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**FOCUSED FEASIBILITY STUDY REPORT  
Tinkham Garage Superfund Site  
Route 102  
Londonderry, New Hampshire**

**NHDES Site #: 199004008  
Project Type: Superfund  
Project Number: 0001880**

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6 June 2025

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TINKHAM GARAGE SUPERFUND SITE  
LONDONDERRY, NEW HAMPSHIRE**

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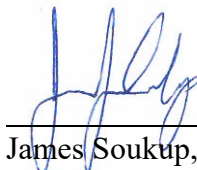
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6 June 2025



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## LIST OF ACRONYMS

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1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
AGQS	ambient groundwater quality standards
ARAR	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cDCE	cis-1,2-dichloroethene
COC	contaminants of concern
CSG	Cannons Sites Group
CSM	Conceptual Site Model
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
ESD	Explanation of Significant Differences
FFS	Focused Feasibility Study (2025)
FIT	Field Investigation Team
FS	Feasibility Study
ft	feet/foot
GAC	granular activated carbon
GMP	Groundwater Management Permit
GMZ	groundwater management zone
gpm	gallons per minute
H&A	Haley & Aldrich, Inc.
HFPO-DA	hexafluoropropylene oxide dimer acid
HI	hazard index
HQ	hazard quotient
IC	institutional controls
LCR	lifetime cancer risk
Memorandum	Remedial Investigation Summary Memorandum (2024)
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
MOM	Management of Migration

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## LIST OF ACRONYMS - (CONCLUDED)

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MtBE	methyl tert-butyl ether
ng/L	nanograms per liter
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NHDES	New Hampshire Department of Environmental Services
NPV	net present value
NUS	NUS Corporation
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
PCE	tetrachloroethene
%	percent
PFAS	Per- and Polyfluorinated Alkyl substances
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutanesulfonic acid
PFHxA	Perfluorohexanoic acid
PFHxS	perfluorohexane sulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
POET	Point of Entry Treatment System
ppb	parts per billion
ppm	parts per million
RAO	remedial action objectives
RI	Remedial Investigation
ROD	Record of Decision
RSLs	regional screening levels
Site	Tinkham Garage Superfund Site
TBC	To Be Considered
TCE	trichloroethene
TMV	toxicity, mobility, and volume
UCL	upper confidence level
VEE	vacuum-enhanced extraction
VOC	volatile organic compound
Weston®	Weston Solutions, Inc.
WSPCC	New Hampshire Water Supply and Pollution Control Commission

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**SECTION 1**

**INTRODUCTION**

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## **1. INTRODUCTION**

This Focused Feasibility Study (FFS) Report has been prepared by Weston Solutions, Inc. (Weston®) at the request of New Hampshire Department of Environmental Services (NHDES) and the United States Environmental Protection Agency (EPA) (together, the Agencies) for the Tinkham Garage Superfund Site located in Londonderry, New Hampshire (Site). The purpose of the FFS is to identify and evaluate potential remedial options to mitigate current and potential future exposure to contaminated groundwater by residents living in proximity to the Site and relying on groundwater as their primary drinking water source. Selection of a potential remedial option for the Site would be an interim remedial measure, as on-going investigations at the Site are required to be completed before a final remedial action is considered for the Site. This FFS is supported by information presented in a Remedial Investigation (RI) Summary Memorandum (Memorandum) prepared by Weston. The RI summarizes previous as well as current remedial investigations being implemented by the Cannons Sites Group (CSG) and data collected under the NHDES Groundwater Management Permit (GMP) Number GMP-199004008-L-001 through -005 issued to the CSG for this Site. The RI Summary Memorandum (WESTON, 2024) includes a Conceptual Site Model (CSM) that presents the Agencies' current understanding of the Site and documents current and potential future risks to residents located northeast, east, and south/southeast of the Tinkham Garage that rely on groundwater for their drinking water. This FFS evaluates and compares a limited set of remedial alternatives, which could mitigate exposure via provision of an alternate drinking water source. Institutional controls (IC) are in place on the use of groundwater as potable water within the Site boundary, as required by the 1986 Record of Decision (ROD) as modified. While previous actions provided waterline connections for many residents, there are currently households within the groundwater management zone (GMZ) established by the GMP, which was expanded by NHDES in 2019 and again in 2024, who continue to rely on groundwater as their primary source of potable water. On-going investigations and monitoring have documented the migration of contaminants from the Site into nearby neighborhoods where residents continue to draw groundwater as a potable source. Institutional controls are not currently in place to manage the use of groundwater outside of the GMZ. Bottled water has been offered by the CSG as a temporary mitigation measure and as required by NHDES administrative rules for contaminated site management. A further agreement with the CSG provided additional households with an offer of bottled water following issuance of federal

maximum contaminant levels (MCL) for certain per- and polyfluoroalkyl substances (PFAS) in drinking water in 2024. Collectively across the neighborhoods, there have been 65 households that have been offered bottled water as a temporary measure.

## 1.1 BACKGROUND

The Tinkham Garage Superfund Site is located in Londonderry, New Hampshire, approximately 1 mile southwest of the intersection of Interstate Route 93 and State Route 102 (**Figure 1**). The Site is approximately bounded by state Route 102 to the north, Gilcreast Road to the east, Ross Drive and Tokanel Drive to the south, and the Woodland Village Condominium complex to the west.

The Site encompasses approximately 375 acres of residential, commercial, and undeveloped land (**Figure 2**). In addition to the Woodland Village Condominium complex, there are single family homes along Mercury Drive to the west, along Gilcreast Road and Boston and Charleston Avenues to the northeast, and Ross, Gail, and Tokanel Drives to the east and southeast. In January 2003, Gilcreast Realty Holdings II, LLC purchased the 95-acre area in the central portion of the Site for development into active senior housing called ‘The Nevins.’ The Nevins Retirement Cooperative Association owns the land upon which individually owned residential structures were constructed from about 2005 through 2013.

For the purposes of this FFS, residences located along Albany Avenue, Boston Avenue, and Charleston Avenue are referred to herein as the “Boston/Charleston/Albany neighborhood.” Similarly, residences located along Ross Drive, Tokanel Drive, and Gail Road are referred to herein as the “Ross/Tokanel neighborhood.”

The Tinkham Realty office and Tinkham Garage are located in the northeastern portion of the Site. In 2003, land to the east/northeast of these properties was sold and a commercial retail development was constructed that contains Home Depot, Staples, The 99 Restaurant, and Dunkin’ Donuts. These properties are included within the Site GMZ because a portion of the former source area east of the Tinkham Garage extends beneath the western end of the parking lot.

The topography of the Site is relatively flat, and surface drainage is from north to south. **Figure 3** provides a LiDAR image of the Site showing topographic features. Several unnamed streams and

intermittent tributaries collect and direct precipitation and discharging groundwater from the Site southward, eventually discharging off-site to Beaver Brook. These streams and tributaries pass through the Site and historically and/or currently through the Ross/Tokanel neighborhood towards the large wetlands southwest of the neighborhood and towards Beaver Brook. The large wetland area located southwest of the Site, where the unnamed streams enter Beaver Brook, eventually discharges to the Merrimack River farther south.

### **1.1.1 Site History**

A detailed discussion of the site history is included in the RI Summary Memorandum (WESTON, 2024) and is summarized here for convenience.

Initial complaints of foam and septic odors occurring in a small unnamed brook crossing Ross Drive and in a residential well, led the Londonderry Health Department to Tinkham Garage in April 1978. The Tinkham Garage served as a facility for the storage, maintenance, and cleaning of tanker trucks associated with Tinkham Enterprises. The Health Department investigation concluded that liquids and sludges allegedly from tanker truck washings, as well as oily materials, had been dumped behind the Tinkham Garage directly onto the ground surface. A subsequent citizen complaint to the New Hampshire Water Supply and Pollution Control Commission (now NHDES) resulted in that department issuing an order to clean up the Site by removing surface contamination. As part of this initial cleanup, a diversion trench was also excavated along the existing stream to redirect surface water runoff from behind the Tinkham Garage away from Ross Drive.

EPA completed a Preliminary Assessment in August 1981 that showed groundwater, soil, and surface water were contaminated with several volatile organic compounds (VOC) and noted that groundwater in the vicinity of the Site was used for potable water supply. In January 1983, the drinking water supply well servicing the Londonderry Green Apartments (now Woodland Village Condominiums) and several residential supply wells along Mercury and McAllister Drive were removed from service because of documented VOC contamination. Prior to removal of the wells from service, the impacted residents were temporarily supplied with bottled water and point-of-entry treatment (POET) systems until a feasibility study could be completed, and the municipal water pipeline could be extended to affected homes. The pipeline was installed in 1983 under a

cooperative agreement between EPA and NHDES. The VOCs identified at the Site included gasoline constituents' benzene, toluene, ethylbenzene, and xylene as well as industrial substances such as chlorinated solvents including tetrachloroethene (PCE), trichloroethene (TCE), and their associated breakdown products.

In September 1983, the Site was added to the National Priorities List. The RI was completed in January 1986 and documented VOC contamination in the overburden and bedrock aquifers as well as in soil and surface water. A Feasibility Study (FS) was completed in September 1986 to evaluate remedial alternatives to address contamination found in soil, groundwater, and surface water. A ROD was filed shortly after completion of the RI/FS in 1986.

The Remedial Action Objectives presented in the 1986 ROD for source control were:

- Mitigating further release of contaminants to the surrounding environmental media.
- Eliminating or minimizing the threat posed to public health, welfare, and the environment from the source area.

Remedial Action Objectives for management of migration were:

- Mitigating further migration of contaminants beyond their current extent.
- Eliminating or minimizing the threat posed to public health, welfare, and the environment from the current extent of contaminant migration.

To achieve those objectives, the ROD included the following components:

- Excavation of contaminated soils and on-site treatment of those soils.
- Pumping of contaminated groundwater from the overburden and bedrock aquifers with off-site treatment at the Derry wastewater treatment facility, which may be preceded by on-site pretreatment, with monitoring.
- Development of legislation by the Town of Londonderry and/or the State of New Hampshire preventing the present and future use of the on-site aquifer.

Following issuance of the 1986 ROD, EPA negotiated an administrative order on consent in September 1987 that required the potentially responsible parties (CSG) to conduct a Pre-Design Study to assess on-site treatment of soils. The results of this study were presented in the Pre-Design Study Report issued in July 1988 (Malcolm Pirnie, 1988).

Based on conclusions presented by CSG in the Pre-Design Study Report, EPA issued an Amended ROD for the Site on March 10, 1989, that selected vacuum extraction as the source control remedy.

A Consent Decree that required CSG to implement the remedial action, among other things, became effective on August 14, 1989. Following issuance of the Consent Decree, CSG began the remedial design and planning for the implementation of the remedial action.

EPA approved a temporary shutdown of the two bedrock groundwater extraction wells (former condominium supply wells LGSW and LGAW) in July 1996 based on a request by CSG and documentation that sample results confirmed the contaminants had achieved steady-state conditions in the water pumped from those wells, as well as other bedrock monitoring wells located throughout the Site. Monthly testing of VOC concentrations in wells LGSW and LGAW was performed from July 1996 through February 2001. The VOC concentrations in both wells and other bedrock wells throughout the Site remained statistically constant, further supporting the conclusion that a steady-state condition was present in bedrock and that further migration of contaminants beyond the current extent was not likely. Monitoring results documented evidence of natural attenuation through active bioremediation in the shallow aquifer. In 1996, CSG predicted natural attenuation would attain groundwater remediation goals in the shallow aquifer within 15 years. EPA reviewed a 1997 request from CSG to permanently shut down the complete groundwater extraction system based on evidence of natural attenuation and attainment of steady-state conditions in the bedrock aquifer. In response to this request, and continued monitoring results, EPA modified the groundwater remedy from active extraction and treatment to monitored natural attenuation (MNA) in the 2003 Explanation of Significant Differences (ESD). The shutdown of active treatment operations did not alter the groundwater remediation objectives or CSG's obligation to restore groundwater quality to drinking water standards.

The 2003 ESD required a long-term monitoring program to assure attainment of the ROD cleanup objectives and implementation of ICs to prevent use of groundwater and noted that if monitoring results demonstrated migration of the plumes (shallow or bedrock) beyond its current extent, or indicated that natural attenuation is no longer adequate to achieve remediation goals, EPA, in consultation with NHDES, may modify the decision to allow MNA and require active extraction or other reasonable actions to attain the required remediation goals (2003 ESD).

Finally, the 2003 ESD established that the State of New Hampshire's 1993 Groundwater Management Permit Program (at the time ENV-Ws410) satisfied the IC objective through establishment of a GMZ, within which use of groundwater would be monitored and managed until ambient water quality standards were attained. The first GMP was issued for the Site to CSG on October 30, 2002 (GWP-199004008-L-001) and is typically reissued every 5 years. The 2003 ESD also required EPA to evaluate the protectiveness of the cleanup every 5 years.

Periodic monitoring of select drinking water wells was performed as part of NHDES' efforts to monitor the water quality in the vicinity of the Tinkham Garage Site. This included monitoring homes along Constitution Drive, Ross Drive, and Tokanel Drive at varying frequencies. In November 2004, NHDES collected samples from select residential wells in the Ross/Tokanel neighborhood, located southeast (downgradient) of the Tinkham Garage source area. During this monitoring event, methyl tert-butyl ether (MtBE) was detected in the water supply well at 30 Ross Drive at a concentration exceeding the ambient groundwater quality standards (AGQS) (NHDES, 2004). NHDES installed a POET system to treat the MtBE and conducted sampling at adjacent homes. MtBE was also detected in the residential well for 28 Ross Drive but resampling of that well did not confirm the initial exceedance. Between 2005 and 2006, NHDES conducted additional random sampling of residential wells in the Ross/Tokanel neighborhood to test for MtBE. Several homes other than 28 and 30 Ross Drive had detections of MtBE and 2-methoxy-2-methylbutane (TAME – which is a gasoline additive similar to MtBE), but none had exceedances of their respective AGQS. MtBE concentrations at 30 Ross Drive had dropped below the AGQS by 2006 and the POET system was removed in 2014, after about 8 years of additional testing with no further exceedances.

During the 2008 GMP monitoring event, the agencies requested that CSG analyze groundwater from selected monitoring wells for the compound 1,4-dioxane, which was an emerging contaminant associated with chlorinated solvents of the type found at the Site (primarily 1,1,1-trichloroethane (1,1,1-TCA)). The sampling results showed that 1,4-dioxane was present at concentrations as high as 350 micrograms per liter ( $\mu\text{g/L}$ ), more than 100 times the NHDES AGQS of 3  $\mu\text{g/L}$  in effect at that time.

The Third Five-Year Review completed by EPA in March 2009 recommended that the nature and extent of 1,4-dioxane contamination in groundwater at and beyond the Site be assessed. Sampling of nine private water supply wells along Ross Drive (3, 6, 10, 11, 14, 20, 21, 26, and 30 Ross Drive – repeating the same households analyzed by NHDES in 2002 and 2004) for 1,4-dioxane was performed again in November 2009 by CSG. 1,4-Dioxane was not detected above the laboratory detection limit of 0.5 µg/L, which was below the AGQS of 3.0 µg/L in place at that time. In a letter to EPA, CSG concluded that no further samples from off-site private water supply wells along Ross Drive were warranted (Haley & Aldrich, Inc (H&A), 2009).

The 2009 Third Five-Year Review also noted that concentrations of VOCs in groundwater at source area wells NAI-K2 and NAI-M1 continued to be elevated, that potential for indoor air impacts require a review against updated screening levels, and that sub-slab depressurization systems should be included in any new homes constructed within the Nevins Development. The 2009 Third Five-Year Review noted that the deep bedrock monitoring wells were completed as open-hole boreholes which could allow cross-communication between fractures. Open borehole wells do not provide detailed information about contaminated fracture zones and can result in ‘averaged’ contaminant concentrations that do not reflect the actual concentration in any single fracture. This was particularly concerning because several deep bedrock monitoring wells were noted to have high concentrations of VOCs (e.g., FW-21D) and some had increasing concentration trends (e.g., FW-11D). The 2009 Third Five-Year Review recommended that additional assessment be conducted on selected open borehole deep bedrock wells to assess contaminant concentrations in discrete fractures. Subsequently, EPA required additional investigations to evaluate the long-term protectiveness of the existing groundwater monitoring program.

A work plan to assess individual fractures within three deep bedrock boreholes (FW-11D, FW-21D, and FW-28D) was submitted in January 2014 and the field work for that assessment was completed later that year. The results indicated elevated concentrations (up to 760 µg/L) of 1,4-dioxane within discrete fractures intercepted by borehole FW-11D. This well is considered to represent bedrock conditions proximate to the Tinkham Garage field where initial releases occurred and immediately downgradient of the former Tinkham Garage source area, east of the Tinkham Garage. In addition, a 1,4-dioxane concentration of 3.2 µg/L was later identified in groundwater within a discrete fracture in monitoring well FW-28D, which is located in an area

which was considered to represent a downgradient location and a sentinel well for migration towards the Ross Drive and Tokanel Drive residential neighborhood at the time. The compound 1,4-dioxane was also found at 4.8 µg/L in a fracture within borehole FW-21, which represents bedrock groundwater conditions in the southwest portion of the Site. Subsequent monitoring of discrete multi-level monitoring wells installed in the open bedrock boreholes has documented concentrations of 1,4-dioxane as high as 1,510 µg/L in FW-11D in fractures up to 90 feet (ft) below grade. These results demonstrated that the horizontal and vertical extent of groundwater contamination had not been fully delineated and further investigation work was warranted.

The Fourth Five-Year Review was issued in September 2014 and indicated that elevated concentrations of Site contaminants including 1,4-dioxane and various chlorinated solvents were found in deep bedrock fractures and that further monitoring of discrete fractures was necessary to assess long-term trends and protectiveness of the MNA remedy.

In November 2014, NHDES, as part of a state-wide MtBE Remediation Bureau investigation, conducted sampling of select residential wells in the Boston/Charleston/Albany neighborhood, located east of the Tinkham Garage source area. The results of that sampling identified concentrations of Site-related contaminants (1,4-dioxane, TCE, and vinyl chloride) in excess of state and federal drinking water standards. The Agencies required CSG to sample several homes in that neighborhood for VOCs and 1,4-dioxane. In total, five homes were found to have Site-related contaminants in their drinking water at concentrations exceeding state and federal standards.

In response to the detection of Site-related compounds in residential wells east of the Tinkham Garage source area on Boston and Charleston Avenues, EPA issued a third ESD in February 2016 that required the connection of impacted households to an existing municipal water line and formally added 1,4-dioxane as a Contaminant of Concern (COC) for the Site, listing the then-current NHDES AGQS of 3 µg/L as the Site groundwater cleanup standard. The 2016 ESD also clarified the process to be used to evaluate attainment of cleanup levels and required additional remedial investigations at the Site to determine the nature and extent of 1,4-dioxane and other Site contaminants in bedrock. Subsequently, NHDES reduced the AGQS for 1,4-dioxane from 3 µg/L to 0.32 µg/L in September 2018.

Sampling of residential wells in the Ross/Tokanel neighborhood in November 2018 and again in May/June of 2019 identified concentrations of 1,4-dioxane in drinking water from 11 homes on Ross and Tokanel Drives above the revised AGQS, confirming that contamination from the Tinkham Garage source area had migrated from the Site into the neighborhood and reached these downgradient water supply wells. CSG provided these impacted homes with bottled water as temporary alternate drinking water. Currently 1,4-dioxane continues to be monitored at residential wells in neighborhoods proximate to the Site. As of 2024, there are 13 households found to exceed the New Hampshire AGQS for 1,4-dioxane, and another 10 residential supply wells on Ross and Tokanel Drives had detections, but at concentrations below the AGQS. The data demonstrate that 1,4-dioxane has and continues to migrate into the neighborhood and annual sampling continues to evaluate the migration and impact within the neighborhoods consistent with the migration pathways being evaluated at the Site. The widespread distribution of 1,4-dioxane also suggests that continued pumping from residential water supply wells may be influencing the migration of contaminants into the neighborhood as well as the spread of contaminants within the bedrock aquifer across the neighborhood. Homes which currently exceed the New Hampshire AGQS for 1,4-dioxane within the neighborhoods have been offered bottled water from CSG. **Figure 4** shows the extent of 1,4-dioxane in bedrock groundwater based on data collected through spring 2023.

In November 2016, EPA issued a Lifetime Health Advisory for two PFAS: perfluorooctanoic acid (PFOA), and perfluorooctanesulfonic acid (PFOS) at a combined concentration of 70 nanograms per liter (ng/L). In a 30 May 2018 letter to CSG, EPA requested that selected source area groundwater monitoring wells be sampled for PFAS to assess whether PFAS may be present at the Site. PFAS have been widely used in many industrial processes such as the those whose wastes were disposed at the Tinkham Garage Site, as well as in consumer products, and are often found in septic wastes.

In 2016, NHDES adopted EPA's Lifetime Health Advisory as an emergency AGQS for PFOS and PFOA: 70 ng/L for each compound individually and in aggregate. In 2020, NHDES established AGQS for four PFAS: PFOA (12 ng/L), PFOS (15 ng/L), perfluorononanoic acid (PFNA at 11 ng/L), and perfluorohexane sulfonic acid (PFHxS at 18 ng/L), based on scientific studies at the time.

In May 2022, EPA updated Regional Screening Levels (RSLs) for five PFAS, which included the lowering of the screening values (representing a hazard index (HI) of 0.1) for PFOA and PFOS to 6 ng/L and 4 ng/L, respectively. The RSLs help support the on-going investigations by identifying those areas of the Site which are above the screening levels, where risk may be present, and where additional investigations are warranted. EPA updated the PFAS RSLs in May 2024 and again in November 2024. The updated RSLs for Resident Risk Based Screening Levels for Tap Water are provided in the table below.

On 10 April 2024, EPA announced the finalization of a National Primary Drinking Water Regulation establishing legally enforceable levels (MCLs) for certain PFAS in drinking water. Individual MCLs were established for PFOA, PFOS, PFHxS, PFNA, and hexafluoropropylene oxide dimer acid (HFPO-DA), and a HI MCL is used for PFAS mixtures containing at least two or more of PFHxS, PFNA, HFPO-DA, and Perfluorobutanesulfonic acid (PFBS), to account for the combined and co-occurring levels of these PFAS in drinking water. EPA also finalized health-based, non-enforceable Maximum Contaminant Level Goals (MCLG) for these PFAS. A summary of those final MCLs and MCLGs are provided in the following table.

PFAS Compounds	EPA Regional Screening Levels (May 2024)		Federal Standards		State Standards
	Tap Water RSL (µg/L)	Tap Water RSL (ng/L)	MCLG (ng/L)	MCL (ng/L)	AGQS (ng/L)
PFBS	6.01E-01 nc	601 nc	N/A	N/A	N/A
PFBA	1.85E+00 nc	1,850 nc	N/A	N/A	N/A
PFHxA	9.92E-01 nc	992 nc	N/A	N/A	N/A
PFHxS	3.94E-02 nc	39.4 nc	10	10	18
PFNA	5.89E-03 nc	5.89 nc	10	10	11
PFOS	2.01E-04 nc	0.201 nc	Zero	4.0	15
PFOA	2.65E-06 ca	0.00265 ca	Zero	4.0	12
HFPO-DA	1.50E-03 nc	1.5 nc	10	10	N/A

**Notes:**

nc = non-cancer

HFPO-DA = hexafluoropropylene oxide dimer acid (GenX Chemicals)

PFBS = Perfluorobutanesulfonic acid

PFBA = Perfluorobutanoic acid

MCLG = Maximum Contaminant Level Goals

EPA RSLs can be found at: <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>

ca = cancer

N/A = no standard available

PFHxA = Perfluorohexanoic acid

RSL = EPA Regional Screening Levels

MCL = Maximum Contaminant Level

On 19 April 2024, EPA also announced that two PFAS, specifically PFOA and PFOS, will be designated as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. In addition to the final rule, EPA issued a separate CERCLA enforcement discretion policy that focuses enforcement on parties who significantly contributed to the release of PFAS chemicals into the environment.

An initial round of PFAS sampling was performed at the Site in June 2018 and consisted of 21 groundwater monitoring wells, 1 non-potable water supply well (TRWS), and 2 surface water locations (stream 1A/1B and SW-2). The results of the initial testing showed that PFAS were found in known source areas, found widespread across the Site and were present in all three media (groundwater, surface water, drinking water) at concentrations as high as 752 ng/L (in groundwater monitoring well NAI-K2 within the Tinkham Garage source area). An expanded confirmatory sampling round was conducted in July/August of 2018 that included 18 groundwater monitoring wells, 2 water supply wells (2 Mercury, Pump Station), 1 non-potable water supply well (TGW), and 2 surface water locations (stream 1D, SW-2). The results confirm the initial findings that PFAS are present in all three media at the Site. As a result, PFAS was added to the list of analytes routinely monitored for at the Site.

In December 2018, sampling for PFAS was expanded to include residential wells near the Site (Boston/Charleston/Albany neighborhood and Ross/Tokanel neighborhood). As reported in the Annual Water Quality Monitoring Report for 2019 (H&A, 2020), PFAS were detected in 62 of 70 water supply wells sampled in those two neighborhoods. Initially, water supply wells at 2 homes in the Boston/Charleston/Albany neighborhood and at 10 homes in the Ross/Tokanel neighborhood were found to contain PFAS concentrations above the NHDES AGQS and were provided with bottled water. Subsequent quarterly and semiannual monitoring of PFAS in the Ross/Tokanel neighborhood has resulted in additional exceedances of the AGQS and 21 residences where PFOA was found to exceed the AGQS in drinking water while PFOS was found to exceed its AGQS at six residences. By November 2022, an additional four residences where PFOA concentrations exceeded the AGQS were identified (2 Gail Road, 19 Ross Drive, 23 and 31 Tokanel Drive), suggesting that PFAS is continuing to migrate into and within the downgradient residential areas.

In April 2024, CSG agreed to provide an additional 23 households that exceeded the MCLs with bottled water. Most of the sampling of residential wells has been conducted under the state issued GMP. In May 2024, EPA requested that 13 additional households within the Boston/Charleston/Albany neighborhood be sampled for PFAS, which were not part of the current GMP sampling program. CSG declined to sample these households and EPA and NHDES directed Weston to sample the 13 households where PFAS data were limited or had not yet been collected. Of those 13 households, seven responded to Weston's inquiry and were sampled in late fall 2024. Of the seven households that were sampled, six were found to have PFAS at concentrations in excess of the federal MCLs and have been offered bottled water as a temporary mitigation measure from Weston on behalf of NHDES and EPA.

The PFOA and PFOS results from collective monitoring events at the Site show widespread impacts of PFAS within and across the Site in both the overburden and bedrock aquifers, as well as throughout the Ross/Tokanel and Boston/Charleston/Albany neighborhoods as depicted on **Figures 5A** and **5B**, respectively. These maps are based on the highest detected PFAS concentration measured through 2023.

