RIFS\Data\Autocad\Risk Assessment Maps