## **1.2 PREVIOUS INVESTIGATIONS AND REMEDIAL ACTIONS**

Site environmental investigations have been conducted since April 1978. The initial investigations included soil, groundwater, and surface water sampling, extensive water supply well sampling, and inspections of the Tinkham Garage and Londonderry Green Apartments properties. The November 2024 RI Summary Memorandum (WESTON, 2024) outlines the chronological investigations which have taken place at the Site and summarizes their general findings. Those studies included a Hydrogeologic Field Investigation and Remedial Investigation performed by the NUS Corporation (NUS) Field Investigation Team. This FFS includes an overview of a 1983 Alternative Water Supply Evaluation and a 1986 Endangerment Assessment performed by NUS, as well as a 1986 Feasibility Study performed by Camp, Dresser, & McKee, Inc., and remedial actions which have been implemented as required by the 1986 ROD, as amended.

### **1.2.1 1983 Alternative Water Supply Evaluation**

In a February 8, 1983, letter from the New Hampshire Water Supply and Pollution Control Commission (WSPCC - now the NHDES) to EPA, a request for assistance is noted to deal with

imminent health hazards related to contamination in residential water supply wells believed to have resulted from improper disposal of hazardous waste at the Tinkham Garage. In a letter dated February 15, 1983, WSPCC provided notice to the Londonderry Green that their well water was considered unacceptable for drinking purposes. Also, in a February 25, 1983 letter, WSPCC indicated to the Town of Londonderry plans to provide emergency and long-term water supply for Londonderry Green apartments and the homes on Mercury and McAllister Drives. In a report dated March 1, 1983, NUS provided an Alternative Water Supply Evaluation for the Tinkham Site Vicinity, Londonderry, New Hampshire (NUS, 1983a). This report evaluated an alternative water supply to the Londonderry Green Apartments and the homes in the immediate vicinity who had been provided with a temporary source of drinking water.

Based on the review of available options and the data for constituents, a water line extension was recommended as the preferred option to provide a replacement water source for those residential units that had a contaminated water supply resulting from hazardous waste disposal at the Tinkham Garage.

The report estimated that the waterline extension would service the nearly 665 people estimated to reside in the 13-unit Londonderry Green Apartments and 20 residences proximate to the Tinkham Garage at the time. In September 1983, EPA completed and released a Remedial Action Master Plan outlining remaining investigations needed to determine the full extent of the cleanup that would be required at the Site (NUS, 1983b).

### **1.2.2 1986 Endangerment Assessment Report**

In May 1986, an Endangerment Assessment was performed to determine the potential risk of harm to public health, welfare, or the environment presented or potentially caused by the threatened or actual exposure of hazardous substances related to the Tinkham Garage Site (NUS, 1986).

The major findings of this assessment were:

- Contamination of the groundwater in the bedrock aquifer resulted in exposure to contaminants by the population in the area that were dependent on this resource for their water supply.
- The actions taken, which provided an alternative water supply, eradicated the ingestion of contaminated groundwater as an exposure route.

- Groundwater contamination remains.
- Soil contamination in the condominium area and in the field at the Tinkham Garage could present a potential for exposure to hazardous materials either by direct contact or ingestion, particularly by children.

The 1985 NUS/Field Investigation Team (FIT) Tinkham's Garage Site Remedial Investigation Report (NUS, 1985) described the following groundwater migration pathways:

- Liquid wastes disposed in the field behind Tinkham's Garage migrated vertically through the thin (less than 10 ft) and sandy overburden to the relatively shallow water table. The saturated overburden in the garage area was a source of recharge to the underlying bedrock. Downward migration and dispersion continued through the saturated sands into the less permeable glacial till. Bedrock underlying the dense glacial till is highly fractured in places, permitting contaminated groundwater to enter the bedrock aquifer. Identification of the contaminant migration pathway from the garage area to the bedrock aquifer was supported by analytical results from soil and groundwater samples which detected similar contaminants in both media. Thus, the soils behind Tinkham's Garage remained a continuing source of contamination to the underlying groundwater. Hydrogeologic investigations conducted by NUS/FIT at the Site indicated that, once in the bedrock aquifer, contaminants would have been drawn toward the Londonderry Green Supply Well while this well was in use.
- Contaminants entering the soil beneath the condominium leach fields would migrate downward through the thin sandy overburden into the fractured bedrock and could then be drawn toward the Londonderry Green Supply Well under pumping conditions. In non-pumping conditions (as existed at the time of the assessment), the groundwater flow was still controlled by the bedrock fracture system. It was expected that contamination could remain within a given fracture system, discharge to surface water, or to the ground surface.
- Groundwater from the bedrock aquifer may discharge to the ground surface in the central portion of the Site and portions of the condominium area by artesian flow. Groundwater also discharges into surface water including several unnamed tributaries which flow through the condominium area and enter Beaver Brook and a wooded wetland area north of Ross Drive.

The endangerment assessment determined that the population in the area considered to be potentially at risk of exposure to contaminants included those residents that relied on groundwater as a potable water source, which included residents of the Londonderry Green Apartment and those along Mercury and McAllister Drives. While a waterline had been provided to minimize exposure to those within the Site that relied on groundwater as their drinking water, the assessment included an evaluation of the groundwater based on its potential future use for human consumption. Further,

the assessment identified residents located to the south and southeast of the Tinkham Garage, along Ross and Tokanel Drive as potential receptors still dependent on groundwater via private supply wells.

Risk Characterization was performed to provide a quantitative assessment of the carcinogenic and non-carcinogenic risk from potential exposure to contaminants at the Site, based on data available at the time. Details of that assessment can be found in the report. In summary, excess cancer risks were estimated and compared to EPA's acceptable risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ :

- For Groundwater, the upper limit cancer risk estimated for ingestion of contaminated groundwater based on historical exposure to concentrations of contaminants found in residential water supply wells yielded a  $3 \times 10^{-4}$  risk; and exposures based on groundwater monitoring data and potential future use as drinking water to be  $2 \times 10^{-2}$ . Both exposure scenarios exceeded EPA's acceptable risk range, and the report noted that while this risk was based on available data, an additional 16 contaminants detected in groundwater could alter the risk posed. However, sufficient toxicity information was not available to include those contaminants in the risk characterization at the time.
- A non-cancer assessment was performed on those contaminants that had established standards and toxicity information. Contaminants that did not have established standards at the time included acetone, benzene, chloroform, 1,2 dichloroethane and vinyl chloride and these compounds were not included. A non-cancer HI of 1.9 was derived for exposure to water supply wells based on exposure over a lifetime of 70 years, and an HI of 32.4 was calculated based on exposure to the highest concentrations found in Site groundwater. These HI values exceed the EPA's target non-cancer cumulative HI of 1.0.
- A risk characterization was performed for soil and surface water and noted unacceptable risk to soils ranging from  $1 \times 10^{-3}$  excess cancer risk with an HI of 1.7 in soils at the Tinkham Garage area to a  $9 \times 10^{-6}$  excess cancer risk with an HI of 0.04 from exposure to soils in the condominium area.

The endangerment assessment concluded that the major routes of exposure were the ingestion of contaminated groundwater and contaminated soil. The provision for the waterline in 1983 was determined to be justified as it significantly reduced exposure to ingestion of contaminated groundwater estimated to have an excess cancer risk of  $3 \times 10^{-4}$  and an HI of 1.9; both of which exceed EPA's acceptable risk range and as such warranted action to protect human health.

Groundwater at the Site was deemed to be an unsuitable source of drinking water for area residents due to the current degree of contamination and a calculated  $2 \times 10^{-2}$  excess cancer risk and HI of 32.4. Because the potential for continued exposure to groundwater (as drinking water) and soil

remained and unacceptable risks were present due to these potential exposures, remedial actions to address these risks were warranted.

### 1.2.3 1986 Feasibility Study

In 1986, EPA issued an FS to assess potential remedial alternatives for unacceptable risks related to potential exposure to the soil, groundwater, and surface water contamination identified during the RI. The FS identified cleanup levels, general response actions and associated technologies that were applicable to the site conditions as presented in the RI. It was concluded, based on the risk assessment, that PCE and TCE concentrations in (unsaturated) soil in the source areas could be used as a guideline for the soil remediation. The highest concentrations of PCE and TCE noted were 94 milligrams per kilogram (mg/kg) and 32 mg/kg, respectively, with average concentrations of 20.2 mg/kg and 6.5 mg/kg, respectively. Based on a  $10^{-6}$  risk level, the soil cleanup targets were set at 0.240 mg/kg for PCE and 0.407 mg/kg for TCE. Cleanup targets for groundwater were set to the MCLs in place at the time: 5 µg/L for both PCE and TCE.

Separate groups of remedial alternatives were developed for source control and management of migration. Four source control alternatives were evaluated:

- SC-1 No Action
- SC-2 Excavation of impacted soils with on-site treatment
- SC-3 Excavation of impacted soils with off-site incineration
- SC-4 Excavation of impacted soils with off-site disposal at an approved landfill

Source control alternative SC-2 on-site treatment of contaminated soils was the preferred alternative. The on-site treatment options developed for SC-2 included aeration, composting, and soil washing.

Three Management of Migration (MOM) alternatives were evaluated:

- MOM-1 No Action.
- MOM-2 Groundwater extraction from bedrock using existing production wells LGAW and LGSW with on-site treatment and discharge to the unnamed tributary.
- MOM-3 Groundwater extraction from bedrock using existing production wells LGAW and LGSW with pretreatment via air stripping followed by discharge to the Town of Derry treatment plant for final treatment and discharge to surface water.

Management of Migration alternative MOM-3 was identified as the preferred alternative. Groundwater extraction and treatment also supported the preferred remedy of on-site treatment of contaminated soils. These alternatives were selected because implementation of the 1983 waterline extension provided alternative water for impacted residents relying on groundwater as drinking water at the Site. The current and potential future risks to human health from ingestion of contaminated groundwater were mitigated via the water line, allowing restoration of groundwater to cleanup levels via implementation of the selected source control and management of migration remedies. As such, the early mitigation of exposure (extension of the water line) allowed for the undertaking of the remainder of the Remedial Investigations and selection and implementation of the long-term remedy.

#### **1.2.4 Malcolm Pirnie Pre-Design Study**

In 1988, Malcolm Pirnie, Inc. on behalf of CSG, conducted a Pre-Design Study to gather information necessary to design the remedial actions evaluated in the FS and required under the 1986 ROD. The objectives of the Pre-Design Study were to:

- Assess which of the VOCs within the condominium leach fields posed a threat to groundwater to determine the extent of remediation needed.
- Better estimate the volume of soil in the Tinkham Garage area, soil pile, and solvent swale area that required remediation.
- Evaluate which of four soil treatment options (vacuum extraction, water extraction, biological treatment, and thermal aeration) was most appropriate given site-specific conditions.
- Characterize the quality of groundwater to be captured by the extraction system and further evaluate the need for pretreatment prior to discharge to the Derry wastewater treatment plant.

The investigations performed to meet these objectives included:

- Installation and sampling of monitoring wells around leach fields I/J and L/K.
- Collection and analysis of soil samples in the soil pile and solvent swale areas.
- Collection and analysis of soil samples from the unsaturated zone in the Tinkham Garage source area.
- Collection of representative soil samples for bench scale treatability testing for biological treatment and water extraction.

- Field pilot testing of in situ dual phase (vapor and groundwater) vacuum extraction.
- Installation and sampling of groundwater monitoring wells downgradient of existing well FW-17.
- Performance of a 72-hour pumping test for proposed extraction wells LGAW and LGSW, including collection of groundwater samples from selected monitoring wells.

The results of the study determined that soils associated with the solvent swale were below the cleanup objective of 1 part per million (ppm) total volatile organics and did not require remediation. Contaminated soils from the leach fields (estimated at 2,000 cubic yards) and the soil pile (estimated at 500 cubic yards) were to be excavated and transported to the area behind the Tinkham Garage for treatment via dual phase vacuum extraction.

The results of the combined pumping test showed observed drawdown was very similar to the single-well pumping tests performed during the RI and FS; the estimated specific capacities for the two wells were also very similar to those previously measured. It was concluded that pumping the two wells at a combined rate of approximately 60 gallons per minute (gpm) would provide capture of the VOC plume in bedrock. It was determined that pre-treatment of pumped groundwater would not be required prior to discharge to the Derry wastewater treatment plant.

### **1.2.5 Remedy Implementation**

As described above, the ROD was amended in March 1989 to change the remedial approach for soils to vacuum-enhanced extraction (VEE) which allowed the shallow groundwater extraction remedy to be modified from the planned trench behind the Tinkham Garage building to a well system installed as part of the VEE. The 1989 ROD Amendment required that groundwater extraction would proceed for a 2-year period from the date of implementation. At the end of the 2-year period, an evaluation would be made by EPA to assess progress towards meeting the remedial objectives for the cleanup of groundwater at the Site. If steady state conditions have been reached, and it is evident remedial objectives are not achievable, EPA would re-evaluate the objectives and its remedial approach for groundwater at the Tinkham Site.

The soil vacuum extraction began operations in November 1994. Groundwater extraction was initiated in May 1995. Bedrock groundwater was extracted from the two previous condominium supply wells, LGAW and LGSW, and was conveyed back on-site via a dedicated pipeline. At the

Tinkham Garage source area, shallow groundwater was removed using the vacuum extraction wells and pretreated on-site via an air stripper and carbon before both were discharged to the Derry wastewater treatment plant. Following attainment of the soil remedial goals within the former source area in November 1995, the VEE system was dismantled, and the shallow groundwater extraction system was then modified to include six independent wells pumping a combined flow of 4,500 gallons per day; however reduced contaminant levels allowed pretreatment to be discontinued, with direct discharge to the Derry wastewater treatment plant.

In July 1996, CSG requested a temporary shutdown of the two bedrock pumping wells on the basis that VOC contamination had reached steady-state conditions. CSG's consultant, GEI, prepared a report: Revised Request for Temporary Shutdown of Bedrock Pumping Systems dated July 8, 1996. The 1986 ROD, as amended in 1989, required the pumping of shallow groundwater and contaminated bedrock aquifers for a period of up to 2 years, until the treatment goal of 5 µg/L of PCE and TCE were reached at each monitoring well, or until a decision was approved to cease pumping either following the 2-year period or if/when steady state conditions were reached and/or remedial objectives were deemed not to be achievable. In May 1997, CSG requested that EPA consider the permanent shutdown of the complete groundwater extraction system based on evidence of natural attenuation through biodegradation in the shallow aquifer, attainment of steady-state conditions in the bedrock aquifer, and an estimate that drinking water standards were expected to be achieved within a 15-year period.

Groundwater pumping of the two bedrock wells (former condominium supply wells), which had a combined flow rate of 110,000 gallons per day, was suspended in 1997, though monitoring continued, as the groundwater plume was deemed to have reached steady state conditions (i.e., was no longer expanding). The provision of the alternate drinking water source (1983 waterline) had reduced the potential for exposure to contamination at the Site and protected public health while cleanup activities were being completed. The 2003 ESD documented the data collected to support the change from the 1986 cleanup to the use of natural attenuation processes to further reduce concentrations in groundwater at the Site to attain cleanup goals that would be protective of public health and the environment. The MNA remedy required continued monitoring of groundwater at the Site to document progress towards attainment of Remedial action objectives (RAO) and in the interim, relied upon established ICs (NHDES GMZ) to manage the use of groundwater.

### 1.2.6 Long-Term Monitoring of Groundwater

Construction within the Site boundary has continued since approximately 2002-2003 and both a large 165-unit residential retirement development (The Nevins) as well as several commercial properties (Home Depot, Staples, Dunkin Donuts, etc.) utilize potable water supplied through an extension of the water line originally installed in 1983. A GMP was issued by the NHDES in 2007 and renewed in 2012, 2019 (revised in 2021), and again in 2024, which ensured that the existing ICs remain in place until cleanup levels are achieved at the Site. The GMP established a GMZ that is defined as the subsurface volume in which groundwater contamination associated with Site is contained. Long-term monitoring was a required component of the 1986 ROD and included in the 2003 ESD, which suggested that anaerobic degradation processes are reducing chlorinated VOCs in groundwater at the Site, thereby supporting a change in the remedy from active groundwater extraction and treatment to natural attenuation.

As reported by CSG in monitoring conducted under the GMP, concentrations of VOCs have decreased in many locations. However, concentrations of several VOCs (TCE, PCE, 1,2-dichloroethane (1,2-DCA), cis-1,2-dichloroethene (cDCE), benzene, and vinyl chloride) still exceed their target cleanup levels for groundwater remediation, well beyond the original 15-year estimate developed in 1997. Based on recent reporting of data collected under the GMP, the GMZ boundary southwest and downgradient of the Woodland Condominium potential source area is not adequately monitored, as FW17, MP-1-3S, HA23-12-145, and the irrigation well at 11 Reed Street have all reported 1,4-dioxane concentrations above the New Hampshire AGQS. Concentrations of 1,4-dioxane in RD-S along the southern GMZ boundary also exceeded the AGQS, at 0.852 parts per billion (ppb) in November 2023, while the Pump Station well exceeded AGQS for 1,4-dioxane in May 2023 (0.413 ppb), but not in November 2023 (0.266 ppb). The recent inclusion of PFAS compounds in Site monitoring, have indicated detections upgradient, within, and outside of the GMZ boundary in excess of the New Hampshire AGQS and Federal MCLs; with the highest concentrations found in groundwater within known Site source areas as well as in downgradient residential water supply wells (H&A, 2024).

NHDES reissued the GMP to CSG in the fall of 2024. The GMZ, which was expanded in 2019 to include areas of 1,4-dioxane impacted groundwater in the Mercury/McAllister and Ross/Tokanel neighborhoods, was again modified in the 2024 GMP to include several more properties with

1,4-dioxane exceedances of the AGQS. The GMZ boundary shown in the Figures for this FFS are based on GMP No. GWP-199004008-L-005 issued on October 4, 2024. It is anticipated that the GMZ boundary will be updated and further expanded by NHDES upon EPA designation of PFAS as Site COCs.

### **1.2.7 Bedrock Remedial Investigation**

In response to concerns raised in the 2009 Third Five-Year Review and as required by the 2016 ESD, CSG contracted with H&A to perform a remedial investigation of the bedrock to assess the source, nature, and extent of site-related impacts in the bedrock aquifer and assess potential contaminant migration pathways from the source areas to residential supply wells. The Bedrock RI has been summarized in the RI Summary Memorandum (WESTON, 2024) and the reader is directed to that document for details of the work.

## **1.3 CONCEPTUAL SITE MODEL**

This section summarizes the CSM presented in the RI Summary Memorandum. It provides the EPA's current understanding of the releases, a description of identified and potential migration pathways, and the distribution of contaminants at and from the Site.

### **1.3.1 Description of Releases**

Tinkham Enterprises operated a fleet of tanker trucks that were used to transport septic and liquid industrial wastes to disposal sites during the 1970s. The Tinkham Garage served as a facility for the storage, maintenance, and cleaning of tanker trucks associated with Tinkham Enterprises. The tanker trucks were periodically washed out and the wash water and residual sludges were allowed to flow onto the ground surface via trenches located behind (southeast of) the garage building as well as the field located east of the Tinkham Garage. Wastes contained in the tanker trucks reportedly included septage, detergents, acids, oils, and hazardous substances.

Environmental investigations in 1982 also identified high levels of VOCs within a water-filled trench or trenches located in a wooded area behind Buildings E/F of the Londonderry Green Apartments. This location was designated the 'solvent swale' and was covered with several feet of soil in 1982 by the property owners at the request of EPA to prevent direct human contact with the contaminated surface water and sediments.

Initial environmental investigations also identified elevated levels of VOCs within and downslope of leaching fields serving several of the former Londonderry Green Apartments, and liquid wastes from Tinkham Enterprises were discharged into the various septic system/leach fields servicing these apartments. A pile of soil located behind condominium Building C was also identified and found to be contaminated with VOCs as this pile was understood to be the bedding materials from leaching fields that had failed and had been dug out. By the mid-late 1980s all of the leach fields had been replaced by the owners of the apartments. However, the subsurface impacts to soil and groundwater from those discharges were not addressed by the limited short-term remedial efforts. The initial RI Report and 1986 ROD identified many, if not all, of the leach fields as being potential sources of groundwater contamination from disposal activities. The Pre-Design Investigations identified the leach fields associated with Buildings K/L, I/J, and C as being the most contaminated.

Based on the initial investigations and subsequent environmental studies and testing results, four confirmed release areas or “source areas” were identified (see **Figure 2**):

1. The field/wetland areas southeast of the Tinkham Garage, and the trenches directly behind (east) of the Tinkham Garage.
2. The ‘solvent swale’ located south of condominium Building F.
3. The leach fields of the Londonderry Green apartments (now the Woodland Village Condominium Complex), with the leach fields for Buildings K/L, and I/J being deemed the most contaminated.
4. A soil pile behind condominium Building C believed to be contaminated bedding material previously excavated from failed leach field(s).

The solvent swale, which was reported as an open, water-filled trench, was noted as containing extremely high levels of toluene (15 ppm) and 1,1,1-TCA (6 ppm) in surface water and 2 ppm of toluene and 35 ppm of 1,1,1-TCA in soils in October 1982 (NUS, 1983 and 1984). This trench was backfilled on November 18, 1982. Remediation of the solvent swale included covering of the swale with clean fill to reduce potential contact and incidental ingestion. However, subsurface impacts to soil, groundwater, and surface water are not known based on the limited and short-term nature of the historical investigative efforts.

In addition to the four documented source areas listed above, there may be other areas of contamination which may require further investigations to complete a fate and transport assessment on potential residual contamination. These include remaining leach fields, historical sand and gravel mining areas and other locations on the properties owned by John Tinkham and/or his family at the time he was operating Tinkham Enterprises, and which have not been investigated for 1,4-dioxane and PFAS contamination.

### 1.3.2 Migration Pathways

Following each successive release from tanker trucks, there was contaminant 1) infiltration into the ground surface, 2) runoff into and transport via surface water pathways accentuated during precipitation, and 3) groundwater discharge into and subsequent transport via perennial surface water pathways. Contaminants that were discharged directly to the ground surface and not washed into streams by precipitation and carried downstream infiltrated the overburden soils and migrated downward into deep overburden, and eventually bedrock, providing residual columns of contaminants in soil media, which produce and sustain groundwater contamination over time. Vertical contaminant migration through the overburden was slowed by the dense to very dense tills, where present, in the lower portion of the overburden, which likely acted as and continues to act as a potential longer term “sink,” or storage reservoir for contaminants via adsorption and diffusion processes. Thus, following initial portions of the release history, contaminants which had penetrated deeply into the soil column and invaded into the till matrix represent a secondary source zone of stored or residual contaminants which allow for the sustained slow release of dissolved contaminants to groundwater over decades in the Tinkham Garage source area and to a lesser extent in the Woodland Village Condo source areas.

As well as affecting till and other materials in the lower portion of the overburden, vertical downward migration of contaminants would have also impacted underlying bedrock, likely accumulating at capillary barriers such as along the overburden/bedrock contact, eventually locally penetrating further into the bedrock via migration along fractures of various orientations. The effect of these many and varied contaminant migration pathways has resulted in a patchwork of composite secondary sources in shallow overburden, till, and bedrock within the broad regions of primary contamination shown on **Figure 6**.

As noted above, some of the contaminants that were discharged to the ground surface would have been transported away from the source areas, toward and into nearby residential areas via the surface water channels and pathways that dissect the Site and generally flow to the south and east, effectively connecting the numerous and geographically distributed source areas to the downgradient residential areas. Contaminants that were transported out of the initial release or source areas via surface water pathways could then infiltrate into the overburden at downgradient locations when flow sufficiently slowed. Potential for further downward migration into bedrock existed at these points as well as at intermediate locations at various distances from the source areas. Stream 1D has been observed to routinely overflow its bank at the shallow, man-made 90-degree bend where the stream was diverted circa 1978 to divert flow away from Ross Drive and where it currently turns to flow through the Nevins residential area. Surface water continues to flow south from this location, into the large wooded wet area where extensive pooling is commonly observed to the east of the Nevins. During periods of heavy flow and ground saturation, surface water periodically flows out of the wooded wet area southward along intermittent drainageways through the Ross/Tokanel neighborhood as depicted on **Figure 7**. The stone wall which runs within the Site and parallel to Ross Drive in this area, incorporated these intermittent stream passageways which are assumed to have been constructed during early agricultural uses of these lands and prior to development of the Nevins (see photographs on **Figure 7**).

As precipitation and associated runoff wanes, water becomes ponded in the wooded area immediately behind the residences along the north side of Ross Drive, as well as proximal to the residences located along these drainage paths which continue through the neighborhoods as can be seen on **Figure 7**. The ponded water infiltrates over time and can impact overburden groundwater. The original complaint by residents along Ross Drive was of foamy, odorous water within Stream 1D, which previously drained from the Site through the Ross/Tokanel neighborhood. Recent observations of foamy groundwater were encountered during drilling and/or sampling activities at HA20-03, HA20-04, and FW11DX in the Tinkham Garage source area, near the headwaters of Stream 1D, suggesting the continued presence of a direct connection between the source areas near the former Tinkham Garage and the downgradient residences via pathways involving both groundwater and surface water.

Similarly, contaminants which were disposed or released within the Woodland Village Condo area would be expected to infiltrate into the overburden and bedrock, as evidenced by the elevated concentrations seen in ERT-06 during the initial RI, as well as having been transported to the south and southeast by Streams 1A and 1B, respectively. Shallow overburden wells FW18 and FW19 were formerly located proximate to the leach field of Buildings E/F (which at the time of the initial RI were located in the front of the buildings, near Stream 1B) and found to be contaminated. The leach fields for Building E/F were later constructed behind the buildings, in the area of the former solvent swale. Streams 1A and 1B are converging streams which pass to the west of the Ross/Tokanel neighborhood and enter a large wetland which continues to flow toward the south/southwest ultimately discharging to Beaver Brook.

Surface water/groundwater interactions have also likely played a significant role in contaminant fate and transport at the Site. The groundwater/surface water interaction study performed by H&A demonstrated that groundwater discharges into the upper reaches of Stream 1D in the vicinity of the Tinkham Garage source area. Overburden groundwater in the Tinkham Garage source area has been shown to flow to the east toward Stream 1D. Concentrations of 1,4-dioxane were significantly higher in groundwater than in surface water where upward gradients were observed, suggesting that as groundwater is passing under the stream, some of the overburden groundwater from the Tinkham Garage source area discharges to the upper reaches of Stream 1D, while the remaining groundwater passes beneath the stream and continues to flow further east and southward. Neutral and downward gradients have been shown to exist at least during certain portions of the year in the lower reaches of Stream 1D, beginning northeast of FW28D. 1,4-Dioxane concentrations in surface water are roughly double those in groundwater where neutral to downward gradients are observed, suggesting that the impacted surface water of Stream 1D recharges groundwater in the lower reaches of the stream, in addition to traveling along its flow path across the Nevins to Stream 1C and ultimately discharging into Beaver Brook. Contaminants released at the multiple Tinkham Garage source areas have thus been transported downstream via surface water and recharge and interact with groundwater where they can then migrate downward into bedrock near the Ross/Tokanel neighborhood as well as migrate toward further downgradient regions via both the surface water and groundwater pathways.

Contaminants in the Tinkham Garage source area migrate downward through the fill and overburden deposits into the underlying till units, and eventually deep into bedrock via the high angle to near vertical fractures that have been shown to pervade the Site. Once in bedrock, contaminants are then transported from initial release sites or secondary source areas to distant areas, traveling through interconnecting fractures within the bedrock. Three predominant fracture sets have been mapped at the Site: 1) a primary fracture set that trends NE to NNE and is parallel to the strike of regional structural trends, 2) a secondary fracture set that is roughly perpendicular to the primary fracture set (trending roughly NW to WNW), and 3) sheeting fractures that are low angle to near horizontal and cross-cut the other two fracture sets. With the exception of the sub-horizontal “sheeting” fractures, the other fracture sets are steeply dipping, near vertical in many cases. Strike-parallel fractures include near vertical as well as fractures which generally follow the foliation (layering) in the rocks and dip moderately to steeply to the northwest. The higher frequency of the primary strike-parallel fracture set relative to the other two imparts a strong NE to NNE anisotropy on the bedrock groundwater flow system. However, NW to WNW trending fracture sets cross-cut the strike-parallel features and thus provide pathways where groundwater can migrate across strike in response to hydraulic gradients which are directed generally from north to south.

The upper portion of the bedrock warrants particular attention relative to groundwater movement and contaminant transport. As noted above, the overburden/bedrock contact zone is an important horizon as the interface is typically characterized by large contrasts in permeability and hydraulic conductivity. In this respect, groundwater and contaminants commonly migrate laterally on this interface, often accumulating in localized low spots. The bedrock/overburden interface is also typically characterized by an uppermost zone of weathering with variable thickness. This uppermost “weathered zone” is characterized by irregular intervals of chemically altered or “weathered” bedrock as well as intervals of more intense fracturing. As mentioned above, sub-horizontal sheeting fractures are flat features that occur in the upper part of bedrock masses. Such sheeting fractures are more prevalent near the upper portion of the bedrock including the weathered layer, with sheeting fracture density decreasing with increasing depth below the bedrock-overburden contact. Shheeting fractures commonly act as important groundwater and

contaminant migration pathways, and while they are more prevalent in shallow bedrock, they may persist to depths of hundreds of feet below ground surface.

The nature of the weathered bedrock layer requires that for many drilling and well installation technologies, this area or interval is typically cased off by permanently installed steel casing to prevent cave-ins, fluid loss or other potential problems during the drilling of deeper bedrock holes. Drilling programs therefore often systemically overlook this interval by virtue of the typical installation of permanent steel casings, which by design, “seal off” and obfuscate the weathered zone. Given the prevalence of fracturing and variable weathering in the uppermost bedrock, this zone requires scrutiny. The present CSM for the Site currently does not have adequate evaluation of this zone, as most of the borings to date have either targeted shallow overburden materials or deeper bedrock intervals and have used permanently grouted steel casing across these zones to do so. The nature of potential groundwater and contamination migration pathways which utilize the overburden/bedrock contact or occur within the upper part of this weathered bedrock remains a significant data gap related to understanding contaminant migration. The possibility of contaminant migration pathways involving the top-of-till surface is another data gap, particularly near the initial release areas at Tinkham’s Garage and in the former Londonderry Green condominium complex area. Additional activities to address these data gaps will be addressed in the on-going RI at the Site.

Groundwater moves through the bedrock via the three fracture sets in response to the hydraulic gradient. The overall hydraulic gradient across the Site is to the east-southeast towards Beaver Brook (see **Figures 8a** and **8b**), but because the primary fracture set in the bedrock imparts a strong anisotropy, actual groundwater flow paths (and therefore contaminant migration) will follow a more complex pattern and may not flow directly down the hydraulic gradient. Further, the distribution of fractures is not uniform; there are areas where either fractures are better developed (larger, longer or more open) or are more frequent (clustered). These areas represent preferential pathways in bedrock. These preferential bedrock pathways can be expressed as linear features on the ground surface and/or can be confirmed, located, and mapped by surface geophysical methods. Lineament analysis and surface geophysics were employed at this Site in an effort to identify and further delineate potential preferential pathways. Identified lineaments and surface geophysical anomalies are shown on **Figure 6**. The results of the transducer groundwater elevation monitoring

program were used to assess which of the mapped lineaments and geophysical anomalies might represent viable hydraulic and contaminant migration pathways. Hydraulic connections identified from the transducer data are shown on **Figure 9**.

Historical transport of contaminants within bedrock groundwater appears to have been influenced by the pumping of the LGSW which drew contaminants from the Tinkham Garage source area to the southwest along the major axis of anisotropy, parallel to the predominant fracture strike. This is evidenced by the drawdown ellipse that was observed during the pumping test that was carried out as part of the 1983 NUS/FIT Field Investigation (see **Figure 10**). Londonderry Green Supply Well was pumped at a constant rate of 20 gpm to simulate pumping conditions prior to the shutdown of LGSW in January 1983. The drawdown ellipse extended from LGSW to the northeast and through a portion of the Tinkham Garage source area where Site COC concentrations are the highest reported for the Site (e.g., FW11D). Surface geophysics conducted at the Site as part of the current RI identified a potential northeast-southwest fracture zone extending from LGSW toward the Tinkham Garage source area and while it was not mapped as extending beneath the Nevins, based upon the drawdown observed during the LGSW pump test, the fracture zone does extend beyond The Nevins to the southwest and at least through the Tinkham Garage source area to the northeast.

The Boston/Charleston/Albany neighborhood is situated to the east of the Tinkham Garage source area. Strike-parallel transport along the primary axis of anisotropy under pumping conditions likely drew the contaminants from the Tinkham Garage source area to that neighborhood, which would explain the similar contaminants observed in the Boston/Charleston/Albany neighborhood. Several homes in this neighborhood were connected to the existing water line in this neighborhood by the 2016 ESD, which reduced pumping stress placed on the bedrock aquifer. Contaminant concentrations from these wells following cessation of pumping have declined significantly.

Another fracture zone mapped by the surface geophysics (see **Figure 6**), trending roughly northwest to southeast (parallel to the secondary fracture set), connects LGSW to the LGAW, which is located approximately 1,120 ft to the south-southeast of LGSW. Londonderry Green Auxiliary Well was allegedly never used for water supply due to sulfide contamination; however, that well is artesian suggesting recharge from an area to the north or northeast that has higher

groundwater elevations. During the LGSW pumping test, drawdown was not observed (see **Figure 10**), indicating that pumping LGSW at 20 gpm was not enough to overcome the artesian conditions at LGAW. However, it is possible that contaminants migrated south-southeast along the identified fractures from LGSW to LGAW under the natural hydraulic gradient at the Site. Historical analytical data indicate that Site COCs have been present in LGAW at elevated concentrations since sampling was initiated in 1982. It is also possible that the contamination in LGAW could be from releases associated with the Woodland Village Condo including the nearby solvent swale and leach fields E/F. The contamination present at LGAW continues to migrate southeast to the southern end of the Ross/Tokanel neighborhood.

The LGSW water supply well was removed from service in January 1983 with the waterline connections to the condominiums and nearby households on Mercury and McAllister Drives as required by EPA. Pumping of this well was resumed temporarily along with LGAW as a component of the Remedial Action operating from May 1995 through July 1996. Contaminant migration in bedrock to the southwest from the Tinkham Garage source area would have slowed during non-pumping durations and instead would be influenced by the ambient bedrock hydraulic head field directed to the south, facilitated by fracture flow to the south along the NNW-SSE and N-S striking fracture as well as tertiary (sheeting fractures) fractures. Pumping-induced stresses from the nearby neighborhoods to the south likely increased southward directed flow gradients. Contaminants that existed in bedrock groundwater in the vicinity of the former Londonderry Green Apartments (now Woodland Village Condos) were subject to continued pumping stresses from the residential wells in the southern portion of the Ross/Tokanel neighborhood. As expected, pumping-induced stresses on bedrock groundwater are likely to have increased and/or have had some variability as the neighborhoods have developed and new supply wells installed over the 40 years since the initial releases occurred.

A fracture zone was identified during the surface geophysics study that originates in the former field east of the Tinkham Garage (northeast of wells FW20, HA20-03, and OW2S/D) and runs through the northern portion of the Ross/Tokanel neighborhood, thereby connecting the Tinkham Garage source area to the northern portion of the Ross/Tokanel neighborhood. Contamination released in the Tinkham Garage fields would likely have migrated easterly to this area before entering the bedrock. Groundwater samples from FW20 (a shallow bedrock well) and OW2D (an

overburden well) have had elevated concentrations of 1,2-DCA, cDCE, PCE, TCE, and vinyl chloride before, during, and after completion of the initial remedial actions, suggesting that the short-lived remedial efforts had limited effectiveness. As noted above, the surface geophysics performed by CSG identified a series of ‘high confidence’ bedrock structures that trend NW-SE (parallel to the secondary fracture set) and extend into and through the northern end of the Ross/Tokanel neighborhood. The presence of both PFAS and 1,4-dioxane has been documented in residential water supply wells along this pathway, within the northern end of the Ross/Tokanel neighborhood. PFAS were recently detected in bedrock monitoring well FW25D, which is located just south of an identified fracture pathway and where 1,4-dioxane was also detected in the spring of 2022. Additionally, 1,4-dioxane was detected in November 2022 for the first time at well FW26D, which is also along a potential migration pathway suspected to reach the Boston/Charleston/Albany neighborhood. This suggests that the bedrock groundwater plume along these potential migration pathways may be continuing to expand, likely in response to reduced pumping of water supply wells within the Site and continued pumping in the Ross/Tokanel neighborhood and nearby areas.

**Figures 11A** and **11B** summarize the CSM for the groundwater and surface water pathways, respectively.

### 1.3.3 Contaminant Distribution

Based upon the data collected to date, it is evident that VOCs migrated downward into and through the till units of the Tinkham Garage and Woodland Village Condo source areas. The VOCs would have adsorbed to soil within the till units, which may continue to act as a secondary source for continued low-level releases to bedrock in those areas. Initially, VOCs migrated laterally within the overburden to the east and southeast from the Tinkham Garage source area as indicated by elevated concentrations measured in FW11 and the M- and K-series monitoring wells (no overburden wells were located downgradient of FW11, so the full extent of the initial overburden impacts was not determined). Currently, lateral migration of VOCs outside of the Tinkham Garage and Woodland Village Condo source areas within the overburden appears to be limited. This is apparent from review of the current overburden and bedrock groundwater VOC plume maps (**Figures 12A** and **12B**, respectively), with plume geometries generally restricted to the source areas and limited detections in the residential areas. Additionally, the characteristics of site-related

chlorinated VOCs generally lend themselves to migrating downward and are less likely to be widespread than other, lighter, and more mobile VOCs under conditions that persist at the Site (low transmissivity of the till and lower hydraulic stresses after pumping of LGSW ceased). The highest historical and present-day concentrations of VOCs at the Site exist within the Tinkham Garage source area. Similar contaminants were found in the Condominium area and in residential wells in the Boston/Charleston/Albany neighborhood in 2014, which were the subject of the 2016 ESD.

The 1,4-dioxane concentrations in groundwater at the Site exceed EPA's unacceptable cancer risk set at  $1 \times 10^{-4}$ , are several orders of magnitude above the site cleanup level set at  $3 \mu\text{g/L}$  in the 2016 ESD, and well above the current NHDES AGQS of  $0.32 \mu\text{g/L}$  in and downgradient of the source areas. This compound has been detected in monitoring wells across the 375-acre Site at concentrations exceeding the ROD cleanup level as well as in the Boston/Charleston/Albany neighborhood and in the Ross/Tokanel neighborhood above the current New Hampshire AGQS since the compound was initially analyzed (see **Figure 4**).

Given the highly soluble and recalcitrant nature of 1,4-dioxane as well as its vertical distribution, it appears that residual 1,4-dioxane is being transported from former release areas at the Site into the neighborhoods via bedrock fractures along deeper flow paths. In the 2020 Annual Water Quality Monitoring Report (H&A, 2021b), H&A updated their CSM to acknowledge that 1,4-dioxane from the Tinkham Garage source area had migrated into the Ross/Tokanel neighborhood. Continued migration of 1,4-dioxane along this pathway is illustrated by the observed increasing concentration of 1,4-dioxane within discrete fractures and increasing trends within deeper intervals such as at FW28. Closer to the Tinkham Garage source area, at FW11D and FW11DX, 1,4-dioxane concentrations increase with depth to about 300 ft and then decrease, suggesting that the core of the plume is likely shallower near the release area, as would be expected. As noted above, the 1,4-dioxane plume then moves deeper under predominantly downward vertical gradients present along the major migration pathways as it moves downgradient towards the receptors. This observation is further supported by the potential hydraulic connections that were identified during the evaluation of transducer data. These potential connections appear to link the Tinkham Garage source area to downgradient locations FW28D, HA20-01, HA20-02, and HA20-06 as shown on **Figure 9**.

While less studied than the southeastern pathway, it is likely that a northern pathway exists from the FW20 area eastward to FW25 and into the northern portion of the Ross/Tokanel neighborhood where 1,4-dioxane has historically been detected below the New Hampshire AGQS at 4 and 10 Ross and 3, 5, and 7 Tokanel. Surface geophysics has mapped several large high-confidence anomalies along this pathway that may represent water-bearing fractures. Further investigation and monitoring of the northern pathway is ongoing.

Finally, as evident from **Figure 4**, the majority of the 1,4-dioxane migration has occurred to the southwest from the Tinkham Garage source area toward former water supply well LGSW. While it was originally postulated that historical operation of that well had pulled contamination in that direction along the bedrock pathway identified during the pumping tests performed during the initial RI and pre-design investigations, the fact that 1,4-dioxane concentrations along that pathway have not significantly attenuated since termination of pumping in 1996 (about 27 years ago) suggests that there may be a natural component of flow along that pathway.

Similar to 1,4-dioxane, PFAS are widely distributed across the Site, with the highest concentrations currently found to be in the Tinkham Garage source area as well as a residential water supply well along Ross Drive, and proximate to a surface drainage feature of Stream 1D (see **Figures 5A and 5B**). Concentrations which exceed EPA MCLs as well as AGQS for PFOA and/or PFOS are found across the Site and have been noted in residential supply wells throughout the neighborhoods monitored, as of the November 2023 sampling event. EPA RSLs were updated in May 2024 and Site data indicate there are exceedances of PFAS RSLs in nearly all residential water supply wells. Elevated PFAS concentrations are found at the northeastern portion of the Ross/Tokanel neighborhood, with several homes found to be in exceedance of the EPA MCL for PFAS. This suggests that PFAS may also be migrating along fractures (“the northern pathway”) discussed above and still under investigation as part of the current RI.

#### **1.4 EVALUATION OF CLEANUP LEVEL ATTAINMENT**

The 1986 ROD established that PCE and TCE concentrations in groundwater at the Site be reduced to below the MCL of 5 µg/L. It was expected that if these two compounds were reduced to below 5 µg/L that other VOCs in groundwater would be at or near detection levels and thereby no longer a concern. Once the MCLs for PCE and TCE have been achieved, EPA will make a determination

as to whether the aquifer cleanup has satisfied the remedial objectives and assure that water quality is adequately protective of public health and the environment. Transition of the remedy from active groundwater extraction and treatment to MNA after cessation of pumping as documented in the 2003 ESD has slowed remedial progress at the Site. At the time of cessation of active pumping, it was estimated that MCLs would be achieved within 15 years. After more than 25 years, TCE and PCE concentrations in the Tinkham Garage source area still exceed the MCLs by as much as nine times.<sup>1</sup>

Further, the subsequent detections of emerging contaminants 1,4-dioxane and PFAS, which are resistant to natural degradation in the environment, has called into question the efficacy of the MNA remedy. Ongoing RI efforts continue to focus on determining the extent and migration pathways of these contaminants and assessing potential exposure to human health and the environment. Both 1,4-dioxane and PFAS have been found in groundwater within the Site and in drinking water wells in the Boston/Charleston/Albany neighborhood and the Ross/Tokanel neighborhood. The 2003 modification of the remedy to MNA was approved prior to Site discovery of 1,4-dioxane and PFAS. Currently there is little scientific understanding that natural attenuation would effectively address these contaminants. Historical data collected before, during, and after the active remedial action documented that contaminants were present in wells downgradient of those areas where treatment was targeted, suggesting migration of the plume was likely more extensive than may have been understood at the time of the ROD. Monitored natural attenuation, which allows for the continued migration of groundwater through and from the Site into the neighborhoods, is therefore not capable of minimizing migration (which may be exacerbated by groundwater pumping from these neighborhoods) or mitigating exposure for these receptors via the drinking water pathway. This FFS was prepared to develop and evaluate remedial options that could be implemented as an interim action to mitigate exposure from use of contaminated groundwater as drinking water, and minimize migration caused by pumping from residential wells, while on-going investigations assess the long-term cleanup of groundwater.

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<sup>1</sup> TCE and PCE concentrations in well NAI-K2 in May 2022 were 45 µg/L and 24 µg/L, respectively.

## 1.5 EXTENT OF CURRENT AND POTENTIAL FUTURE RISK IMPACTS

Since the fall of 2018, 1,4-dioxane and PFAS have been found in private drinking water wells the Boston/Charleston/Albany and Ross/Tokanel neighborhoods, as well as homes along Gilcrest Road that are not connected to the existing municipal water line (WESTON, 2024).

To evaluate the extent of the current and potential future risks related to the use of groundwater for drinking water, an exposure assessment was performed. As part of the 2016 ESD, 1,4-dioxane was identified as a Site COC. For this exposure assessment and FFS, several PFAS were also identified as presenting a significant current or future risk and are considered COCs for the Site.

For the exposure assessment, residential water supply wells that are currently monitored or have been monitored for either 1,4-dioxane, PFAS, or both at least once since 2014 were considered. Of these, 75 of 81 homes in these neighborhoods have been tested and over 90 percent (%) have had PFOA, PFOS, and/or 1,4-dioxane detected in their drinking water at some point between 2018 and 2022. Permission is required for residential monitoring and the number of households who agree to have their well water analyzed varies per sampling event.

### 1,4-Dioxane

Concentrations of 1,4-dioxane found within the condominium area wells are likely associated with the known disposal of hazardous substances within the leach fields and the solvent swale as well as migration from the Tinkham Garage area due to the continuous pumping of the condominium supply well and nearby residential wells up until the early 1980s. 1,4-Dioxane has been found in water supply wells to the east of the Tinkham Garage, within the Boston/Charleston/Albany neighborhood, along with other chlorinated VOCs, which prompted, in part, the connection of the waterline for those households in 2016 as well as the inclusion of 1,4-dioxane as a Site COC and establishment of a Site cleanup level. Within the Ross/Tokanel neighborhood, 1,4-dioxane is found to be migrating from the Tinkham Garage source area into and across the southern portion of the neighborhood consistent with the primary groundwater flow direction. It has also been found in water supply wells and monitoring wells within the northern portion of the neighborhood, consistent with bedrock lineament features indicating potential migration pathways into and across the neighborhood. To date, the MNA remedy has not minimized or reduced the uncontrolled migration of 1,4-dioxane from the Site into the neighborhoods. It does appear that significant water

bearing fractures documented within the central lower portion of the Site may both support facilitated groundwater flow into the neighborhood as well as dilution. Continued migration, a complex bedrock fracture network, varying depths of residential wells, and continued pumping from the bedrock aquifer appears to result in an increasing number of households where 1,4-dioxane is detected. Concentrations found within the residential wells, primarily within the south-southwestern portion of the Ross/Tokanel neighborhood, currently exceed the EPA RSL of 0.46 µg/L as well as the current New Hampshire AGQS of 0.32 µg/L.

### **PFAS**

The evaluation of PFAS as an emerging contaminant found in Site groundwater and water supply wells has changed rapidly since the first data were collected for these compounds in 2018. The State of New Hampshire currently reports nine PFAS compounds and has drinking water standards for four. EPA recently established enforceable MCLs for six PFAS which includes two of the most widely found compounds: PFOA and PFOS, as well as MCLs for four additional PFAS individually or as a mixture.

EPA also recently updated its RSLs for PFAS based on current toxicological information. A comparison to the site-specific residential (tapwater) risk-based screening levels for the Site indicates that concentrations found in groundwater within Site source areas in both the overburden and bedrock aquifer and within residential water supply and irrigation wells downgradient of the Site exceed risk-based screening levels. As such, PFAS compounds are included as Site COCs which exceed their RSLs and are part of the evaluation of risk performed to support this FFS.

Consistent with EPA guidance, an interim remedy may be warranted at a site before the remedial investigations are complete and before the formal baseline or supplemental risk assessment is performed. Whenever there is a release or substantial threat of release of a hazardous substance into the environment which may present an imminent and substantial danger to public health or welfare, CERCLA provides EPA with the authority to take any response action consistent with the National Contingency Plan (NCP) deemed necessary to protection human health.

The 1986 Endangerment Assessment concluded that an unacceptable risk was present for residents whose wells were found to be impacted with VOCs in the early 1980s. An action to mitigate exposure to groundwater used as drinking water was implemented in 1983. The Endangerment

Assessment also determined that there was an unacceptable risk for future use of the contaminated groundwater at the Site and the 1986 ROD selected remedial response actions to mitigate that risk via extraction and treatment towards attainment of groundwater cleanup levels. The 2003 ESD modified the response action for groundwater but did not alter the required attainment of drinking water standards in groundwater at the Site as required by the 1986 ROD and added attainment of the NH AGQS for 1,4-dioxane. The 2016 ESD determined that the exceedances of federal MCLs and State AGQS warranted connections to the existing waterline for households within the Boston/Charleston/Albany neighborhood, as well as the need for further investigations to assess the extent of those impacts to human health at the Site.

While interim action RODs do not require a completed baseline risk assessment, enough information must be available to demonstrate an exposure, the potential for risk, and the need to take action. Data sufficient to support the interim action decision is in the ongoing RI and monitoring at the Site and set out in this FFS, which includes a short analysis of a limited number of alternatives (55 Fed. Reg. at 8704). This FFS includes information which supports a completed exposure (ingestion), assesses risk related to that exposure, the need to take action, and includes a comparison of alternatives developed to mitigate exposure for residents who continue to rely on groundwater for their household use, including as drinking water.

A site wide risk assessment will be performed at the completion of the RI for all media at the Site. This FFS includes an assessment of receptors downgradient of the Site, who are exposed via ingestion of groundwater to contaminants that (as documented in the RI Summary Memorandum) may have migrated or continue to be migrating from the Site. Because other risks may be assessed at the Site at the completion of the RI, this risk evaluation expresses only one pathway (ingestion of groundwater) for receptors in support of an interim action.

### **1.5.1 Risk Evaluation for Residential Use of Groundwater**

A completed exposure pathway has been documented for residents living near the Site for ingestion of groundwater that has been, or potentially may be, impacted by contaminants released at the Site via uncontrolled migration of groundwater, transport via surface drainage, and/or from stresses placed on the bedrock aquifer related to continuous pumping of water supply wells. Concentrations of contaminants including 1,4-dioxane and PFAS are currently found in water

supply wells in excess of federal and State applicable or relevant and appropriate requirements (ARAR) and RSLs and a risk evaluation of cancer and non-cancer risks has been performed by an EPA risk assessor. The complete Risk Evaluation Memorandum is presented in **Appendix A** and is summarized below.

Groundwater within the Site has been previously documented to pose an unacceptable risk and remains unsuitable for drinking water. The groundwater remedial investigations are on-going and will include an assessment of residual sources which may continue to leach contaminants into the groundwater or nearby streams, and the pathways for migration of those contaminants across the Site and into nearby neighborhoods. The final remedial investigations are expected to result in a modified remedy to address unacceptable risks posed by exposures to contaminated media at the Site and allow for attainment of groundwater cleanup levels in the future. As such, this FFS and interim remedial action will not establish or modify cleanup levels for Site media at this time.

The risk evaluation was performed using private well data for approximately 80 residences collected between 2014 and 2023 for 1,4-dioxane and for selected PFAS compounds including PFOA, PFOS, PFNA, PFBS, PFBA, PFHxS, and PFHxA. Private well data were unavailable for Perfluorodecanoic acid; therefore, it was not included in the risk evaluation. Additionally, EPA does not currently have toxicity values available for Perfluoroheptanoic Acid (PFHpA) or Perfluoropentanoic Acid (PFPeA); therefore, risks for these compounds could not be estimated.

A residential tapwater scenario was used for the risk evaluation which assumes potable uses of water such as drinking and bathing and that a person may be exposed to contaminants through ingestion, dermal, and inhalation routes. There is currently limited dermal toxicity data for PFAS compounds. Additionally, EPA does not currently have inhalation toxicity data available for PFAS compounds, therefore there is potential for risks to be underestimated due to limited toxicity information for the dermal and inhalation pathways.

### **1.5.1.1 Estimation of Exposure**

In risk assessment, to evaluate the magnitude of potential human exposures, the concentrations of contaminants must be estimated. An estimate of this concentration is referred to as an Exposure Point Concentration (EPC). EPA guidance recommends calculation of the 95% upper confidence level (UCL) on the arithmetic mean concentration for estimation of risk. The 2014 Office of Solid

Waste and Emergency Response (OSWER) Directive on Determining Groundwater EPCs generally recommends that concentrations from the core of the plume be used to assess exposure and that data for private wells be evaluated on an individual basis because there may be limited availability of construction information to determine if wells are comparable. However, for this interim action at the Site, the collective use of the extensive volume of residential data from all individual residential wells was combined to represent the EPC for groundwater used as drinking water within these downgradient target neighborhood areas of concern and used to calculate the 95% UCLs for 1,4-dioxane and the selected PFAS compounds for this risk evaluation. While it is noted that the approach of evaluating an exposure scenario by combining residential well data may increase uncertainty about representativeness of the EPC, this method was determined to be a reasonable approach for this risk evaluation for residential receptors as it includes both the higher concentration data and non-detect data points. As documented in the RI Summary Memorandum (WESTON, 2024), contaminant migration in fractured bedrock is driven by both the hydraulic gradient and the orientation of the fractures. The residential wells in this data set are comparable in that they are all located within the bedrock aquifer and hydraulically downgradient of the Site or along predominant fracture orientation which has been mapped at the Site. Patterns for the migration of contaminants have been noted for Site contaminants, including 1,4-dioxane and PFAS, which have raised concerns about the uncontrolled migration of Site contaminants, the continued use of private wells, and the further pulling of Site contamination toward residences.

The 95% UCLs for PFOA, PFOS, PFNA, PFBA, PFBS, PFHxS, PFHxA, and 1,4-dioxane were calculated using ProUCL (version 5.2), using residential well data from target neighborhoods and are as follows:

PFOA	PFOS	PFNA	PFBA	PFBS	PFHxS	PFHxA	1,4-dioxane
13.08 ng/L	4.74 ng/L	1.72 ng/L	2.94 ng/L	4.28 ng/L	2.36 ng/L	3.76 ng/L	0.197 µg/L

### 1.5.1.2 Calculation of Risk

The EPCs obtained for the PFAS compounds and 1,4-dioxane representing the 95% UCLs were used in the EPA RSL calculator to generate estimates of risk for residential tap water use within the target neighborhoods. For comparison, estimations of risk are also provided using the minimum concentrations detected for PFAS and 1,4-dioxane, and estimations of risk are provided using the

maximum concentrations detected for PFAS and 1,4-dioxane. All default exposure parameters were used to estimate risks for the resident.

Estimates of incremental lifetime cancer risk (ILCR) represent the lifetime incremental risk of cancer from the Site. Hazard quotient (HQ) estimates represent the risk of health effects other than cancer from exposure to Site contaminants. An HI is obtained by summing HQs for individual contaminants. The risk estimates for the minimum detected concentrations and the maximum concentrations are provided for comparison only. Risk managers use the results for the 95% UCLs to base the risk management decision.

Risk results based on the 95% UCLs indicate that the total ILCR exceeds the EPA target cancer risk range of  $10^{-4}$  to  $10^{-6}$  due to concentrations of PFOA and 1,4-dioxane. The results for non-cancer hazard based on the 95% UCLs indicate that the total non-cancer HI exceeds a target limit of 1. Non-cancer hazard was then broken down by target organ to determine if organ specific HIs exceed the target limit of 1. The breakdown by target organ indicates that the HI for developmental effects exceeds the target limit of 1 due to concentrations of PFOA, PFOS, PFNA and PFHxA.

For comparison, risk results were also calculated using minimum detected concentrations of PFAS and 1,4-dioxane. The risk results using minimum detected concentrations show that minimum detected concentrations of PFAS and 1,4-dioxane also result in cancer risk exceeding the target risk range and non-cancer hazard exceeding the target limit of 1 for developmental effects. Additionally, risks were calculated using maximum detected PFAS and 1,4-dioxane which showed significantly increased risks from cancer and non-cancer effects.

The results from the risk evaluation indicate that cancer and non-cancer acceptable risks are exceeded for the residential well data. The calculated ILCR based on the 95% UCL values for PFAS and 1,4-dioxane was  $4.93 \times 10^{-3}$ , which exceeds the EPA target cancer range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ . The calculated non-cancer HI estimate of 24.2 exceeded the EPA total non-cancer HI target limit of 1. Therefore, based on this risk evaluation, continued use of residential wells is found to pose both a current unacceptable risk for ingestion and a future unacceptable risk should groundwater continue to be used as a drinking water source.

## **1.5.2 Basis for Interim Action**

As described in the preceding sections, PFAS and 1,4-dioxane are present in bedrock groundwater within and downgradient of the Site within the Boston/Charleston/Albany, Gilcreast Road, and Ross/Tokanel neighborhoods. The majority of all households sampled had detectable levels of PFAS in their drinking water. Residents in these neighborhoods use groundwater as their source of potable water, relying on individual supply wells that tap the bedrock aquifer. The risk evaluation performed by EPA has concluded that concentrations of PFAS and 1,4-dioxane based on the 95% ULC found in bedrock groundwater within the target neighborhoods represents an unacceptable risk with regard to both cancer and non-cancer risks for residential receptors. Therefore, there is a need for an interim remedial action to mitigate ongoing ingestion of contaminated groundwater by residents. Mitigation of exposure to PFAS and 1,4-dioxane via ingestion would remove or otherwise significantly reduce risk to residents living near the Site.

The 95% UCL used in the risk evaluation included results from all homes sampled in the affected neighborhoods (with the exception of a few that declined sampling of their tap water, and several households within the Boston/Charleston and Albany neighborhood which were later sampled by Weston for the NHDES). As such, the 95% UCL represents the average exposure concentration in bedrock groundwater within the neighborhoods. The results of historical private well sampling since 2018 have shown there is a high degree of spatial and temporal variability in contaminant concentrations, particularly for PFAS. This is due to the nature of groundwater flow through fractured bedrock and also to the highly variable pumping rates/durations of the residential wells. Because all of the individual water supply wells are screened in the same bedrock aquifer, contamination can migrate from the Site and between homes via interconnected fractures. Continued use of individual wells can draw contamination from one property onto an adjacent property, thus spreading the contaminant plume and increasing exposure to homes previously unaffected. This is particularly true if some homes are provided with alternative water (and therefore cease or reduce their pumping of bedrock groundwater) while adjacent homes are not (and therefore continue to pump bedrock groundwater). As a result, for the purposed of this FFS, the action to be taken to mitigate risk by reducing or removing current and potential future exposures would apply to all households currently relying on groundwater as their drinking water source within these target neighborhood areas of concern.

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**SECTION 2**

**REMEDIAL ACTION OBJECTIVES**

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## 2. REMEDIAL ACTION OBJECTIVES

This section discusses ARARs, the COCs for the Site, and the RAOs for this FFS and the proposed interim action.

### 2.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The ARARs are promulgated, enforceable federal and state environmental and facility siting laws that have been determined to be legally applicable or relevant and appropriate to the hazardous substances, remedial actions, or other circumstances at a site. Section 300.430(f)(1)(ii)(B) of the NCP (Title 40 of Code of Federal Regulations Section 300.430(f)(1)(ii)(B)) states that on-site remedial actions at CERCLA must meet ARARs unless there are grounds for invoking a waiver. A waiver is required if ARARs cannot be achieved. CERCLA Section 121 requires primary consideration be given to remedial alternatives that attain or exceed ARARs.

An interim action must comply with (or waive) those federal and state requirements that are applicable or relevant and appropriate to the limited-scope action. Because this FFS supports a limited interim action, the ARARs discussion herein will focus only on those ARARs specific to the interim action and the remedial alternatives presented in this FFS.

The purpose of ARARs is to ensure that response actions are consistent with other pertinent federal and more stringent state environmental requirements to meet the national goals of remedy selection, to protect human health and the environment, to maintain protection over time, and to minimize untreated waste. The two classes of ARARs, "applicable" and "relevant and appropriate," are defined by Section 300.5 of the NCP as follows:

- ***Applicable Requirements*** - “means those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state [Massachusetts] environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.”
- ***Relevant and Appropriate Requirements*** - “means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state [Massachusetts] environmental or facility siting laws that, while not ‘applicable’ to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar

to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.”

To Be Considered standards and guidance (TBC) are comprised of non-promulgated advisories or guidance issued by federal or state regulatory bodies that are not legally binding but may be useful in developing cleanup alternatives. The ARARs and TBCs are subdivided into three categories: chemical-specific (that apply to establishing chemical standards), location-specific (that apply to certain locations such as rivers and wetlands), and action-specific (that apply to certain activities such as dredging and filling). The potential chemical-specific, location-specific, and action-specific ARARs and TBCs identified for this FFS are presented in **Appendix B**.

## 2.2 CONTAMINANTS OF CONCERN

The 1986 ROD identified the following COCs, all VOCs, in Site groundwater: benzene, ethylbenzene, toluene, xylenes, chloroform, 1,1-DCA, 1,2-DCA, trans-1,2-dichloroethylene, PCE, 1,1,1-trichloroethane, TCE, vinyl chloride, methylene chloride, acetone, and 2-butanone (methyl ethyl ketone). The 1986 ROD also indicated that remediation of soil source areas and groundwater would be evaluated in terms of reduction in levels of PCE and TCE, with the assumption that treatment to target levels for these compounds would result in non-hazardous levels for the other COCs. In addition to those COCs, the 2016 ESD formally identified 1,4-dioxane as a COC for the Site.

The PFAS compounds have been evaluated in Site groundwater and water supply wells since 2018. As discussed above, concentrations of PFAS compounds found in groundwater within Site source areas in both the overburden and bedrock aquifer and within residential water supply and irrigation wells downgradient of the Site exceed risk-based screening levels and represent an unacceptable risk. For this FFS and the proposed interim remedial action, PFAS compounds [specifically PFOA, PFOS, PFNA, PFBA, PFBS, PFHxS and PFHxA] are identified as Site COCs.

As discussed above, the results of EPA’s risk evaluation indicate that the concentrations of 1,4-dioxane and PFAS in private wells pose unacceptable risk to human health, with the total ILCR exceeding EPA’s target cancer range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  and the total non-cancer HI exceeding the target limit of 1. The proposed interim remedial action will address risk associated with exposure to the COCs 1,4-dioxane and PFAS in groundwater used as drinking water.

## 2.3 REMEDIAL ACTION OBJECTIVES

The RAOs must be established prior to the development and evaluation of remedial alternatives. Remedial action objectives are developed to protect human health and the environment, and to provide the foundation upon which remediation alternatives can be developed. Separate RAOs were established in the original 1986 ROD for Source Control and Management of Migration as follows:

### Source Control RAOs:

- Mitigating further release of contaminants to the surrounding environmental media.
- Eliminating or minimizing the threat posed to public health, welfare, and the environment from the source area.

### Management of Migration (MOM) RAOs:

- Mitigating further migration of contaminants beyond their current extent.
- Eliminating or minimizing the threat posed to public health, welfare, and the environment from the current extent of contaminant migration.

As described above, based on the findings to date from the collected data obtained by the on-going remedial investigation and monitoring conducted as part of the GMP, this FFS is being undertaken because EPA has determined that an interim remedial action is appropriate to protect human health in the short term while a final remedial solution is being developed. An interim remedial action is limited in scope and only addresses areas/media that will also be addressed by a comprehensive final site remedy, which will be documented in a future ROD Amendment.

This FFS does not modify or alter the existing RAOs for the Site (as outlined in the 1986 ROD, as amended and restated above). This FFS does identify RAOs specific to the proposed interim action. Specifically, the RAOs developed for this FFS and the proposed interim action are as follows:

- Prevent current and potential future exposure to Site contaminants in groundwater (including 1,4-dioxane and PFAS) via ingestion of groundwater from individual supply wells at levels that pose an unacceptable risk.
- Reduce or minimize continued migration of contaminated groundwater from the Site by reducing the hydraulic stresses on the bedrock aquifer via removal from service of those residential water supply wells that continue to draw groundwater for household use.

As discussed above, the data indicate that human health risk exceeding EPA's acceptable risk ranges for both cancer and non-cancer health effects exists at residential properties located in the following neighborhoods:

- Residences located in the Boston/Charleston/Albany neighborhood that are not connected to the existing municipal water line.
- Residences located along Gilcreast Road that are not connected to the existing municipal water line.
- Residences located in the Ross/Tokanel neighborhood that are not connected to the existing municipal water line.

Further, the Site data suggest that pumping from residential wells in these neighborhoods is contributing, in part, to the continued migration of COCs in groundwater, including into residential wells at these neighborhoods. To address the RAOs, EPA has identified these neighborhoods as "target neighborhoods" of concern to be addressed by the proposed interim remedial action.

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**SECTION 3**

**IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES**

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### **3. IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES**

The objective of this section is to identify and screen remedial technologies that will, if implemented as a component of an interim remedial measure, meet the RAOs for this FFS and proposed interim action, as identified above.

General response actions and technologies were not evaluated for effectiveness at remediation of sitewide contamination including contamination that may remain in the Tinkham Garage source area or in Site-wide groundwater. In Section 4, the remedial technologies that are retained from this Section 3 technology screening are combined into remedial alternatives that encompass a range of appropriate cleanup options designed to meet the RAOs, protect human health, and comply with ARARs.

The technology identification and screening process presented in this section includes the following steps:

- Identification of general response actions and remedial technologies.
- Evaluation of the likelihood that the remedial technologies could meet the stated RAOs.
- Screening and evaluation of remedial technologies and process options to assess the benefits and disadvantages of each technology and option, and to select representative processes for each technology type that will be retained for further consideration.
- Develop remedial alternatives from retained technologies and process options.

#### **3.1 GENERAL RESPONSE ACTIONS**

General response actions were evaluated for their applicability to site-specific conditions, the environmental media of concern, the nature of the contaminants, their ability to mitigate potential risks and attain the RAOs. The general response actions and/or technologies determined to be inappropriate for the site-specific conditions were eliminated from further consideration. The general response actions identified as applicable for this FFS and proposed interim redial action include the following:

- No Action
- Alternate Water Supply
- Limited Action

- Hydraulic Containment
- Physical Containment
- In Situ Treatment

## **3.2 SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS**

As described above, a total of six general response actions were identified as possible candidates for use at this Site, including No Action, which serves as a baseline for comparison. The general response actions, remedial technologies, and associated process options evaluated are presented in **Table 1**. The technologies and process options are evaluated, and representative process options are selected, based on effectiveness, implementability, and cost. The technologies and process options selected are retained for further evaluation and selection of remedial alternatives. Each general response action and the evaluation of its associated technologies and process options are discussed below.

### **3.2.1 No Action**

The No Action alternative does not implement any remedial technology and does not include monitoring or restricting access to contaminated media. The No Action alternative is used as a baseline for comparison to the other alternatives and will be carried forward for that reason only. The No Action alternative does not mitigate the ongoing and/or potential future risks to residents in the target neighborhoods because it would not prevent or reduce exposure to the groundwater contaminants. Because it does not require specific actions to be taken, it is easily implemented and has the lowest cost relative to the other response actions.

### **3.2.2 Alternate Water Supply**

This general response action would focus on mitigating the risk to residents of the target neighborhoods by providing an alternate drinking water source, either by treating the groundwater pumped from the bedrock aquifer by the individual residential wells before use or by replacing that pumped groundwater with water supplied by an alternate source. Consistent with EPA guidance, the general response action “alternate water supply,” as evaluated in this FFS, includes

technologies that provide new supplies and technologies that treat existing supplies at impacted residential groundwater wells.<sup>2</sup>

### **3.2.2.1 Replacement Water Supply**

The provision of a replacement drinking water source directly addresses the RAOs by preventing current and future exposure to impacted groundwater pumped from private water supply wells and may minimize contaminant migration should stresses on the aquifer be removed. This technology includes two process options, both of which are well proven, widely available, and can be implemented in a timely manner. The two process options identified for this technology are the provision of bottled water and the extension of and connection of the homes to a municipal water supply line. Providing an alternative water supply may involve furnishing drinkable water on a permanent or temporary basis. Providing bottled water would be considered a temporary replacement water supply until such time as groundwater attained drinking water standards or a permanent replacement water supply is provided whereas providing an extension of and connections to an existing water line would be considered a permanent replacement water supply.

The provision of bottled water would minimize exposure via ingestion but would not minimize contaminant migration because the private wells would still be used to provide water for non-potable uses (bathing, washing clothes, irrigation, etc.). Providing bottled water would have a very low upfront capital cost but the long-term cost would be moderate to high because it would have to be conducted until groundwater is restored to drinking water quality or a permanent alternative water supply is provided. The water line extension and the connection of the water line to each household would have a higher upfront capital cost, however there would be no operation and maintenance (O&M) costs and as a result the overall cost would be moderate. Homeowners would be required to pay for the water supply once the water line connections are established. Both of these process options are retained for further consideration.

### **3.2.2.2 Residential Well Treatment**

The residential well treatment technology includes POET systems as a process option. The POET systems can be installed in individual residences to remove contaminants from groundwater

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<sup>2</sup> *Guidance Document for Providing Alternate Water Supplies*, EPA 540/G-87/006, OSWER Directive 9355.3-03 (Feb. 1988), p. 2-1.

pumped from private wells. Such systems can provide effective treatment of groundwater and protect residents from exposure to PFAS and 1,4-dioxane. However, POET systems would still require pumping of groundwater from the individual wells and would therefore continue to stress the bedrock aquifer and would not limit contaminant migration.

POET systems need to be custom designed for each individual residence based on the type and concentration of groundwater contaminants in the specific private well and on the configuration of the well pump and plumbing system in the residence. POET systems typically consist of multiple vessels that contain a treatment medium, such as granular activated carbon (GAC) that absorbs the contaminants from the water. Other system components include a flow meter, cartridge filter, interconnecting piping, valves, fittings, and pressure gauges. POET systems may also require upgrades to the well pump if necessary to overcome pressure losses in the treatment vessels.

POET systems require regular maintenance including replacement of filter cartridges and change out of the treatment medium. Properly designed and operated POET systems would address the primary RAO by preventing current and future exposure to impacted groundwater pumped from private water supply wells. Improperly designed and/or operated and maintained POET systems may not provide sufficient contaminant removal and, therefore, may not fully mitigate risks associated with groundwater contamination in private residential wells. A POET system would require the continued pumping and use of the groundwater within the bedrock aquifer as a potable source following treatment and would not minimize stresses on the aquifer.

POET systems are routinely used to treat a variety of contaminants in residential settings and therefore are easily implemented. The materials and labor needed to design, install, and operate/maintain such systems are readily available. POET systems tend to be more costly than other options due to the high upfront capital costs associated with custom design and installation of the systems combined with high operations, maintenance, and monitoring costs. Extensive monitoring is required to determine when the filter media reaches capacity and must be replaced. POETs are typically used as a temporary or interim option until a more permanent solution is available or until groundwater attains drinking water standards and the use of the POET is no longer deemed necessary.

The use of POET systems for receptors is retained for further consideration.

### 3.2.3 Limited Action

The Limited Action general response action includes the associated technologies of monitoring and ICs.

#### 3.2.3.1 Monitoring

Monitoring involves collecting drinking water samples from homes within the target neighborhoods and analyzing them for COCs to estimate receptor exposure. This remedial technology is the primary component of the current remedy for Site groundwater, MNA, which relies on natural processes to degrade or reduce contaminant concentrations in groundwater to the point that they no longer represent a risk to the residential receptors. Monitored Natural Attenuation has been the primary remedy for the Site since 2003, when the initial selected remedy using active groundwater extraction and treatment was terminated and the remedy modified to MNA.

While MNA can be effective for VOCs under certain conditions, it is generally not considered effective for 1,4-dioxane and PFAS, which are highly stable compounds that are not easily degraded by naturally occurring microorganisms (biological degradation is typically the major component of MNA). While physical dispersion is also a component of MNA, this is not as prominent in fractured bedrock as it is in porous media where groundwater flow through soil pores tends to spread contaminants laterally and vertically. Much less attenuation occurs during flow through bedrock fractures. Adsorption to organic materials in soils will help to attenuate some contaminants but sorption is typically much reduced in crystalline bedrock of the type found at this Site, which tends to have very low natural organic carbon. The COCs for the Site that are relevant to this FFS and proposed interim response action (1,4-dioxane and PFAS) pose a risk at very low concentrations. Therefore, attenuation to levels that no longer pose a risk to receptors is unlikely in the foreseeable future. Lastly, natural attenuation, to the extent that it occurs at the Site, would be a very slow process and would take many years to reduce groundwater contamination to a point where it would not pose a risk to residents.

Costs associated with monitoring are highly variable and based on the extent of the monitoring network, frequency, and the length of time it must be performed. Costs for monitoring can range from high to low depending on these factors.

Monitored Natural Attenuation would also allow continued pumping and use of the groundwater within the bedrock aquifer as a potable source and would not minimize stresses on the aquifer. The monitoring technology alone, therefore, would not achieve RAOs for this FFS and proposed interim response action. For these reasons, monitoring is not considered to be a viable response action by itself. However, monitoring of groundwater can be used to assess the effectiveness of other technologies as well as to confirm protectiveness. As such, monitoring will be retained for consideration as a supporting technology for remedial alternatives as appropriate.

### **3.2.3.2 Institutional Controls**

Institutional controls include legal restrictions and management on the use of groundwater including the pumping and contacting of contaminated groundwater, thereby mitigating current and potential future risk. Response actions that could be used as ICs to manage groundwater use include deed notices, covenants, and town ordinances. While this option would be effective at preventing exposure to contaminated groundwater, it cannot be implemented on its own because it does not provide for an alternate source of water. For this reason, ICs are not evaluated further as a stand-alone response action. However, ICs can be combined with other general response actions/technologies to develop comprehensive remedial alternatives.

### **3.2.4 Hydraulic Containment**

Hydraulic containment refers to controlling groundwater flow such that impacted groundwater cannot migrate from source areas at the Site to the target residential neighborhoods where it can enter the residential supply wells. Applicable technologies would include groundwater extraction and treatment to intercept the contaminant plume, treat the impacted groundwater with one or more process options to remove the contaminants and discharge of treated effluent to the subsurface or to the publicly owned treatment works. This approach could effectively manage migration of contaminated groundwater, preventing it from reaching the residential supply wells. This technology is well proven, and the materials and labor required to implement it are readily available. Groundwater extraction and treatment is very expensive, with high upfront capital costs and high long-term O&M costs that are often required for many decades.

However, the contaminated groundwater plume currently extends into and through the neighborhoods and has reached residential supply wells. Hydraulic containment may be effective

at mitigating potential future risks from contaminated groundwater, but it would not address the current risk. It would likely take many years<sup>3</sup> for the groundwater downgradient of the hydraulic containment system to attenuate to below risk levels at all of the impacted residential wells. As a result, this response action would not mitigate the risk in a timely manner and therefore does not meet RAOs for this FFS and proposed interim response action. Hydraulic containment is not retained for further evaluation.

### 3.2.5 Physical Containment

Physical containment is similar to hydraulic containment in that the objective is to prevent migration of impacted groundwater from the contaminant source area to the private water supply wells. A physical barrier wall consisting of an injected grout curtain could be used to redirect contaminated groundwater away from the private supply wells in the target neighborhoods. As with hydraulic containment, this approach would manage migration of contaminated groundwater, preventing it from reaching the residential supply wells. Construction of a physical containment barrier between the source areas on the Tinkham Garage Site and the downgradient residential areas would be very difficult and costly. Studies have shown that the contaminant plume extends over 300 ft into the underlying bedrock aquifer. Construction of a barrier within the bedrock to those depths would be extremely expensive.

However, it would likely not be possible to fully contain the contaminated groundwater in the contaminant source area or across the Site and contaminated groundwater has migrated and is already impacting the nearby residential supply wells. Even if migration of all contaminated groundwater away from source area could be completely stopped, it would likely take decades for the groundwater downgradient of the physical containment system to attenuate to below risk levels as described for the hydraulic containment option above. As a result, this response action would not mitigate the risk in a reasonable time period and therefore does not meet RAOs for this FFS and proposed interim response action. Physical containment is not retained for further evaluation.

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<sup>3</sup> The 2003 ESD included an estimate of 15 years for the VOC contamination identified at that time to attenuate to below the MCLs. Concentrations of TCE and PCE still remain above MCLs after 20 years. PFAS and 1,4-dioxane do not naturally attenuate as quickly as VOCs so the expected timeframe for these compounds to attenuate to safe levels is substantially greater than 20 years.

### 3.2.6 In Situ Treatment

This response action involves the application of treatment technologies to groundwater in the subsurface. There are several in situ groundwater treatment technologies that are readily available including in situ chemical oxidation, in situ chemical reduction, in situ biological treatment, and in situ thermal treatment. Each of these technologies has several process options that could be employed, as listed in **Table 1**. While these technologies are all readily available and have been shown to be very effective at treating VOCs, their application to 1,4-dioxane and PFAS is much less proven. Chemical oxidation has been shown to break down longer chain precursor PFAS, but the more stable end members such as PFOA and PFOS can be resistant to chemical oxidation. Chemical oxidation can be used to destroy 1,4-dioxane but very high oxidation energies are needed to break the molecule and those can be challenging to create and maintain in the subsurface. Biological degradation of 1,4-dioxane has been shown to be viable in certain circumstances but it is not widely employed and biological degradation of PFAS has not been confirmed. Neither 1,4-dioxane or PFAS are considered volatile compounds so thermal treatment would need to rely largely on thermal destruction. Thermal destruction of 1,4-dioxane and PFAS requires very high temperatures (generally >600 degrees Celsius), especially for the longer chain PFAS. None of these technologies have been widely applied to the target contaminants and therefore their effectiveness is unproven. Due to the large size of the mapped contamination plume and the depth (over 300 ft into fractured bedrock), the cost of any in situ option would be extremely expensive.

Regardless of the specific technology chosen, in situ treatment could not be employed within the residential areas because of safety and access challenges. The in situ chemical applications all require the injection of treatment chemicals into the subsurface which would then enter the water supply wells and endanger the residents. Similarly, thermal treatment of the subsurface to temperatures needed to destroy the 1,4-dioxane and PFAS would warm the soil and groundwater to the point that the pumped groundwater would be unusable for the residents. As a result, any in situ technology would need to be implemented well upgradient of the neighborhood and would be subject to the same limitations as the hydraulic and physical containment options. For those reasons, in situ treatment is not retained for further evaluation.

### 3.3 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based on the general response action and technology screening presented above, five technology types and their associated process options were deemed appropriate for further evaluation:

- No Action
- Replacement Water Supply (Bottled Water, Municipal Water Line Extension)
- Residential Well Treatment (Point of Entry Treatment)
- Monitoring
- Institutional Controls

The No Action alternative was included only to provide a baseline for comparison of the other options. While one representative process option for each technology type is typically retained for further evaluation, due to the nature of the RAOs and the limited scope of the proposed interim remedial action, the three process options provided under Alternate Water Supply general response action (including both options under the New Water Supply technology type) were all retained for detailed analysis, and form the basis of the three remedial alternatives evaluated in addition to No Action. Monitoring and Institutional Controls were retained as components to the Alternate Water Supply alternatives as these actions are currently being implemented at the Site and required by previous decision documents. **Table 2** summarizes the general response actions, technologies, and process options that were combined to create the four remedial alternatives described in **Section 4** and evaluated in **Section 5**.

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**SECTION 4**

**DESCRIPTION OF REMEDIAL ALTERNATIVES**

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## 4. DESCRIPTION OF REMEDIAL ALTERNATIVES

This FFS evaluates three remedial alternatives for providing an alternate source of water for the homes within the target neighborhoods to mitigate current and potential future risks associated with ingestion of contaminated groundwater: 1) bottled water, 2) POET systems, and 3) connection to a municipal water line extension. A fourth remedial alternative, No Action, serves as the comparison baseline. No other alternatives were developed or screened. This section provides a general description of the important elements of each alternative. The detailed evaluation and comparative analysis of the alternatives is provided in **Section 5**.

### 4.1 ALTERNATIVE 1 – NO ACTION

In accordance with Section 300.430(e)(6) of the NCP, Alternative 1, the No Action Alternative, is required to be evaluated and is used as a baseline for comparison to the other alternatives. “No Action”, as used in this FFS, means no additional actions to maintain or improve current conditions at the Site, limit migration of groundwater contaminants, or to limit ingestion of Site contaminants in groundwater. Under this alternative, no additional action would be taken to address risk to human receptors in the target neighborhoods and RAOs would not be achieved. Any reduction in toxicity or concentration of contaminants would occur solely because of on-going natural processes. Long-term monitoring of groundwater Five-Year Reviews of the Site are currently being performed for the existing remedy and would continue to be required because COCs would remain on-site at concentrations exceeding levels that would allow for unrestricted use and exposure. There is no cost estimated as part of this alternative.

### 4.2 ALTERNATIVE 2 - BOTTLED WATER

This alternative involves providing an alternate drinking water supply to impacted residents in the target neighborhoods through the provision of bottled water. Bottled water would be offered to households that are currently not connected to a municipal water supply. This includes all households who continue to rely on the bedrock aquifer for their potable water source within the Boston/Charleston/Albany neighborhood, Gilcreast Road, and the Ross/Tokanel neighborhoods. Because the provision of bottled water would require continued pumping of groundwater from the individual wells for other household uses, this alternative would continue to stress the bedrock aquifer and would not minimize contaminant migration.

For cost purposes an estimated 89 households reside within those target neighborhoods. Bottled water would be supplied for drinking, cooking, and other potential ingestions uses (e.g., brushing teeth) but would not be provided for other uses (showering, bathing, washing dishes, etc.). Bottled water would be supplied on a routine basis depending on the number of persons at each residence and the estimated rate of consumption until such time as groundwater attains drinking water quality. Currently, bottled water has been offered to residents in the Ross/Tokanel, Gilcreast and Boston/Charleston neighborhoods by CSG or the Agencies as a temporary action following detection of Site contaminants in compliance with the NHDES Contaminated Site Management Rules and as agreed to by CSG following federal issuance of MCLs for PFAS in 2024. This alternative and the estimated costs allow for the offering of bottled water to all households within the target neighborhoods utilizing groundwater as drinking water such time as a permanent alternative water source in the form of a connection to a nearby water line occurs or until groundwater is restored to drinking water quality.

For the purposes of developing a cost estimate for this FFS, it was assumed that each household would be provided with monthly shipments of 10 cases of six 1-gallon jugs (60 gallons) and 5 cases of 0.5-liter bottles. That volume of supplied water is based on discussions with local water companies and represents demand for an average household. The assumed bottled water supply volume/frequency used to develop the costs estimate under this Alternative is also consistent with what is currently being provided to homes by CSG.

Monitoring of Site groundwater would continue under the current 1986 ROD (as amended), the on-going remedial investigations, as well as a component of the GMP. Samples collected from the residential wells would be analyzed for VOCs, PFAS, and 1,4-dioxane. The results of all sampling events would be reported to the residents and regulatory agencies. No additional costs for monitoring are included in this Alternative because the monitoring is already part of ongoing work.

CERCLA Five-Year Reviews, which are currently being performed every 5 years for the existing remedy, will continue and will also assess the protectiveness of the selected interim remedy. Data collected as part of on-going monitoring efforts would be used to support the Five-Year Review. No additional costs are included for Five-Year Reviews because they are already being performed.

For costs estimate purposes, Alternative 2 includes providing bottled water to all 89 households within the targeted neighborhoods, who are not currently connected to the existing water line, for a period of 30 years. There are no upfront capital costs for this alternative, only the monthly cost of providing bottled water. The total estimated cost for Alternative 2 is approximately \$2,800,000.

### **4.3 ALTERNATIVE 3 – POINT-OF-ENTRY TREATMENT SYSTEMS**

Alternative 3 requires treating the groundwater as it enters household water supply wells to reduce concentrations and mitigate the risk from ingestion of contaminated groundwater. POET systems can provide effective treatment of ground water to protect residents from 1,4-dioxane and PFAS and would be offered to households that are not currently connected to a municipal water supply line and who continue to rely on groundwater as their drinking water source within the target neighborhoods. The POET system would be installed in-line at each home to treat groundwater from the water supply well which would then be available for all household uses including showering, bathing, dish washing, etc. The installation of the POET system is used as a temporary measure to mitigate human health risks resulting from ingestion of contaminated groundwater until groundwater attains drinking water quality and treatment is no longer needed or a permanent alternate water supply is provided. Because POET systems require continued pumping of groundwater from individual wells, this alternative would continue to stress the bedrock aquifer and would not minimize contaminant migration.

For cost purposes an estimated 89 households would receive a POET as well as long term monitoring, operation, and maintenance. Each home would require its own specific engineered POET system based on the contaminant concentrations detected in the influent water, including treatment of other constituents in the influent water (metals, etc.), and based on household demands and the configuration of the plumbing system. Treatment for 1,4-dioxane and PFAS would require the typical POET system to include at a minimum: a particle filter to remove particulates, and at least two GAC vessels for a lead/lag system to remove 1,4-dioxane and PFAS. While activated carbon generally provides effective removal of PFAS at the range of concentrations detected in private wells at the Site, its effectiveness for removal of 1,4-dioxane is more limited. However, because the 1,4-dioxane concentrations in the private wells to be treated are relatively low, the use of GAC for this application is deemed to be acceptable. To ensure the complete removal of 1,4-dioxane and PFAS, the design (size and number of GAC vessels) and operating/monitoring

parameters (frequency of monitoring and carbon changeout) for POET systems will need to account for the reduced effectiveness of GAC for treatment of 1,4-dioxane. Alternative treatment media/processes do exist for treatment of 1,4-dioxane and may be deemed effective for PFAS. However, those processes are relatively complex and are not well proven for use in POET systems. Therefore, for the purpose of this FFS, GAC is included for the combined treatment of 1,4-dioxane and PFAS.

The POET systems would allow for performance monitoring via sampling ports upstream, between, and downstream of the carbon vessels to track contaminant breakthrough, pressure gauges to monitor plugging of the GAC, an in-line flow meter to document water use, and all necessary appurtenances for interconnection into the plumbing systems of the residences. These systems would require scheduled maintenance (changeout of the filter cartridges and GAC) and monitoring to ensure they are operating properly and reducing concentrations below drinking water standards. **Figure 13** provides a schematic diagram of a typical POET system.

Because contamination is expected to remain in groundwater for an extended period, long-term O&M would be required for each installed POET system. The O&M and long-term monitoring required for each individual system may differ based on the specific engineered system. The O&M program would include collection of water samples from the influent, between the GAC chambers, as well as the treated water (after the lag chamber) to document the contaminant loading, monitor for breakthrough, and verify that the contaminants are fully treated. The GAC will be replaced periodically based on the results of the system performance monitoring. For the purposes of this FFS, it was assumed that the treatment media (GAC) would be replaced annually on average. This frequency was based on media changeouts performed at POET systems treating similar levels of 1,4-dioxane and PFAS at other sites in New Hampshire.

Monitoring of groundwater quality in the residential wells within the target neighborhoods under the GMP would be continued in order to document contaminant concentrations in the water supply wells. This would allow for continued assessment and the need for future modification of POET systems if required. Samples collected from the private residential water supply wells would be analyzed for VOCs, PFAS, and 1,4-dioxane. In addition, samples would also be collected from the

sampling ports between the two carbon vessels and from the effluent of the POET system. The results of all sampling events would be reported to the residents and regulatory agencies.

Monitoring of Site groundwater quality would continue under the 1986 ROD (as amended), as part of on-going remedial investigations, and as a component of the GMP. No additional costs for monitoring of groundwater beyond that require for O&M of the POET system is included in this alternative because monitoring is already part of on-going work.

CERCLA Five-Year Reviews, which are currently being performed every 5 years for the existing remedy, will continue and will also assess the protectiveness of the selected interim remedy. Data collected as part of on-going long-term monitoring efforts would be used to support the Five-Year Review. No additional costs are included for Five-Year Reviews because they are already being performed.

For cost estimate purposes, Alternative 3 includes the design and installation of POET systems in 89 homes within target neighborhoods, O&M of the POET systems for 30 years, including monitoring to ensure effectiveness of each system. The upfront capital cost for this alternative is estimated at approximately \$892,492. The annual O&M cost for the POET systems (including changeout of the treatment media), periodic repairs of the treatment systems, and annual costs associated with monitoring is approximately \$436,850. The total estimated cost for Alternative 3 is approximately \$8,000,000.

#### **4.4 ALTERNATIVE 4 – MUNICIPAL WATER LINE EXTENSION**

Alternative 4 consists of extending an existing municipal water line that currently runs within the Site, along Gilcreast Road and within portions of the Boston/Charleston/Albany neighborhood into the target neighborhoods to provide a permanent alternate water source for residents that are currently relying on groundwater as their drinking water source. Use of a water line would reduce or remove the continuous pumping from residential wells and reduce or minimize continued migration of contaminated groundwater from the Site by reducing the hydraulic stresses on the bedrock aquifer. For cost purposes, an estimated 89 homes within the target neighborhoods would be connected to municipal water under this alternative. Following connection to the municipal water line, private water supply wells would be disconnected and removed from service to prevent

future exposure to the contaminated groundwater or modified and used for future long term monitoring activities at the Site with the approval of the homeowner.

The connection of receptors to water lines in 1983 (Londonderry Green condominiums and Mercury/McAllister neighborhood) and again in 2016 (Boston/Charleston neighborhood) appears to have reduced hydraulic stresses within the bedrock in those areas and VOC concentrations subsequently decreased within those former supply wells based on results of subsequent sampling. The connection of receptors in the target neighborhoods to the waterline would be expected to facilitate achieving the RAO related to minimizing stresses on the aquifer, which over time may reduce the overall plume extent by minimizing contaminant migration at the Site.

Under Alternative 4, it would be expected that the existing water line on Gilcrest Road would be extended into the Ross/Tokanel neighborhood and into the Boston/Albany/Charleston neighborhood, and that all households within these target neighborhoods would be connected to the municipal water line. The total estimated length of the water line extension is 8,300 linear feet. Design and installation of the water line extension would need to be coordinated with the local water purveyor (Pennichuck East). The proposed layout of the water line extension is shown on **Figure 14**. Water line installation would consist of road opening and trenching to a depth below the frost line (approximately 4-5 ft); installation, connection, and testing of the new water pipe; backfill; and road restoration. Blasting of bedrock or other means for removal of bedrock may be required in portions of the Ross/Tokanel neighborhood to attain the proper installation depth for the water line. It has been estimated that 30% of the construction along Ross Drive and the end of Tokanel Drive (~2,500 linear feet) would be impeded by bedrock and require blasting or other means for removal of bedrock (see **Figure 14** for the locations requiring bedrock removal). Design and construction of the water line would require an upfront capital investment and specialized engineering, but once installed would be largely maintenance-free.

Once the water line is extended into the neighborhoods, each residence would require a unique plan for connection to the waterline. That plan would include interior as well as exterior plumbing considerations, and landscape impacts and restoration. Upon completion of the water line extension, connection to all residences, and removal of the residential wells from service or modification to a groundwater monitoring well, there would be immediate and long-term risk

mitigation to human health. There would be minimal long-term O&M costs related to the water line, and the on-going long-term monitoring, remedial investigations and the monitoring program under the GMP would address residential well conversion to a groundwater monitoring well as required or warranted to meet the objectives of those programs. Consistent with EPA policy, following the connections and property restoration, the on-going costs (payments) for the water provided to each household would be the responsibility of each resident.

Long-term monitoring of Site groundwater to confirm protectiveness of the interim remedy would not be required as this is a permanent alternative water supply. Long-term monitoring of groundwater would continue, however, as a component of the initial remedy, as amended. Institutional controls in the form of a town ordinance or deed notices or restrictions would be implemented as part of the final remedial action for the Site following the completion of the remedial investigations and selection of a final remedial action to manage the use of groundwater within the GMZ.

CERCLA Five-Year Reviews, which are currently being performed every 5 years for the existing remedy, will continue and will also assess the protectiveness of the selected interim remedy. Data collected as part of on-going long-term monitoring efforts would be used to support the Five-Year Review. No additional costs are included for Five-Year Reviews because they are already being performed.

For cost estimate purposes, it was assumed that shallow bedrock would be present along approximately 30% of the proposed alignment (or about 2,500 linear feet) and would require removal (blasting, etc.) to install the water line in those areas. The total estimated cost of Alternative 4, which includes upfront capital costs for design, construction, and connection of the homes to the water line extension, is estimated at approximately \$6,832,000.

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**SECTION 5**

**COMPARATIVE ANALYSIS OF ALTERNATIVES**

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## 5. COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a detailed evaluation and comparative analysis of the remedial alternatives relative to specific evaluation criteria provided in the NCP and provides a comparison to identify the advantages and disadvantages of each alternative relative to one another.

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences, including: (1) a requirement that EPA's remedial action, when complete, must comply with all federal and more stringent state environmental standards, requirements, criteria or limitations, unless a waiver is invoked; (2) a requirement that EPA select a remedial action that is cost-effective and that uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (3) a preference for remedies in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances is a principle element over remedies not involving such treatment.

Building upon these specific statutory mandates, the NCP articulates nine evaluation criteria to be used in assessing the individual remedial alternatives. These criteria are divided into three groups: Threshold Criteria, which each alternative must meet to be carried forward in the analysis; Balancing Criteria, which measure the performance of each alternative; and Modifying Criteria, which are assessed after this FFS and Proposed Plan are presented for public review and comment.

In the subsections that follow, each criterion is explained and then the four remedial alternatives described in **Section 4** are evaluated with respect to how they satisfy the goals of that criterion. The evaluation was conducted in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies* under CERCLA (EPA, 1988b) and summarizes the relevant information necessary to compare each alternative with respect to their benefits and drawbacks. An overview of the comparative analysis is presented in **Table 3**.

### 5.1 THRESHOLD CRITERIA

Assessment against the two threshold criteria relate directly to statutory findings that must ultimately be made in a future decision document. Therefore, these are categorized as threshold

criteria (i.e., each remedial alternative must satisfy them in order to be selected). The two threshold criteria are as follows:

- Overall Protection of Human Health and the Environment: The assessment against this criterion describes how the remedial alternative, as a whole, achieves and maintains protection of human health and the environment.
- Compliance with ARARs: The assessment against this criterion evaluates how each of the remedial alternatives complies with ARARs, or if an ARAR waiver is required and how the waiver is justified.

### **5.1.1 Overall Protection of Human Health and the Environment**

The No-Action Alternative (Alternative 1) would not be protective of human health. Exposure to contaminated groundwater through ingestion as drinking water would remain as an exposure pathway, which would not be mitigated, and because Alternative 1 would not remove residential water supply wells from service, it does not achieve the RAO of reducing hydraulic stresses on the bedrock aquifer and does not reduce or minimize continued migration of contaminated groundwater from the Site. Alternatives 2, 3, and 4 would all provide adequate protection of human health, and include both temporary and permanent actions, with Alternative 4 providing the greatest overall protection.

Alternative 2 (Bottled Water) would temporarily provide safe drinking water to mitigate the ingestion risk from drinking and cooking with contaminated groundwater, but it would not address risks associated with incidental ingestion during showering or bathing.

Alternative 3 (POET Systems) would treat all groundwater entering the homes and provide clean water for all household uses, mitigating all current and future risk to residents. Performance of monitoring and O&M would be required under Alternative 3 to ensure that the POET systems continue to operate properly. Because Alternative 3 would not remove residential water supply wells from service, it does not achieve the RAO of reducing hydraulic stresses on the bedrock aquifer and does not reduce or minimize continued migration of contaminated groundwater from the Site.

Alternatives 2 and 3 offer temporary actions that would continue until such time as groundwater attains drinking water quality in the future or a permanent alternative water is provided.

Alternative 4 (Water line) would provide the highest level of protection to human health as it would mitigate or remove exposure to groundwater used as drinking water and therefore mitigate all risk associated with household use of groundwater. Extension of and connection to a nearby water line would provide a permanent alternate source of water for all household uses. Alternative 4 would not require any O&M or monitoring to ensure protectiveness and so is the most straightforward for the residents.

### **5.1.2 Compliance with Applicable or Relevant and Appropriate Requirements**

Compliance with ARARs addresses whether or not a remedy will meet all federal, as well as more stringent State environmental standards, requirements, criteria or limitations, unless a waiver is invoked under CERCLA §121(d)(4). Each alternative must be assessed to determine whether it can attain ARARs under federal and State environmental or facility siting laws or provide grounds for invoking a pertinent waiver. This action is an interim remedy to mitigate exposure to Site contamination through the provision of an alternative water supply and is not expected to attain chemical-specific ARARs for groundwater throughout the Site.

Alternative 1 takes no action and as a result, there are no ARARs associated with this alternative. Alternatives 2, 3, and 4 would comply with the substantive requirements of any chemical-specific, location-specific, and action-specific ARARs that are either applicable or relevant and appropriate to each alternative. A complete listing of ARARs and to be considered criteria for the selected interim remedial action is provided in Appendix B of this FFS.

## **5.2 BALANCING CRITERIA**

The five balancing criteria are grouped together because they represent the criteria upon which the comparative analysis is based. The five balancing criteria are as follows:

- **Long-Term Effectiveness and Permanence**: The assessment against this criterion evaluates the long-term effectiveness and permanence of remedial alternatives, along with the degree of certainty that the alternative will prove successful, factoring in the magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate. Also, the adequacy and reliability of controls. This factor addresses in particular the uncertainties associated with providing long-term protection and the assessment of the potential need to replace technical components of the alternative and risks posed should the remedial action need replacement.

- Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment: The assessment against this criterion evaluates the degree to which alternatives employ treatment that reduces TMV, including how treatment is used to address the principal threats posed by a site.
- Short-Term Effectiveness: The assessment against this criterion evaluates the effectiveness of remedial alternatives in addressing short-term risks that might be posed to the community during implementation of an alternative; potential impacts on workers during remedial action and the effectiveness and reliability of protective measures; potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and time until protection is achieved.
- Implementability: The assessment against this criterion evaluates the technical and administrative feasibility of remedial alternatives and the availability of required resources, factoring in technical feasibility, including: technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy; administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions); the availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists and provisions to ensure any necessary additional resources; and the availability of prospective technologies.
- Cost: The assessment against this criterion evaluates the capital, O&M, and net present value (NPV) costs of each remedial alternative. A discount rate of 4.5% was used to estimate the present values for this FFS, based on the current (as of May 2025) published U.S. Discount Rate by the Federal Reserve Committee. Although *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000) suggests that a discount rate of 7% should generally be used, it does allow for adjustments to that rate if warranted by current economic conditions. The higher-than-average interest and inflation rates currently in effect warranted the use of an adjusted value.

### 5.2.1 Long-term Effectiveness and Permanence

Because there is no treatment of the existing water supply or provision of an alternate supply of drinking water, Alternative 1 (No Action) would have no expected long-term effectiveness in reducing risk to human receptors exposed to contaminated groundwater.

Alternative 2 (Bottled Water) would mitigate most ingestion risk but would not address incidental ingestion associated with showering and bathing. While bottled water may be an effective temporary response to mitigate exposures, its long-term effectiveness and permanence may be limited due to the inconvenience to residents, as well as the time frame which may be required for

residents to rely on bottled water until a permanent water source is provided or until groundwater returns to drinking water quality in the future, and effectiveness is expected to diminish over time.

Alternative 3 (POETs) would mitigate risk by treating the (groundwater) well water in the home prior to use. This alternative would significantly reduce the risk of ingestion of contaminated groundwater and have the added advantage of eliminating dermal contact as well. It would have some impact on the residential users as it would involve the addition of treatment equipment into their residence and integration of that equipment into their existing plumbing. Residents would be involved with coordination of maintenance work on the POET systems and would be inconvenienced by occasional problems with the systems, which are likely to occur over the long-term. However, there would likely be less inconvenience of use and long-term compliance would likely be higher than for Alternative 2 (Bottled Water). Monitoring is included with Alternative 3 (POETs) to ensure that the systems are working properly and effectively mitigating risk and to assess the need to replace spent media. It is possible that failed POET systems or improper maintenance could result in failure to adequately mitigate risk. While use of POETs may be an effective temporary response to mitigate ingestion exposures, the long-term effectiveness and permanence of POETs may be limited because there is a risk that some POETs would not be maintained properly and, as a consequence, would not provide adequate contaminant removal. The potentially long time frame (up to several decades) for these systems to remain in place until groundwater returns to drinking water quality increases the risk of insufficient maintenance and the resulting poor performance of the POET systems. Additionally, Alternative 3 is not effective at reducing migration of contaminated groundwater from the Site, as residences will continue to draw groundwater for household use.

Alternative 4 (Water Line) provides the greatest long-term effectiveness and permanence and will prevent ingestion of and dermal contact with contaminated groundwater by connecting all homes in the target neighborhoods to a municipal water line. Under this alternative, residents would pay for the municipal water based on their household usage. Operation and maintenance of the pipeline and other components of the water supply system would be performed by the local water purveyor using those fees, providing a high level of confidence that the system will remain effective.

### **5.2.2 Reduction of Toxicity, Mobility, and Volume (TMV) Through Treatment**

There would be no reduction of the TMV under Alternative 1 (No Action) and Alternative 2 (Bottled Water) because those alternatives do not include any treatment of the contaminated groundwater and allow for continued use of water supply wells, which may allow for continued migration and may extend the contaminant plume migration. Alternative 4 also does not provide treatment of groundwater. However, the removal of the water supply wells would be expected to minimize migration into and across the neighborhoods. Alternative 3 (POETs) would reduce concentrations in groundwater used as drinking water through treatment. However, continued use of water supply wells may allow for continued migration from the Site into and across the neighborhoods. Alternative 2 (Bottled Water) and Alternative 4 (Water Line) each provide an alternate source of drinking water obtained off-site, while Alternative 3 (POETs) treats the on-site current source of drinking water.

### **5.2.3 Short-Term Effectiveness**

Alternative 1 (No Action) does not have any short-term effectiveness because it does not provide any mitigation of the risk from ingestion of contaminated groundwater. It also does not present any risks during implementation because it does not involve any work.

Alternative 2 (Bottled Water) would be effective in the short-term at reducing human health risk from ingestion of contaminated groundwater. The short-term impacts associated with implementation of this alternative include an increase in truck traffic in the residential neighborhoods resulting from the delivery of the bottled water. Bottled water would be delivered on a set schedule, and it is estimated that weekly deliveries would be needed to service all homes. This frequency is unlikely to represent a measurable increase in risk when compared to routine package delivery trucks (UPS, Amazon, FedEx, etc.) and other services such as fuel oil and propane that service these neighborhoods.

Alternative 3 (POETs) would have limited short-term effectiveness because it will take time to meet with each homeowner, develop a house-specific POET design, procure the necessary materials and an installation contractor, and complete the installation. This process would likely take a year or more to complete for all homes; however, upon installation each household well water would begin receiving treatment. Short-term effectiveness is less of a concern at this Site

because most impacted residents would continue to be provided with bottled water until their POET system is installed and operational. Short-term risks associated with implementation of this alternative would include increased truck traffic from the contractors accessing the neighborhood and working in residences to install and maintain the systems. This impact would not likely be significant. There would be relatively small short-term impacts during routine maintenance of the POET systems.

The design and construction of Alternative 4 (Water line) may take two or more years to complete field investigations, survey and subsequently design and construct the water line extension and make connections to each household. Short-term effectiveness is less of a concern at this Site because most residents are currently already being offered bottled water, which would continue until the connections of all households are completed. Alternative 4 is associated with greater short-term impacts than the other alternatives. Short-term risks associated with this alternative include primarily risks to workers associated with excavation and subsurface construction. There may also be risks of worker exposure to contaminated groundwater and/or soil during installation of the water line in areas where shallow groundwater is present. Precautions must be taken to protect site workers from any noise, dust, and construction hazards. Precautions must also be taken to protect public and private infrastructure through use of a Dig Safe permit and through administrative controls (access agreements, etc.). Construction will have short-term effects on the community because of increased site activity including the operation of more trucks and construction vehicles on local streets and construction-related noise. Additionally, minor short-term effects will occur on individual properties including the operation of construction equipment when connecting the homes to the water line.

#### **5.2.4 Implementability**

Alternative 1 (No Action) does not require any implementation.

Alternative 2 (Bottled Water) involves only delivery of bottled water to the residents within the targeted neighborhoods. Provision of bottled water is currently being implemented at the Site without difficulty; and the source of the bottled water is in compliance with drinking water regulations. Therefore, there are no concerns with the implementation of this alternative.

Alternative 3 (POETs) involves the design and installation of POET systems in homes and associated O&M. It also requires monitoring to ensure adequate treatment. Routine maintenance would include replacement of treatment media; non-routine maintenance would include repair or replacement of malfunctioning systems. The materials and supplies needed to construct and install POET systems are readily available, as are the technical staff needed to design and install them. There are no concerns with the implementation of this alternative.

Alternative 4 (Water Line) involves the design and construction of a municipal water line extension into and throughout the targeted neighborhoods to provide alternate drinking water (municipal source) to all households. Design and construction of the water line extension would require coordination with the local water purveyor (Pennichuck East). Water line design and installation is a straightforward civil engineering project. The engineering expertise to complete the design is available locally. Similarly, the pipe, connections, and equipment needed for construction are widely available. There are numerous local construction companies that are capable and experienced in water line construction. Shallow bedrock is likely present in several locations along the proposed alignment of the water line extension (see **Figure 14**). While this will complicate the design and installation of the water line, possibly requiring blasting or ripping of the bedrock, this type of work is routinely performed locally and the services, equipment, and materials needed to remove the bedrock are available locally.

### **5.2.5 Cost**

This criterion evaluates the estimated costs of each alternative including capital costs, O&M costs, and total project present-worth costs. Capital costs include those for construction, equipment, materials and services, waste disposal, engineering, startup/shakedown costs, and contingencies associated with initial construction of the remedy. Annual O&M costs include operating supplies and labor costs, maintenance materials and labor, auxiliary materials and energy, disposal of treatment residuals, purchased services, administrative costs, contingency funds, rehabilitation costs, and performance monitoring.

For purposes of estimating costs in this FFS, a period of 30 years has been assumed per EPA guidance (EPA, 1988). The cost for long-term groundwater monitoring as well as CERCLA Five-Year Reviews has not been included because they are already being performed as part of the

current remedy. **Table 4** provides a summary of the estimated cost for each alternative. Detailed cost estimates for each alternative are provided in **Appendix C**. The cost estimates were calculated using an inflation rate of 2.8% and a discount rate of 4.5% based on current financial market conditions. Market volatility would affect the estimated cost for the alternatives.

Alternative 1 (No Action), by definition, does not involve the performance of any work. As a result, the cost to implement Alternative 1 is \$0, which serves as a baseline for comparison of the other alternatives.

Alternative 2 (Bottled Water) includes providing bottled water to all 89 households within the targeted neighborhoods for a period of 30 years. There are no upfront capital costs for this alternative, only the monthly cost of providing the bottled water. The total 30-year NPV for Alternative 2 is approximately \$2,800,000.

Alternative 3 (POETs) includes the design and installation of POET systems in 89 homes within the target neighborhoods, O&M of the POET systems for 30 years, including monitoring to ensure effectiveness of each system. The upfront capital cost for this alternative is estimated at approximately \$892,492. The annual O&M cost for the POET systems (including annual changeout of the treatment media), periodic repairs of the POET systems, and annual costs associated with monitoring is approximately \$436,850. The 30-year total NPV for Alternative 3 is approximately \$8,000,000.

Alternative 4 (Water Line) includes the design and construction of a water line extension from Gilcreast Road along Boston Avenue and through the Ross/Tokanel neighborhood as well as connections within the Boston/Charleston/Albany neighborhood (see **Figure 14**). For the purpose of this analysis, it was assumed that shallow bedrock would be present along approximately 30% of the proposed alignment (~2,500 linear feet) and would require removal (blasting, etc.) to install the water line in those areas. The capital costs include legal and administrative fees associated with establishing institutional controls. The upfront capital cost for design, construction and connection of the homes to the water line extension is estimated at approximately \$6,832,000. Alternative 4 (Water Line) is the only permanent alternative water supply for the estimated costs, while Alternative 2 (Bottled Water) and Alternative 3 (POETs) are considered temporary in that the need

for bottled water or treatment would continue until groundwater attained drinking water quality in the future or a permanent alternative water source is provided.

Based on present-worth cost estimates, the least expensive alternative is Alternative 1 (No Action) with a cost of \$0. Alternative 2 (Bottled Water) has the next lowest cost, with a present worth cost of approximately \$2,800,000. Alternative 4 (Water Line) has the third lowest cost, with a present worth cost of approximately \$6,800,000. Alternative 3 (POETs) is the most expensive alternative, requiring more extensive long-term operation and maintenance, and with a present worth cost of approximately \$8,000,000.

### 5.3 MODIFYING CRITERIA

The modifying criteria include state or support agency acceptance, and community acceptance:

- State Acceptance: This assessment reflects the state's preferences among, or concerns about, remedial alternatives.
- Community Acceptance: This assessment reflects the community's preferences among, or concerns about, remedial alternatives.

These modifying criteria are typically evaluated following receipt of public comments on the Proposed Plan, in which EPA will present its preferred alternative, and are addressed in the Responsiveness Summary included in the decision document selecting the interim remedial action. Therefore, these criteria have not been addressed in this FFS.

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**SECTION 6**

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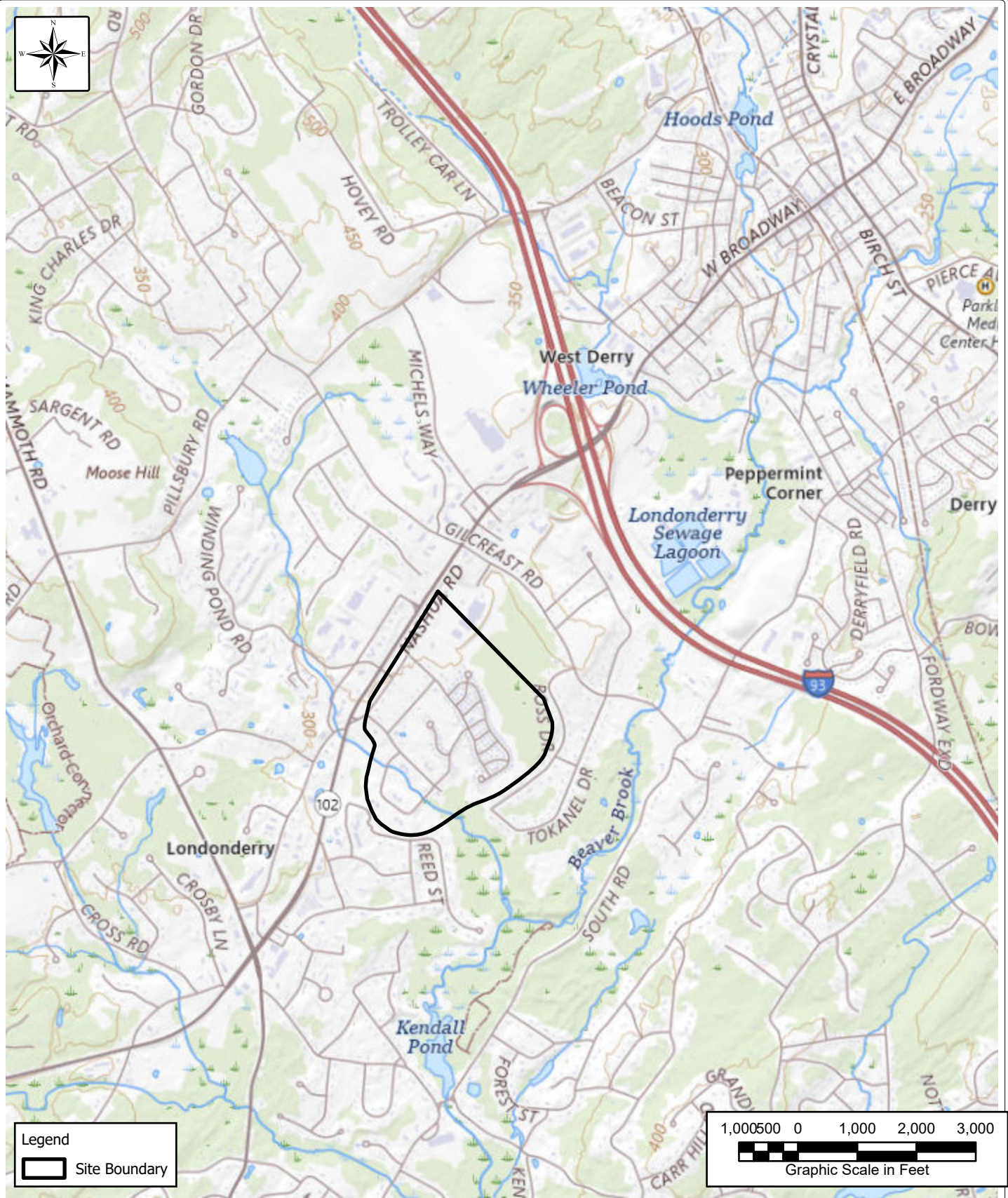
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## FIGURES

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REPORT DATE:  
August 2024

PROJECT MANAGER:  
J. Soukup

TITLE:  
**PROJECT LOCUS**  
**TINKHAM GARAGE SITE**  
**LONDONDERRY, NH**



SAVED DATE:  
August 2024

REVIEWER:  
W. Tift

PROJECT:  
Tinkham Garage

CLIENT NAME:  
NHDES



SPATIAL REFERENCE:  
NAD 1983 StatePlane New Hampshire FIPS 2800 Feet

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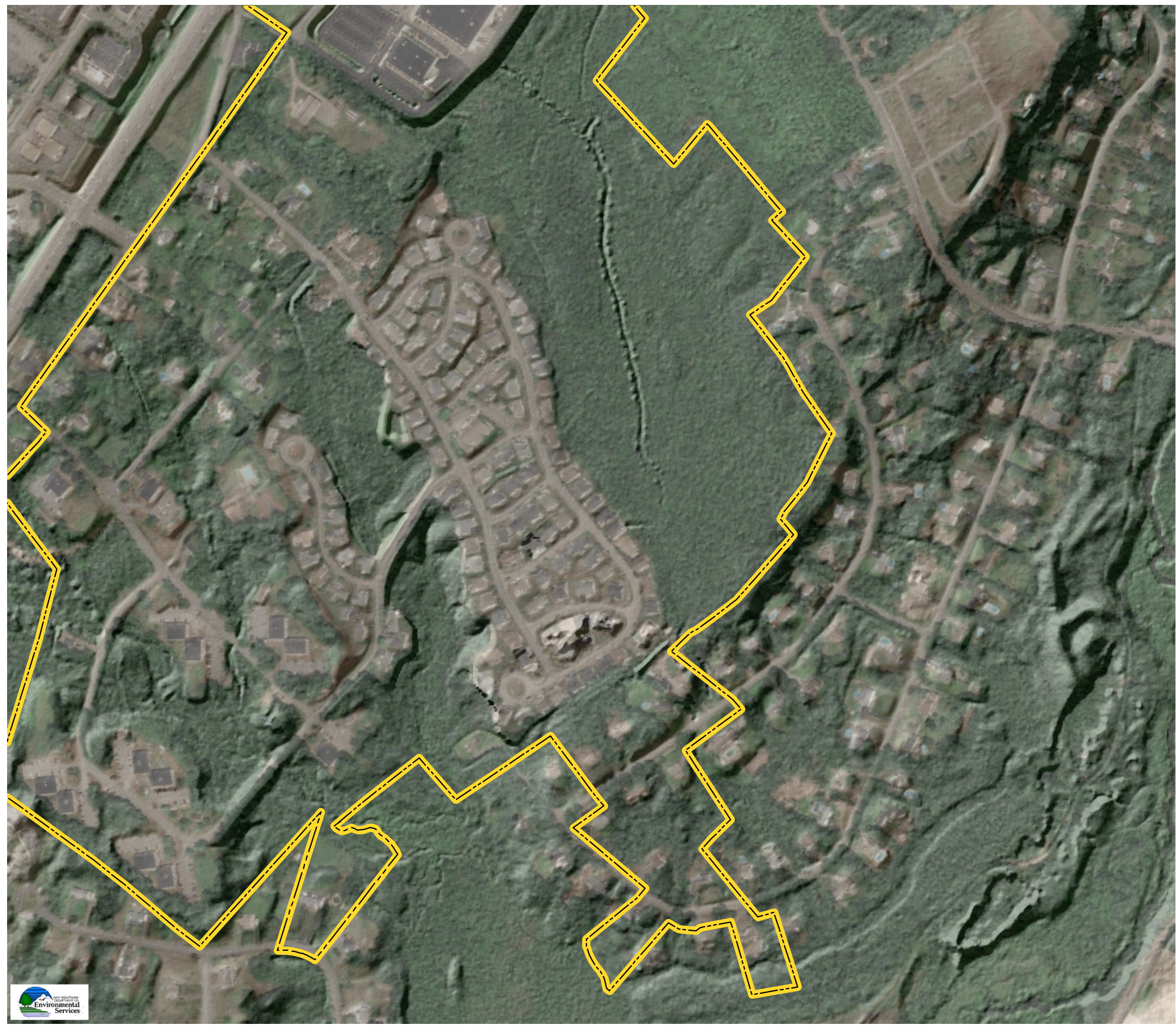
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FIGURE NO:  
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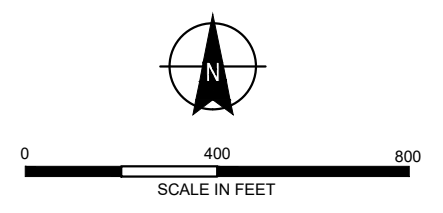
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 GROUNDWATER MANAGEMENT ZONE BOUNDARY

Hillshade Image

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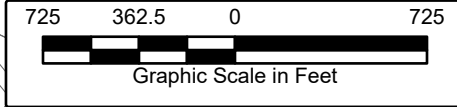
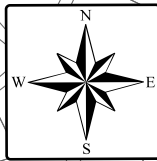
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TINKHAM GARAGE SITE  
LONDONDERRY, NEW HAMPSHIRE  
FOCUSED FEASIBILITY STUDY

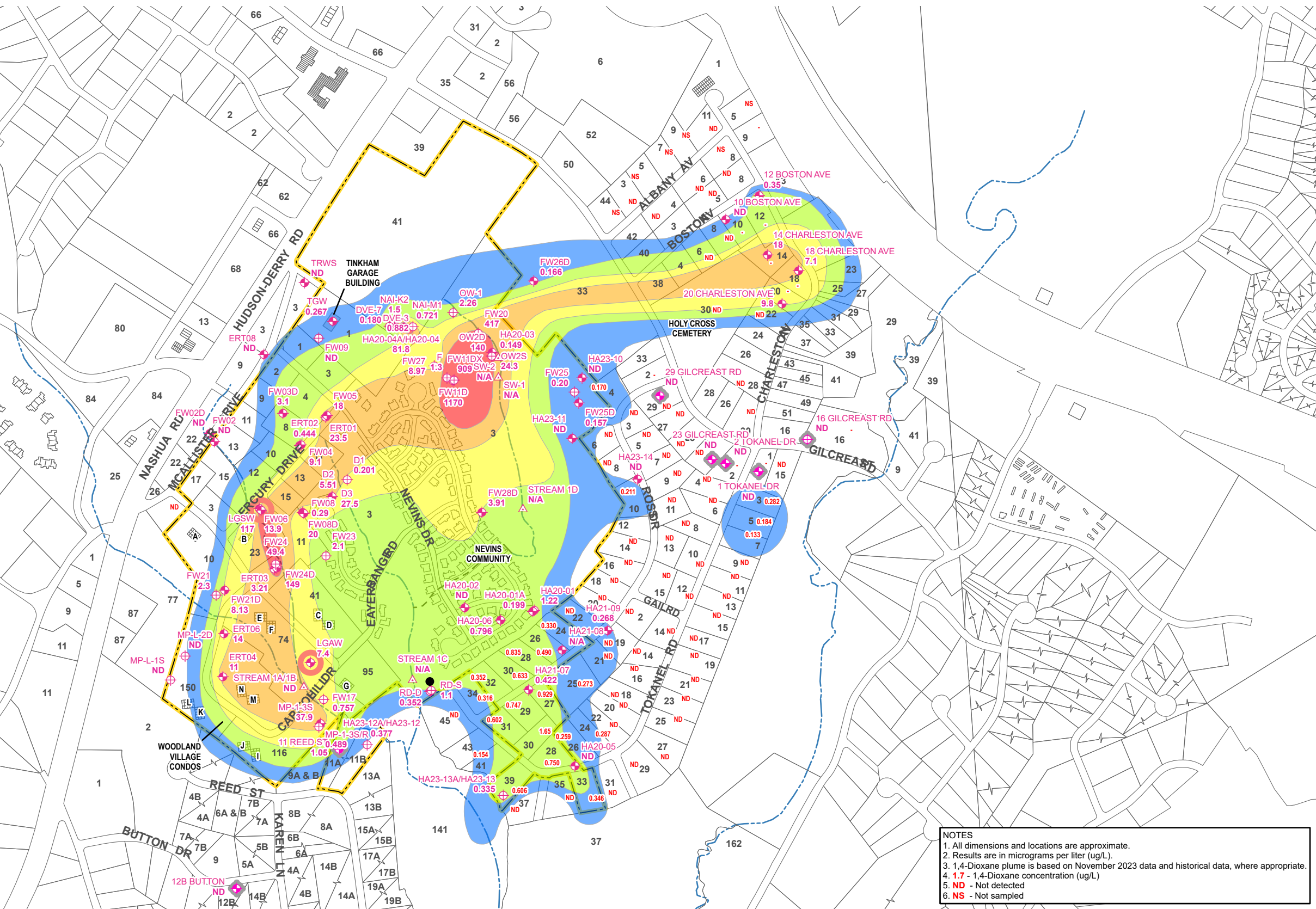
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CHECKED	DATE	SCALE	REVISION	FIGURE NO.
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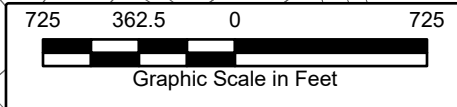
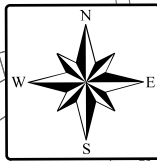
- LEGEND**
- BEDROCK MONITORING WELL
  - OVERBURDEN MONITORING WELL
  - SURFACE WATER
  - FORMER BEDROCK SUPPLY WELL
  - FORMER OVERBURDEN SUPPLY WELL
  - PUMP
  - FORMER WATER SUPPLY WELL
  - STREAM
  - CULVERT
  - GROUNDWATER MANAGEMENT ZONE
  - 1,4-DIOXANE CONCENTRATION >ND - 0.32 UG/L
  - 1,4-DIOXANE CONCENTRATION > 0.32 - 3.0 UG/L
  - 1,4-DIOXANE CONCENTRATION > 3.0 - 10 UG/L
  - 1,4-DIOXANE CONCENTRATION > 10 - 50 UG/L
  - 1,4-DIOXANE CONCENTRATION > 50 UG/L

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- NOTES**
1. All dimensions and locations are approximate.
  2. Results are in micrograms per liter (ug/L).
  3. 1,4-Dioxane plume is based on November 2023 data and historical data, where appropriate.
  4. 1.7 - 1,4-Dioxane concentration (ug/L)
  5. ND - Not detected
  6. NS - Not sampled

REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup	DRAWING TITLE: <b>MAXIMUM 1,4-DIOXANE CONCENTRATIONS 2015 THROUGH 2023 TINKHAM GARAGE SITE LONDONDERRY, NH</b>	
SAVED DATE: March 2025	REVIEWER: W. Tiff		
PROJECT: Tinkham Garage	CLIENT NAME: NHDES	SCALE: 1:8,700	FIGURE NO: 4
SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet		WESTON SOLUTIONS	



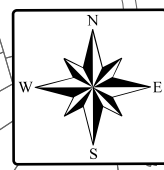
LEGEND	
	FORMER WATER SUPPLY WELL
	PUMP
	BEDROCK MONITORING WELL
	STREAM
	OVERBURDEN MONITORING WELL
	CULVERT
	SURFACE WATER
	FORMER BEDROCK SUPPLY WELL
	GROUNDWATER MANAGEMENT ZONE
	FORMER OVERBURDEN SUPPLY WELL
	PFOA CONCENTRATION >12 NG/L
	PFOA CONCENTRATION >4 - 12 NG/L
	PFOA CONCENTRATION >ND - 4 NG/L
	TG_Community_Road_Extent

**NOTES**

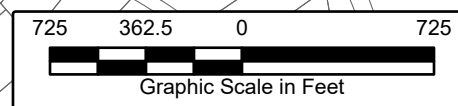
- All dimensions and locations are approximate.
- Results are in nanograms per liter (ng/L).
- Perfluorooctanoic acid (PFOA) plume is based on November 2023 data and historical data, where appropriate.
- Plume extents are based on Maximum Contaminant Levels (MCLs) published on April 10, 2024.
- 1.7 - PFOA Concentration (ng/L)
- ND - Not detected
- NS - Not sampled
- Per- and polyfluoroalkyl substances (PFAS) sampling began in 2018.

REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup	DRAWING TITLE:  <b>MAXIMUM PFOA CONCENTRATION THROUGH NOVEMBER 2023 TINKHAM GARAGE SITE LONDONDERRY, NH</b>	
SAVED DATE: March 2025	REVIEWER: W. Tiffit		
PROJECT: Tinkham Garage	CLIENT NAME: NHDES	SCALE: 1:8,700	FIGURE NO: 5A
		SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet	

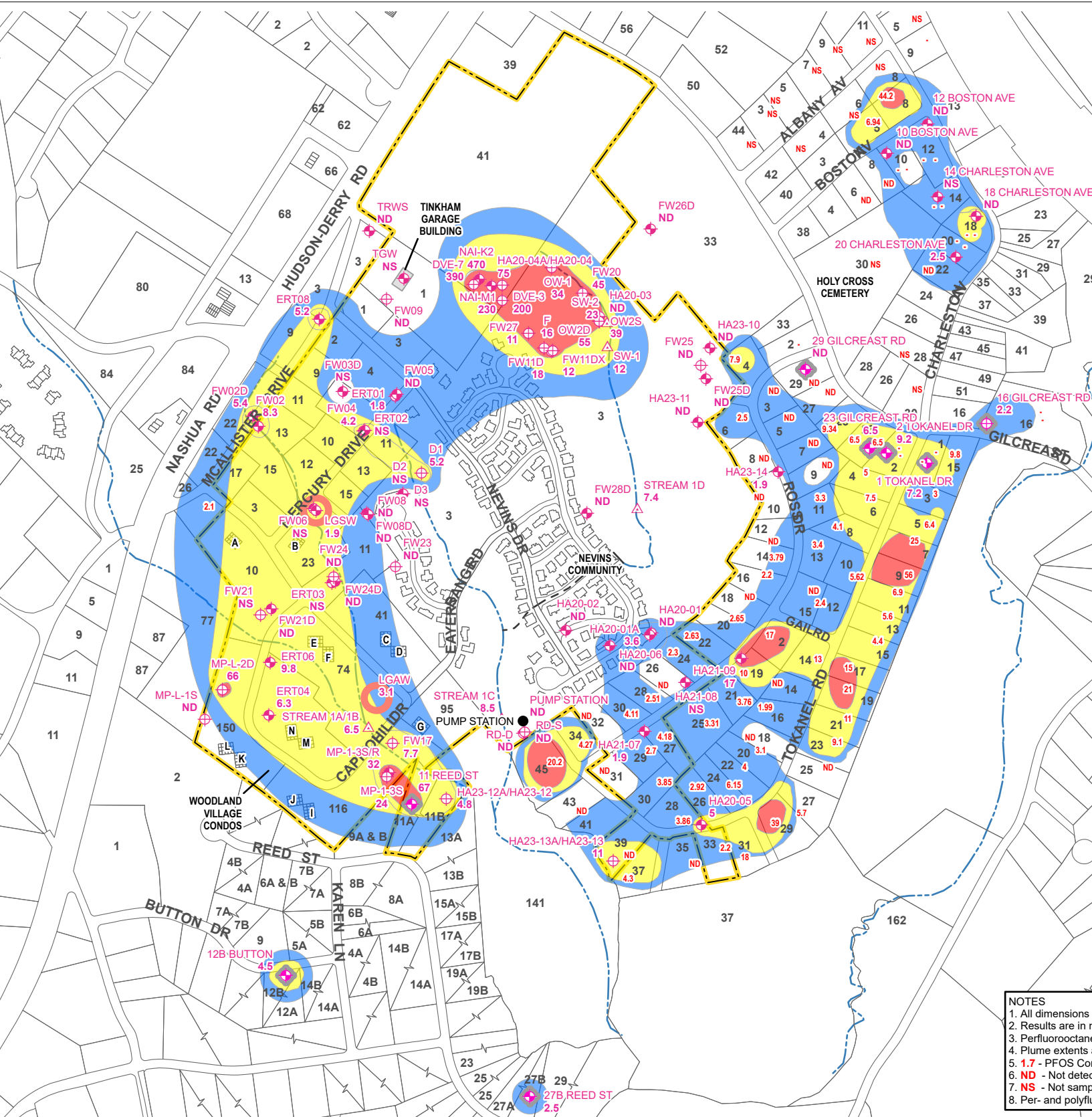
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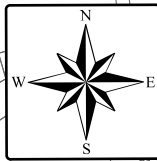
- LEGEND**
- FORMER WATER SUPPLY WELL
  - PUMP
  - BEDROCK MONITORING WELL
  - STREAM
  - OVERBURDEN MONITORING WELL
  - CULVERT
  - SURFACE WATER
  - GROUNDWATER MANAGEMENT ZONE
  - FORMER BEDROCK SUPPLY WELL
  - PFOS CONCENTRATION >15 NG/L
  - PFOS CONCENTRATION >4 - 15 NG/L
  - FORMER OVERBURDEN SUPPLY WELL
  - PFOS CONCENTRATION >ND - 4 NG/L



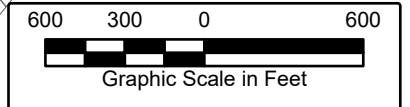
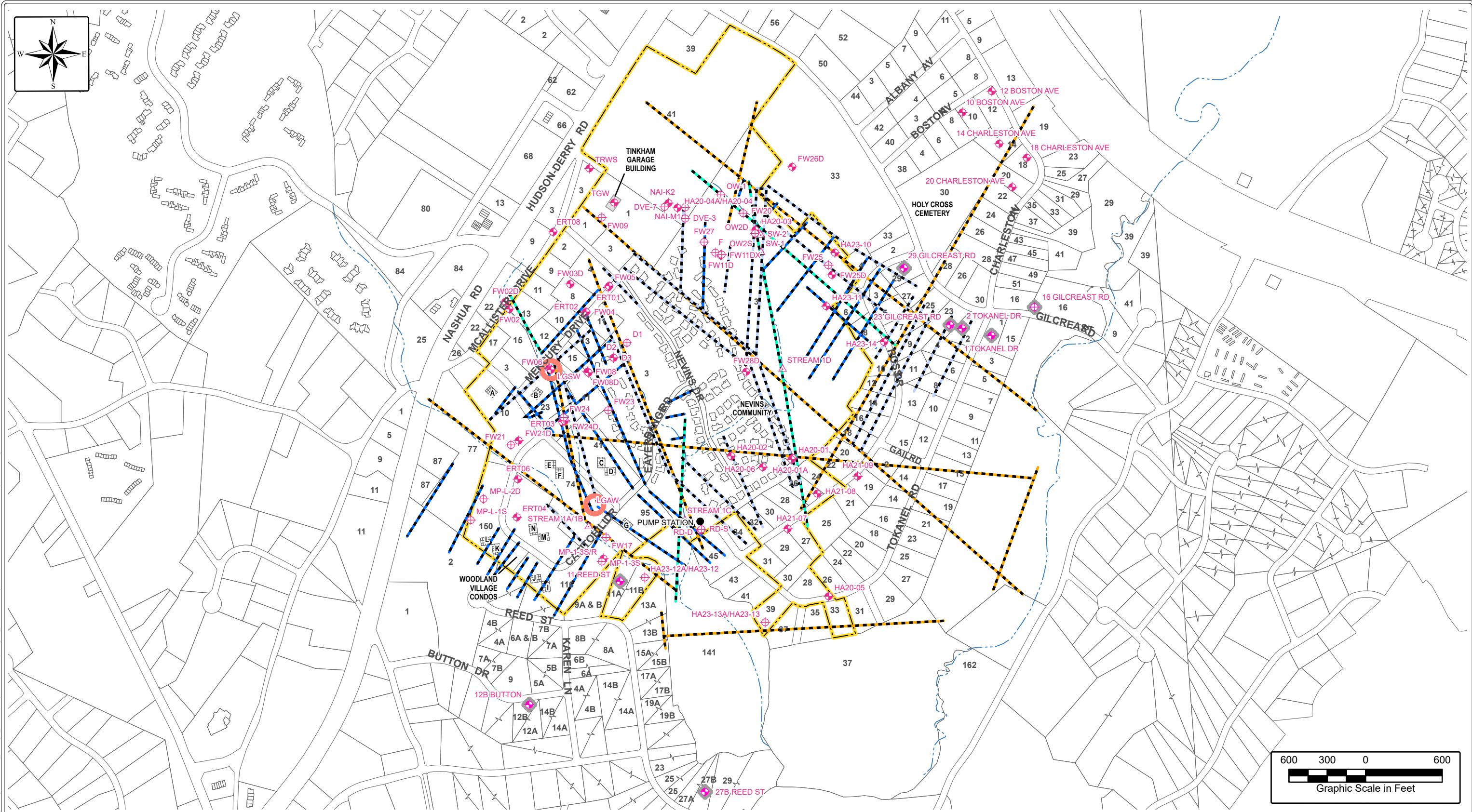
- NOTES**
1. All dimensions and locations are approximate.
  2. Results are in nanograms per liter (ng/L).
  3. Perfluorooctanesulfonic acid (PFOS) plume is based on November 2023 data and historical data, where appropriate.
  4. Plume extents are based on Maximum Contaminant Levels (MCLs) published on April 10, 2024.
  5. 1.7 - PFOS Concentration (ng/L)
  6. ND - Not detected
  7. NS - Not sampled
  8. Per- and polyfluoroalkyl substances (PFAS) sampling began in 2018.

REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup	DRAWING TITLE: <b>MAXIMUM PFOS CONCENTRATION THROUGH NOVEMBER 2023 TINKHAM GARAGE SITE LONDONDERRY, NH</b>	
SAVED DATE: March 2025	REVIEWER: W. Tiffit		
PROJECT: Tinkham Garage	CLIENT NAME: NHDES		
SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet		SCALE: 1:8,700	FIGURE NO: 5B





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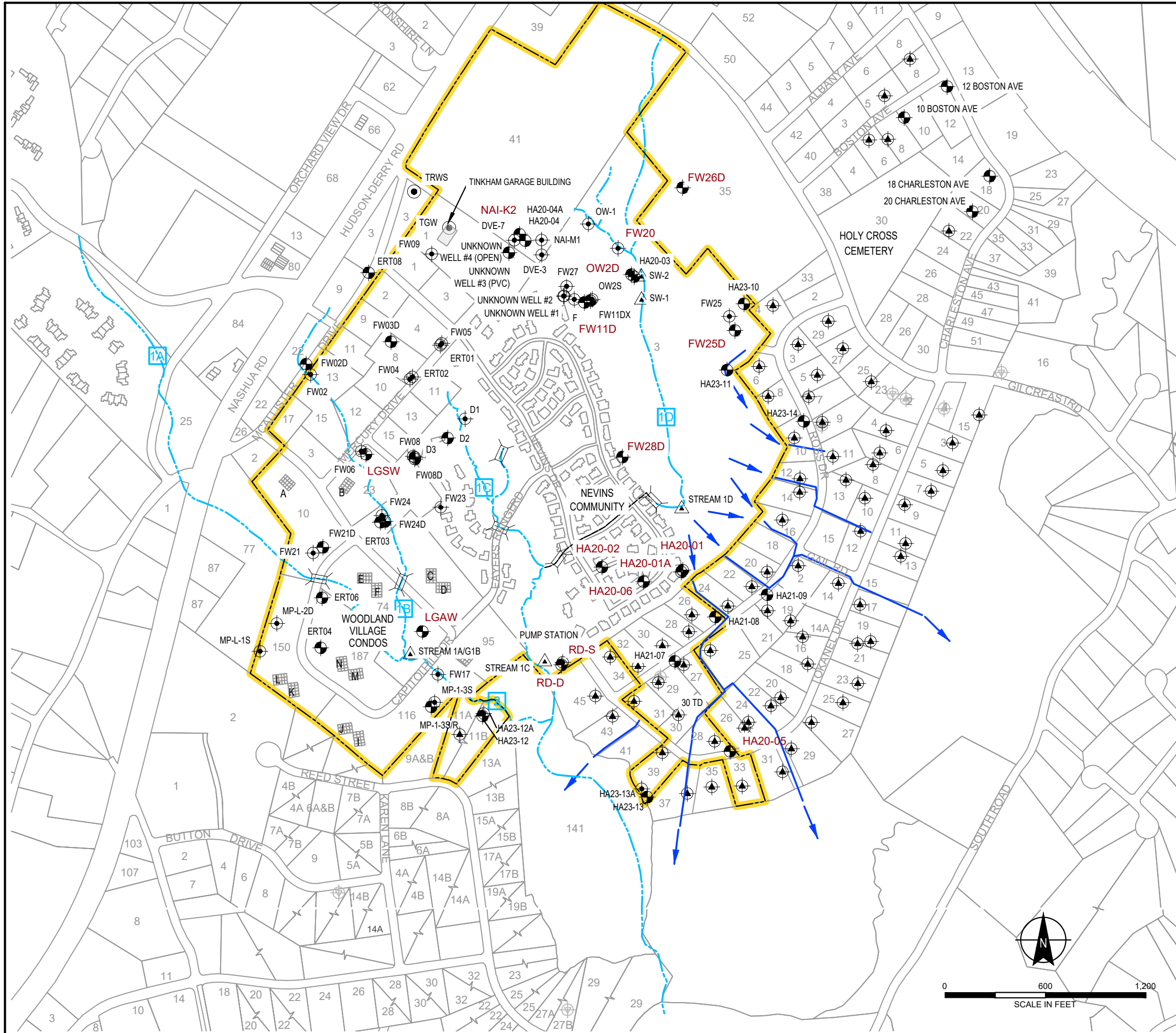
- LEGEND**
- STREAM
  - HGI Structure (Higher Confidence)
  - HGI Structure (Lower Confidence)
  - EPA Lineament
  - H&A Lineament
  - GROUNDWATER MANAGEMENT ZONE
  - FORMER WATER SUPPLY WELL
  - BEDROCK MONITORING WELL
  - OVERBURDEN MONITORING WELL
  - SURFACE WATER
  - FORMER BEDROCK SUPPLY WELL
  - FORMER OVERBURDEN SUPPLY WELL
  - PUMP

REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup
SAVED DATE: March 2025	REVIEWER: W. Tiffit
PROJECT: Tinkham Garage	CLIENT NAME: NHDES
SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet	

DRAWING TITLE: <b>LINEAMENTS/STRUCTURES TINKHAM GARAGE SITE LONDONDERRY, NH</b>
SCALE: <b>1:8,700</b>
FIGURE NO: <b>6</b>



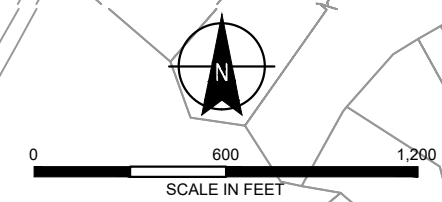
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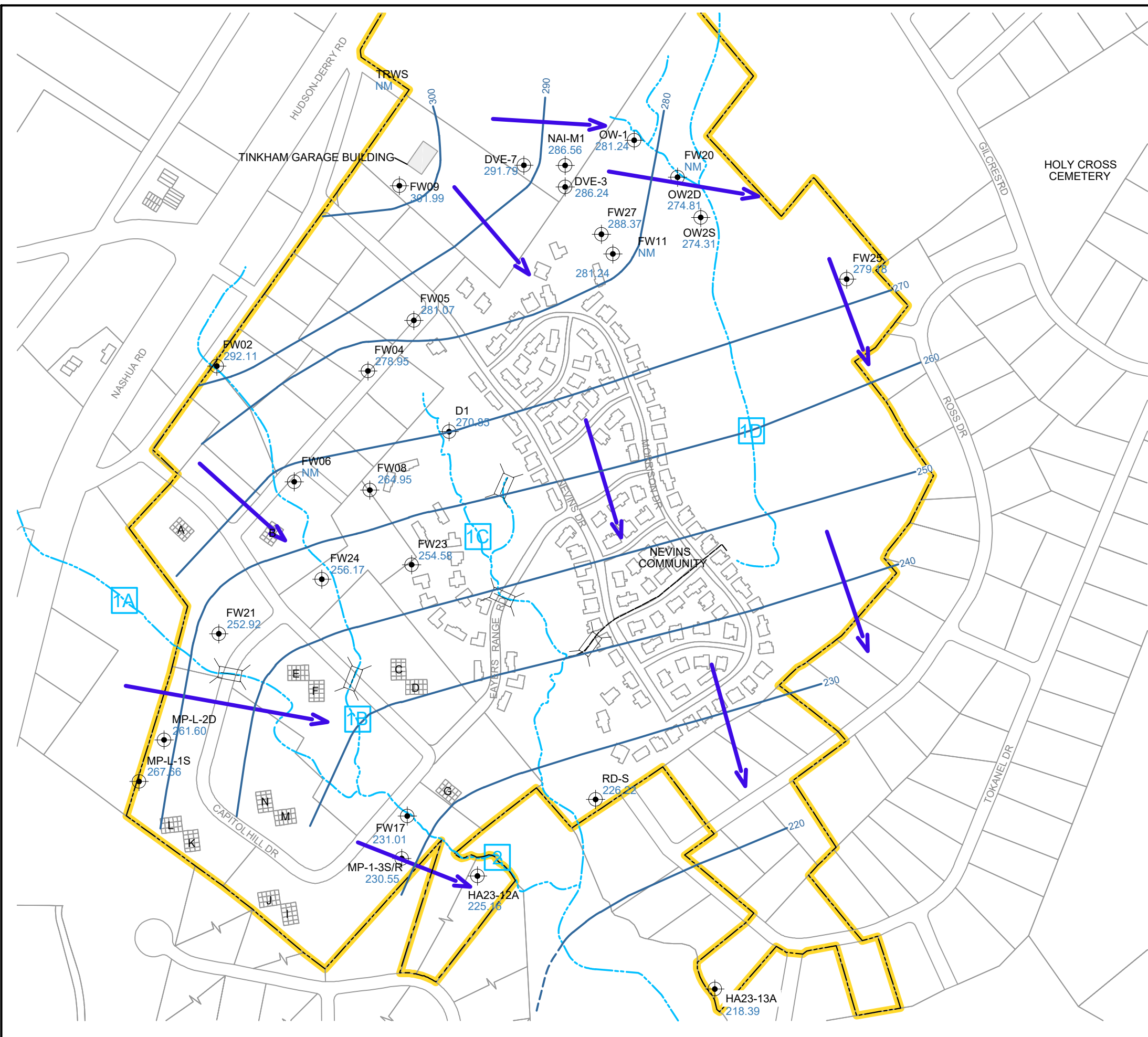
- LEGEND:**
- EXISTING RESIDENTIAL WELL
  - RESIDENTIAL WELL NO LONGER IN USE
  - OVERBURDEN/SHALLOW BEDROCK MONITORING WELL
  - BEDROCK MONITORING WELL
  - SURFACE WATER SAMPLE
  - TAP SAMPLE
  - STREAM
  - APPROXIMATE LOCATION OF STREAM 1D CULVERT
  - STREAM DESIGNATION
  - GROUNDWATER MANAGEMENT ZONE (GMZ)
  - NAI-M1 LOCATION ID
  - FW20 MONITORING WELL WITH PRESSURE TRANSDUCER LOCATION ID
  - SURFACE WATER FLOW PATH
  - SURFACE WATER FLOW DIRECTION

- GENERAL NOTES:**
1. ALL DIMENSIONS AND LOCATIONS ARE APPROXIMATE.
  2. WELL LOCATIONS SURVEYED IN 2016, 2021, AND 2023. SOME OLDER WELLS WERE DIGITIZED FROM A DRAWING TITLED "MONITORING LOCATIONS AND TOTAL VOLATILE ORGANIC CONCENTRATIONS, MAY 2008" BY CANNONS ENGINEERING, ROUX ASSOCIATES, INC.
  3. PRIVATE WELL LOCATIONS WERE SURVEYED WITH A TRIMBLE GEO 7X AND COLLECTED BY HALEY & ALDRICH, INC. IN AUGUST 2020, NOVEMBER 2020, JULY 2021, AND NOVEMBER 2022. RESIDENTIAL WELLS TO BE SURVEYED AT A LATER DATE EITHER COULD NOT BE LOCATED (15 TOKANEL) OR THE HOMEOWNERS COULD NOT BE CONTACTED (15 ROSS) OR DENIED ACCESS TO SURVEY THEIR WELL (18 ROSS, 41 TOKANEL). THE WELL AT 31 TOKANEL REPRESENTS A POTENTIAL WELL LOCATION SINCE THE HOMEOWNER DID NOT KNOW THE LOCATION OF THE WELL AND A TYPICAL WELLHEAD WAS NOT OBSERVED.
  4. RESIDENTIAL WELLS NO LONGER IN USE ARE ONLY SHOWN IF THEIR EXISTENCE HAS BEEN CONFIRMED AND SURVEYED.
  5. PARCEL ADDRESS SOURCE: TOWN OF LONDONDERRY GIS.
  6. TAX ID SOURCE: NH GRANIT GIS.
  7. THE GMZ BOUNDARY SHOWN IS BASED ON GMP NO. GWP-199004008-L-005 ISSUED ON OCTOBER 4, 2024; IT IS ANTICIPATED THAT THE GMZ BOUNDARY WILL BE UPDATED AND FURTHER EXPANDED BY NHDES UPON EPA DESIGNATION OF PFAS AS A SITE CONTAMINANT OF CONCERN (COC).
  8. SURFACE WATER PATHWAY OBSERVATIONS MADE BY WESTON IN JULY 2021

<p><b>TINKHAM GARAGE SITE</b>  <b>LONDONDERRY, NEW HAMPSHIRE</b>  <b>FOCUSED FEASIBILITY STUDY</b></p>				
<p><b>SURFACE WATER PATHWAYS</b></p>				
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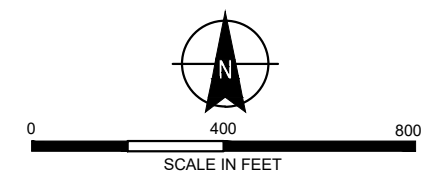


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- LEGEND**
- OVERBURDEN/SHALLOW BEDROCK MONITORING WELL
  - 276.47 GROUNDWATER ELEVATION (NOVEMBER 2021)
  - APPROXIMATE OVERBURDEN GROUNDWATER ELEVATION CONTOUR, IN FEET, 10-FT INTERVAL (NOVEMBER 2021)
  - INFERRED GROUNDWATER ELEVATION CONTOUR
  - INTERPRETED GROUNDWATER FLOW DIRECTION
  - STREAM DESIGNATION
  - STREAM
  - APPROXIMATE LOCATION OF STREAM 1D CULVERT
  - GROUNDWATER MANAGEMENT ZONE BOUNDARY

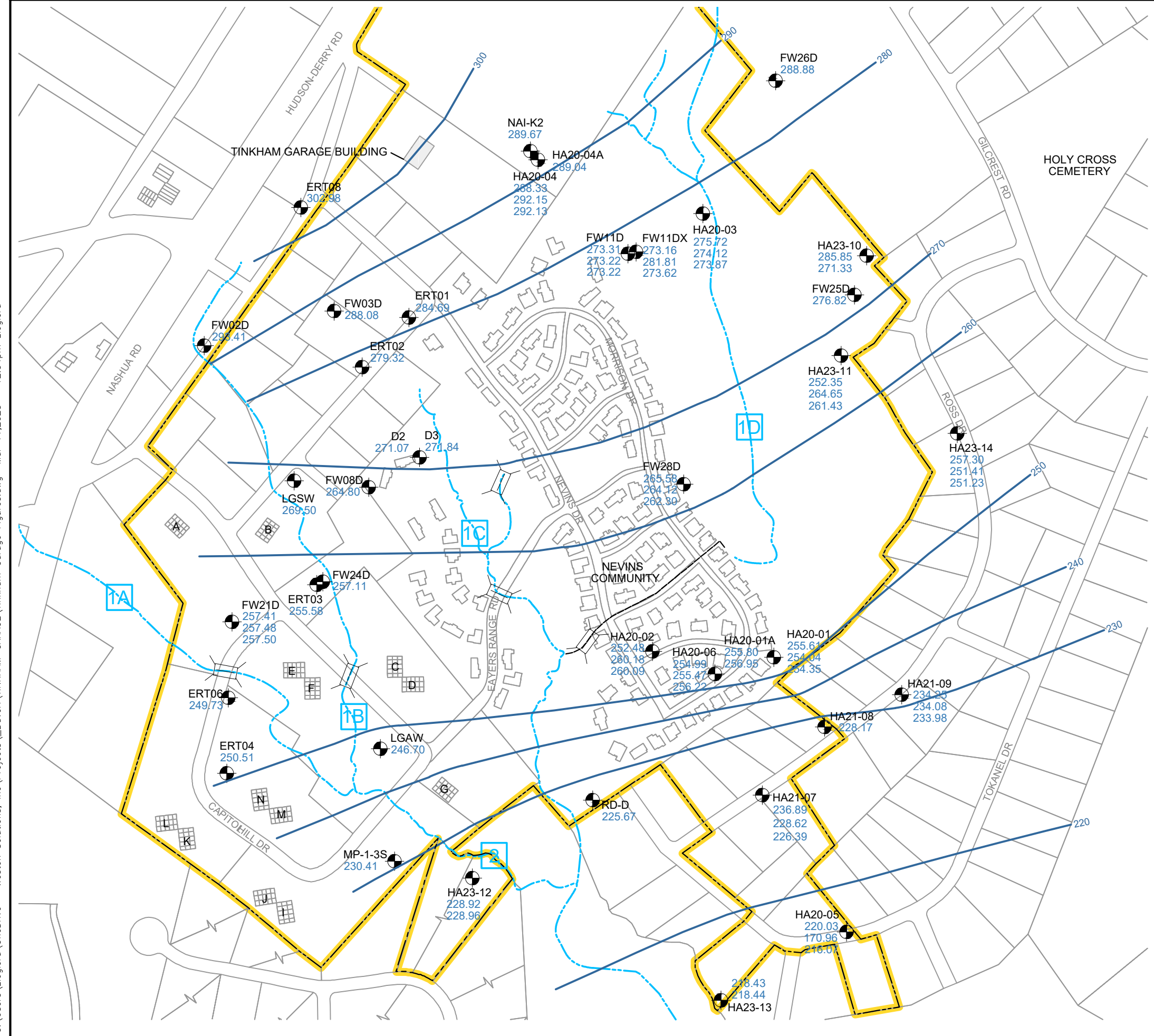
- NOTES**
1. ALL DIMENSIONS AND LOCATIONS ARE APPROXIMATE.
  2. MONITORING WELL LOCATIONS SURVEYED IN 2016, 2021, AND 2023.
  3. STREAM NAME DESIGNATIONS FROM HALEY & ALDRICH WORKPLAN FOR GROUNDWATER/SURFACE WATER INTERACTION, 1 JUNE 2018.
  4. WATER LEVELS MEASURED IN NOVEMBER 2023.
  5. NM = NOT MEASURED
  6. CONTOURS ARE BASED ON LINEAR INTERPOLATION BETWEEN DATA POINTS BUT ALSO CONSIDER TOPOGRAPHY AND SURFACE WATER FEATURES.
  7. MP-1-3S/R WAS NOT INCLUDED IN CONTOURS BECAUSE IT HAS NOT BEEN SURVEYED.
  8. SHALLOW WATER LEVELS ARE MEASURED IN MONITORING WELLS THAT ARE SCREENED IN THE OVERBURDEN, SCREENED ACROSS THE OVERBURDEN AND SHALLOW BEDROCK OR SCREENED WITHIN THE TOP 30 FT OF BEDROCK.
  9. PARCEL ADDRESS SOURCE: TOWN OF LONDONDERRY GIS



<p><b>TINKHAM GARAGE SITE LONDONDERRY, NEW HAMPSHIRE FOCUSED FEASIBILITY STUDY</b></p>				
<p><b>WATER TABLE ELEVATION CONTOURS (NOVEMBER 2023)</b></p>				
DRAWN	DATE	DES. ENG.	DATE	W.O. NO.
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CHECKED	DATE	SCALE	REVISION	FIGURE NO.
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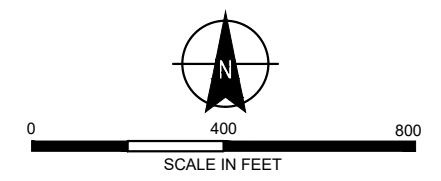
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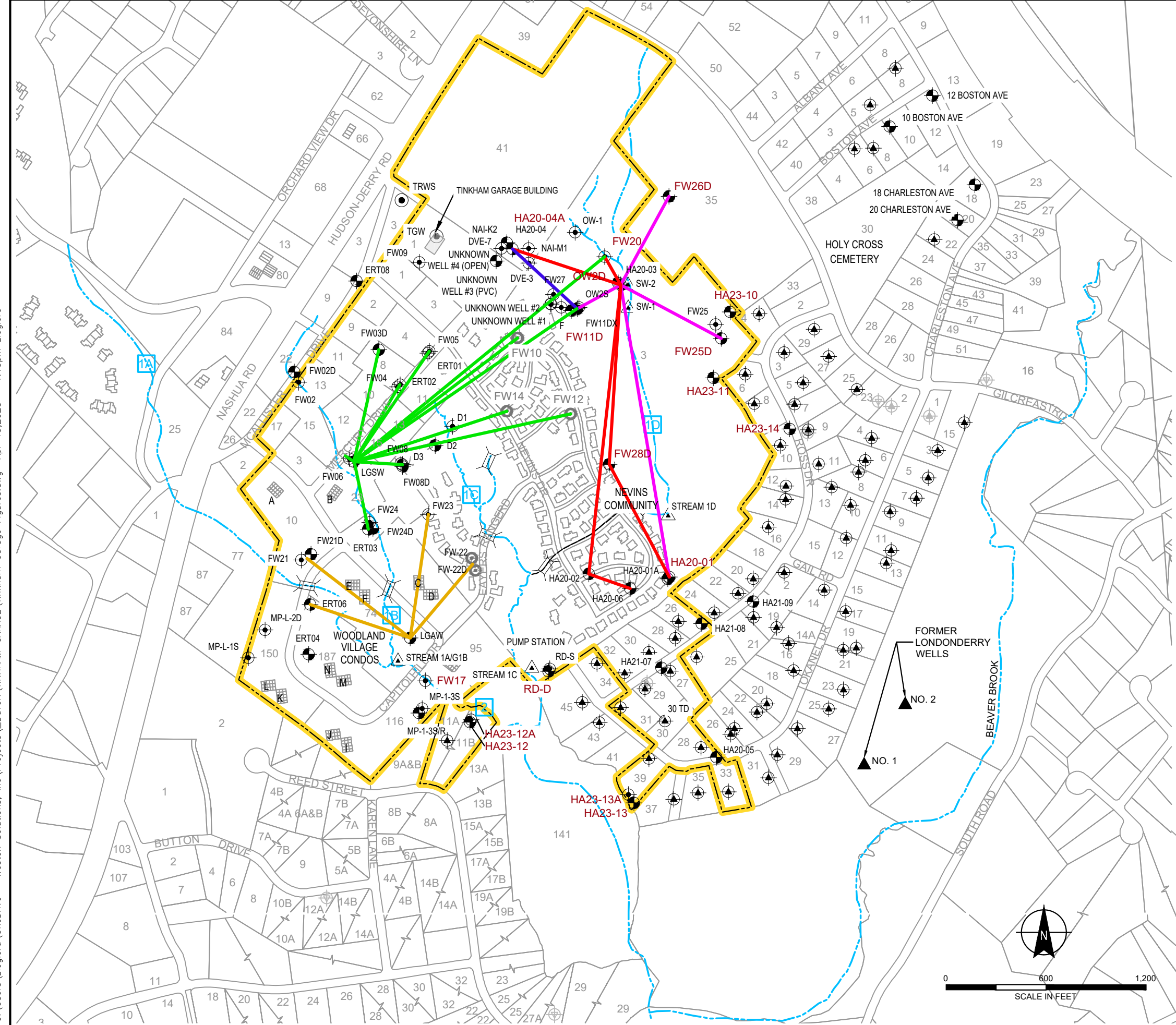
- LEGEND**
- BEDROCK MONITORING WELL
  - 276.47 GROUNDWATER ELEVATION (MAY 2021)
  - APPROXIMATE BEDROCK GROUNDWATER ELEVATION CONTOUR, IN FEET, 10-FT INTERVAL (NOVEMBER 2021)
  - INFERRED GROUNDWATER ELEVATION CONTOUR
  - 2 STREAM DESIGNATION
  - STREAM
  - APPROXIMATE LOCATION OF STREAM 1D CULVERT
  - GROUNDWATER MANAGEMENT ZONE BOUNDARY

- NOTES**
1. ALL DIMENSIONS AND LOCATIONS ARE APPROXIMATE.
  2. MONITORING WELL LOCATIONS SURVEYED IN 2016, 2021, AND 2023.
  3. STREAM NAME DESIGNATIONS FROM HALEY & ALDRICH WORKPLAN FOR GROUNDWATER/SURFACE WATER INTERACTION, 1 JUNE 2018.
  4. WATER LEVELS MEASURED IN NOVEMBER 2023.
  5. FOR MULTI-TIER WELLS, THE THREE GROUNDWATER ELEVATION VALUES CORRESPOND TO SHALLOW, INTERMEDIATE, AND DEEP BEDROCK.
  6. CONTOURS ARE BASED ON LINEAR INTERPOLATION BETWEEN DATA POINTS.
  7. PARCEL ADDRESS SOURCE: TOWN OF LONDONDERRY GIS



<p><b>TINKHAM GARAGE SITE LONDONDERRY, NEW HAMPSHIRE FOCUSED FEASIBILITY STUDY</b></p>				
<p><b>BEDROCK GROUNDWATER ELEVATION CONTOURS (NOVEMBER 2023)</b></p>				
DRAWN	DATE	DES. ENG.	DATE	W.O. NO.
DZ	JUL 2024		JUL 2024	20161.007.001
CHECKED	DATE	SCALE	REVISION	FIGURE NO.
DB	JUL 2024	1:400		8B

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**LEGEND:**

- EXISTING RESIDENTIAL WELL
- RESIDENTIAL WELL NO LONGER IN USE
- OVERBURDEN/SHALLOW BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- SURFACE WATER SAMPLE
- TAP SAMPLE
- ABANDONED/DECOMMISSIONED WELL
- STREAM
- APPROXIMATE LOCATION OF STREAM 1D CULVERT
- STREAM DESIGNATION
- GROUNDWATER MANAGEMENT ZONE (GMZ)
- NAI-M1 LOCATION ID
- FW20 MONITORING WELL WITH PRESSURE TRANSDUCER LOCATION ID
- POTENTIAL CONNECTION - HIGHEST DEGREE OF CERTAINTY
- POTENTIAL CONNECTION - MODERATE DEGREE OF CERTAINTY
- POTENTIAL CONNECTION - LOWEST DEGREE OF CERTAINTY
- CONNECTION - DRAWDOWN DURING LGSW PUMP TEST
- CONNECTION - DRAWDOWN DURING LGAW PUMP TEST

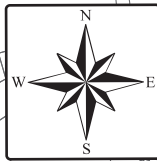
- GENERAL NOTES:**
1. ALL DIMENSIONS AND LOCATIONS ARE APPROXIMATE.
  2. WELL LOCATIONS SURVEYED IN 2016, 2021 AND 2023. SOME OLDER WELLS WERE DIGITIZED FROM A DRAWING TITLED "MONITORING LOCATIONS AND TOTAL VOLATILE ORGANIC CONCENTRATIONS, MAY 2008" BY CANNONS ENGINEERING, ROUX ASSOCIATES, INC.
  3. PRIVATE WELL LOCATIONS WERE SURVEYED WITH A TRIMBLE GEO 7X AND COLLECTED BY HALEY & ALDRICH, INC. IN AUGUST 2020, NOVEMBER 2020, JULY 2021, AND NOVEMBER 2022. RESIDENTIAL WELLS TO BE SURVEYED AT A LATER DATE EITHER COULD NOT BE LOCATED (15 TOKANEL) OR THE HOMEOWNERS COULD NOT BE CONTACTED (15 ROSS) OR DENIED ACCESS TO SURVEY THEIR WELL (18 ROSS, 41 TOKANEL). THE WELL AT 31 TOKANEL REPRESENTS A POTENTIAL WELL LOCATION SINCE THE HOMEOWNER DID NOT KNOW THE LOCATION OF THE WELL AND A TYPICAL WELLHEAD WAS NOT OBSERVED.
  4. RESIDENTIAL WELLS NO LONGER IN USE ARE ONLY SHOWN IF THEIR EXISTENCE HAS BEEN CONFIRMED AND SURVEYED.
  5. PARCEL ADDRESS SOURCE: TOWN OF LONDONDERRY GIS.
  6. TAX ID SOURCE: NH GRANIT GIS.
  7. THE GMZ BOUNDARY SHOWN IS BASED ON GMP NO. GWP-199004008-L-005 ISSUED ON OCTOBER 4, 2024; IT IS ANTICIPATED THAT THE GMZ BOUNDARY WILL BE UPDATED AND FURTHER EXPANDED BY NHDES UPON EPA DESIGNATION OF PFAS AS A SITE CONTAMINANT OF CONCERN (COC).
  8. POTENTIAL CONNECTIONS BASED UPON EVALUATION OF TRANSDUCER DATA COLLECTED DURING BEDROCK INVESTIGATIONS.
  9. LGSW CONNECTIONS BASED UPON MEASURED DRAWDOWN DURING THE LGSW PUMP TEST CONDUCTED BY NUS/FIT, AUGUST 1983.
  10. LGAW CONNECTIONS BASED UPON MEASURED DRAWDOWN DURING THE LGAW PUMP TEST CONDUCTED BY CAMP DRESSER & MCKEE, MARCH 1986.
  11. IN ADDITION TO HISTORIC PUMP TEST DATA, HYDRAULIC CONNECTIONS ARE BASED ON TRANSDUCER DATA COLLECTED DURING RECENT BEDROCK INVESTIGATIONS. ADDITIONAL HYDRAULIC CONNECTIONS LIKELY EXIST.

CONCORD NEW HAMPSHIRE

**TINKHAM GARAGE SITE  
LONDONDERRY, NEW HAMPSHIRE  
FOCUSED FEASIBILITY STUDY**

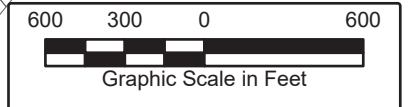
**HYDRAULIC CONNECTIONS  
BASED ON TRANSDUCER  
MONITORING PROGRAM**

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CHECKED	DB	DATE	JUL 2024	SCALE	1:600	REVISION	FIGURE NO.	9



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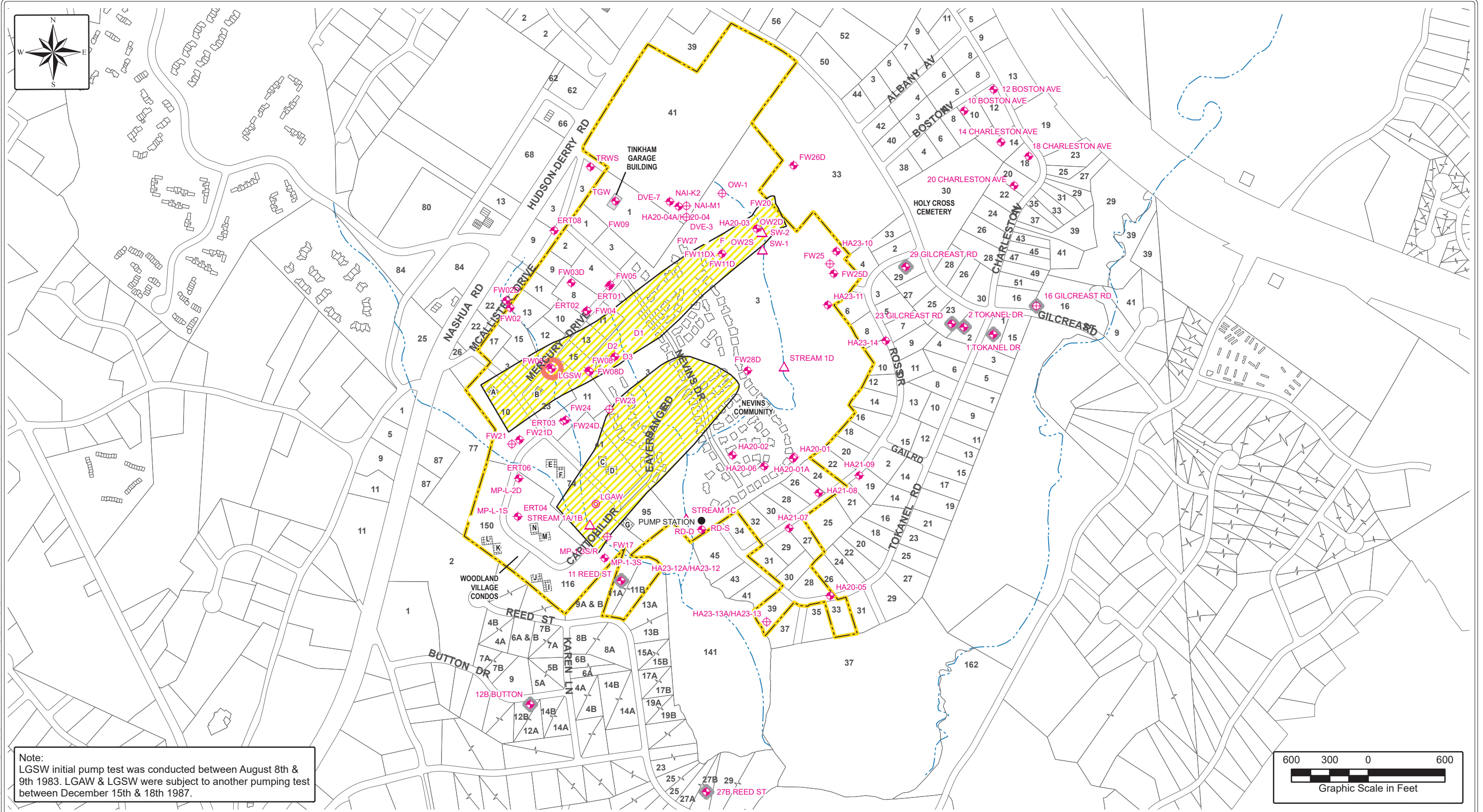
Note:  
LGSW initial pump test was conducted between August 8th & 9th 1983. LGAW & LGSW were subject to another pumping test between December 15th & 18th 1987.



- LEGEND**
- BEDROCK MONITORING WELL
  - BEDROCK EXTRACTION WELL
  - OVERBURDEN MONITORING WELL
  - SURFACE WATER
  - FORMER BEDROCK SUPPLY WELL
  - FORMER OVERBURDEN SUPPLY WELL
  - PUMP
  - DRAWDOWN ELIPSE
  - FORMER WATER SUPPLY WELL
  - STREAM
  - GROUNDWATER MANAGEMENT ZONE

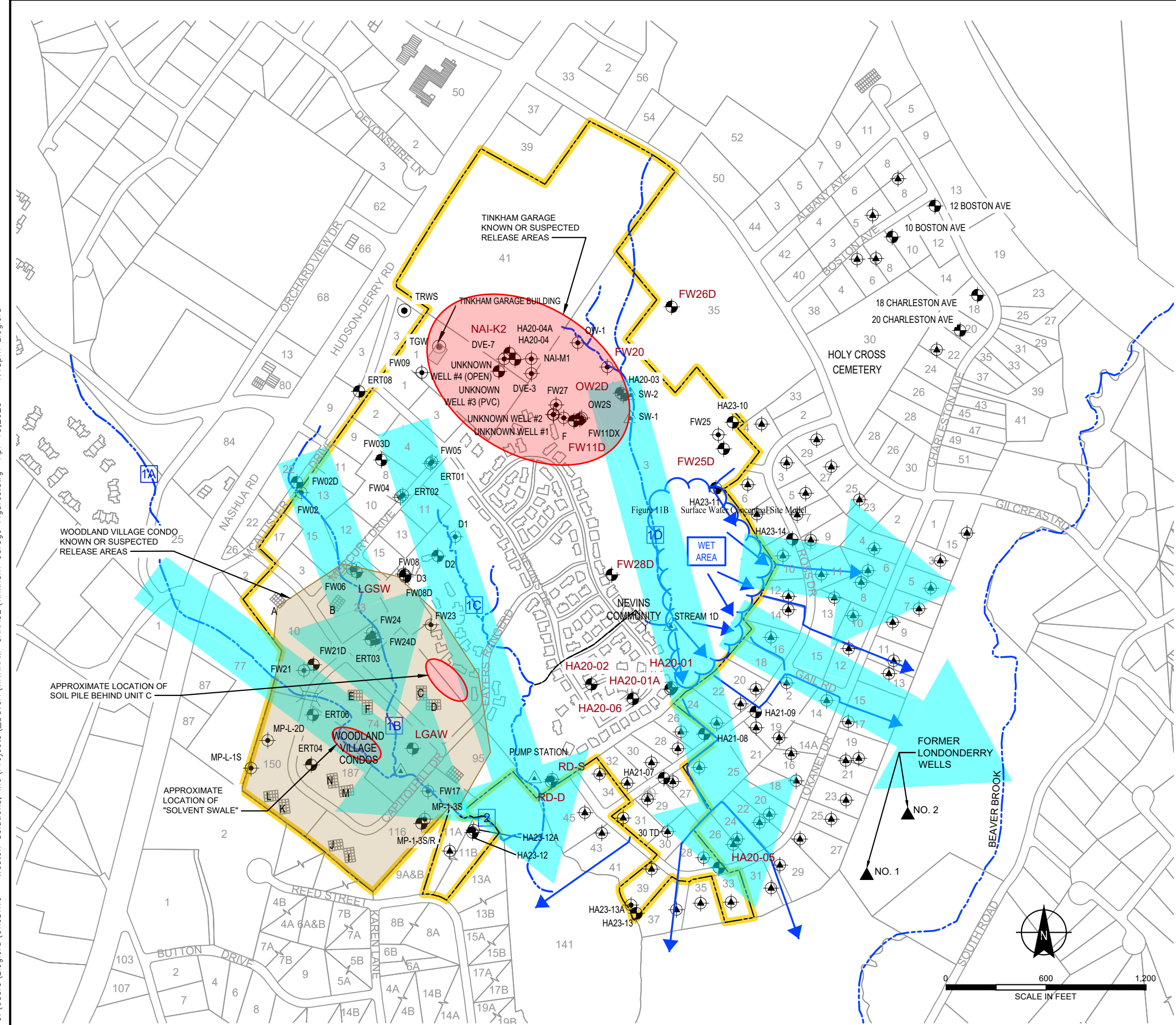
REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup
SAVED DATE: March 2025	REVIEWER: W. Tiftt
PROJECT: Tinkham Garage	CLIENT NAME: NHDES
SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet	

DRAWING TITLE: <b>LGSW PUMP TEST CONE OF DEPRESSION (1983 AND 1987) AND LGAW PUMP TEST CONE OF DEPRESSION (1987)</b> TINKHAM GARAGE SITE LONDONDERRY, NH
SCALE: 1:8,700
FIGURE NO: 18





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 C:\Users\zieglerd\OneDrive - Weston Solutions, Inc\Projects\Tinkham Garage Figures.dwg Apr 15, 2025 1:18:53 PM



**LEGEND:**

- EXISTING RESIDENTIAL WELL
- RESIDENTIAL WELL NO LONGER IN USE
- OVERBURDEN/SHALLOW BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- SURFACE WATER SAMPLE
- TAP SAMPLE
- STREAM
- APPROXIMATE LOCATION OF STREAM 1D CULVERT
- STREAM DESIGNATION
- GROUNDWATER MANAGEMENT ZONE (GMZ)
- NAI-M1 LOCATION ID
- FW20 MONITORING WELL WITH PRESSURE TRANSDUCER LOCATION ID
- SURFACE WATER FEATURE
- SURFACE WATER FLOW DIRECTION

- GENERAL NOTES:**
1. ALL DIMENSIONS AND LOCATIONS ARE APPROXIMATE.
  2. WELL LOCATIONS SURVEYED IN 2016, 2021 AND 2023. SOME OLDER WELLS WERE DIGITIZED FROM A DRAWING TITLED "MONITORING LOCATIONS AND TOTAL VOLATILE ORGANIC CONCENTRATIONS, MAY 2008" BY CANNONS ENGINEERING, ROUX ASSOCIATES, INC.
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  4. RESIDENTIAL WELLS NO LONGER IN USE ARE ONLY SHOWN IF THEIR EXISTENCE HAS BEEN CONFIRMED AND SURVEYED.
  5. PARCEL ADDRESS SOURCE: TOWN OF LONDONDERRY GIS.
  6. TAX ID SOURCE: NH GRANIT GIS.
  7. THE GMZ BOUNDARY SHOWN IS BASED ON GMP NO. GWP-199004008-L-005 ISSUED ON OCTOBER 4, 2024; IT IS ANTICIPATED THAT THE GMZ BOUNDARY WILL BE UPDATED AND FURTHER EXPANDED BY NHDES UPON EPA DESIGNATION OF PFAS AS A SITE CONTAMINANT OF CONCERN (COC).
  8. TINKHAM GARAGE KNOWN OR SUSPECTED RELEASE AREAS INCLUDES THE FIELD/WETLAND AREA SOUTHEAST OF THE GARAGE AND TRENCHES BEHIND THE BUILDING.
  9. WOODLAND VILLAGE CONDO KNOWN OR SUSPECTED RELEASE AREAS INCLUDES THE APPROXIMATE FORMER LOCATION OF THE "SOLVENT WALE", LOCATION OF FORMER CONTAMINATED SOIL PILE BEHIND UNIT C, AND LEACH FIELDS OF CONDO UNITS WHERE WASTES WERE REPORTEDLY DISPOSED.
  10. APPROXIMATE LOCATION OF DERRY'S LONDONDERRY WELLS NO. 1 AND 2.

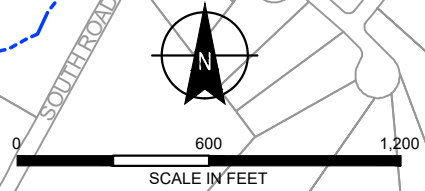
CONCORD NEW HAMPSHIRE

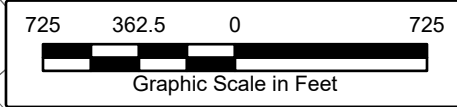
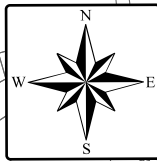
Environmental Services

**TINKHAM GARAGE SITE  
 LONDONDERRY, NEW HAMPSHIRE  
 FOCUSED FEASIBILITY STUDY**

**SURFACE WATER CONCEPTUAL SITE MODEL**

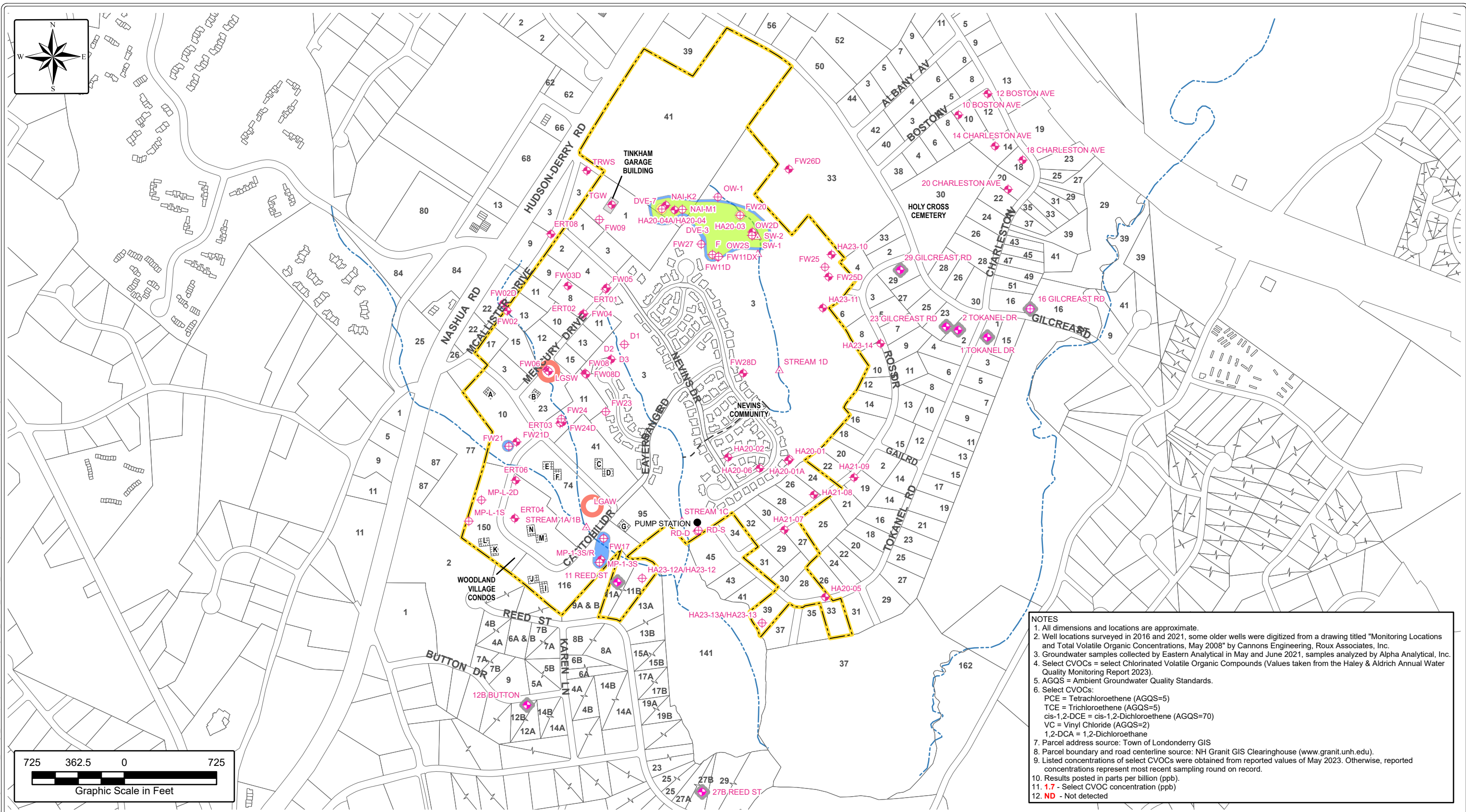
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CHECKED	DB	DATE	JULY 2024	SCALE	1:600	REVISION	FIGURE NO.	11B





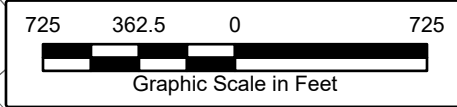
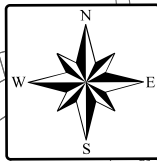
- LEGEND**
- FORMER WATER SUPPLY WELL
  - STREAM
  - CULVERT
  - GROUNDWATER MANAGEMENT ZONE
  - SUM OF SELECT CVOCs > 0 - 10 PPB
  - SUM OF SELECT CVOCs > 10 - 50 PPB
  - SUM OF SELECT CVOCs > 50 PPB
  - BEDROCK MONITORING WELL
  - OVERBURDEN MONITORING WELL
  - SURFACE WATER
  - FORMER BEDROCK SUPPLY WELL
  - FORMER OVERBURDEN SUPPLY WELL
  - PUMP

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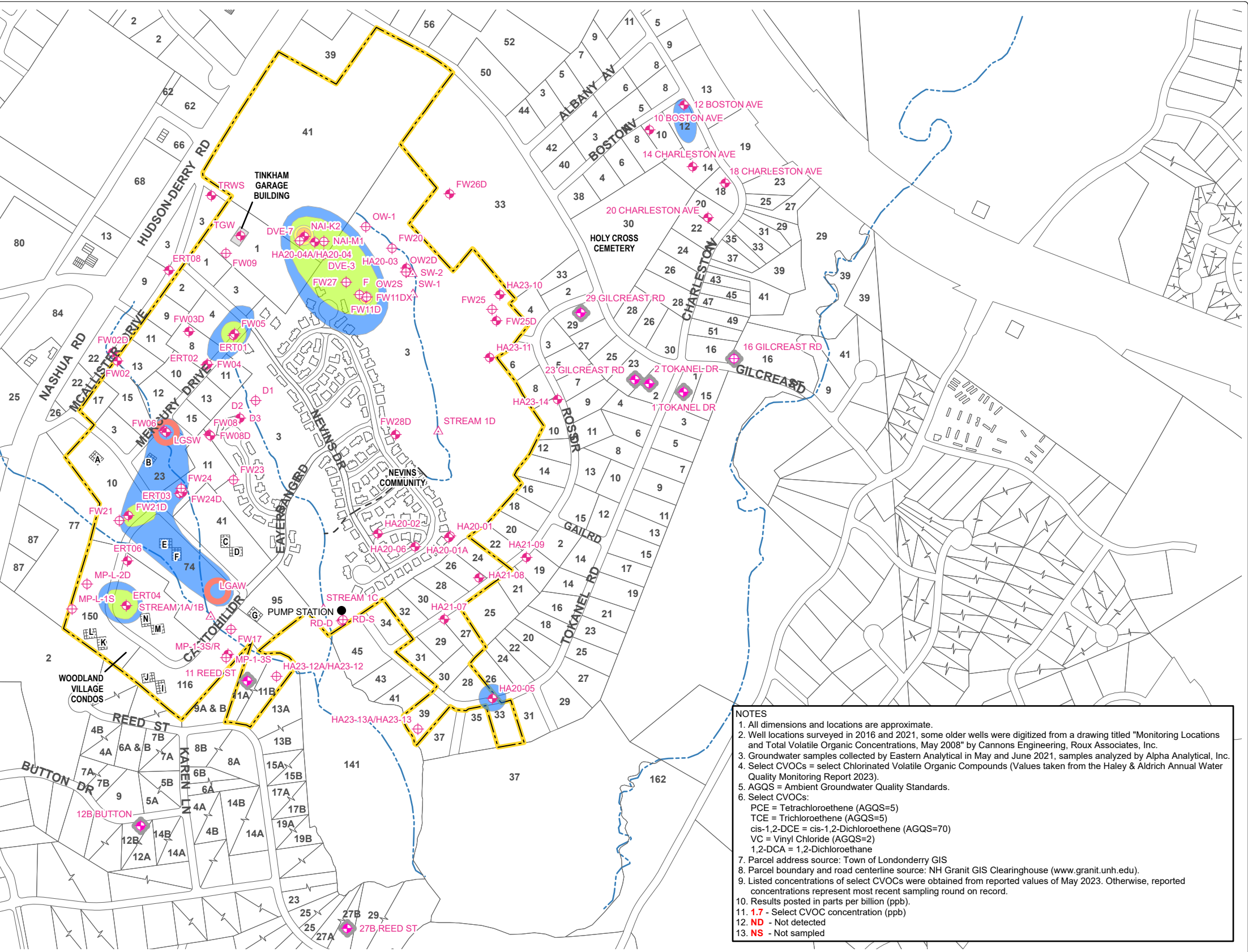


- NOTES**
1. All dimensions and locations are approximate.
  2. Well locations surveyed in 2016 and 2021, some older wells were digitized from a drawing titled "Monitoring Locations and Total Volatile Organic Concentrations, May 2008" by Cannons Engineering, Roux Associates, Inc.
  3. Groundwater samples collected by Eastern Analytical in May and June 2021, samples analyzed by Alpha Analytical, Inc.
  4. Select CVOCs = select Chlorinated Volatile Organic Compounds (Values taken from the Haley & Aldrich Annual Water Quality Monitoring Report 2023).
  5. AGQS = Ambient Groundwater Quality Standards.
  6. Select CVOCs:  
 PCE = Tetrachloroethene (AGQS=5)  
 TCE = Trichloroethene (AGQS=5)  
 cis-1,2-DCE = cis-1,2-Dichloroethene (AGQS=70)  
 VC = Vinyl Chloride (AGQS=2)  
 1,2-DCA = 1,2-Dichloroethane
  7. Parcel address source: Town of Londonderry GIS
  8. Parcel boundary and road centerline source: NH Granit GIS Clearinghouse (www.granit.unh.edu).
  9. Listed concentrations of select CVOCs were obtained from reported values of May 2023. Otherwise, reported concentrations represent most recent sampling round on record.
  10. Results posted in parts per billion (ppb).
  11. 1.7 - Select CVOC concentration (ppb)
  12. ND - Not detected

REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup	<b>SUM OF SELECT CVOCs IN OVERBURDEN AND SHALLOW BEDROCK THROUGH NOVEMBER 2023 TINKHAM GARAGE SITE LONDONDERRY, NH</b>		
SAVED DATE: March 2025	REVIEWER: W. Tift			
PROJECT: Tinkham Garage	CLIENT NAME: NHDES			
		SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet	SCALE: 1:8,700	FIGURE NO: 12A



LEGEND	
	FORMER WATER SUPPLY WELL
	STREAM
	CULVERT
	SUM OF SELECT CVOCS > 0 - 10 PPB
	SUM OF SELECT CVOCS > 10 - 50 PPB
	SUM OF SELECT CVOCS > 50 - 100 PPB
	SUM OF SELECT CVOCS > 100 PPB
	GROUNDWATER MANAGEMENT ZONE
	BEDROCK MONITORING WELL
	OVERBURDEN MONITORING WELL
	SURFACE WATER
	FORMER BEDROCK SUPPLY WELL
	FORMER OVERBURDEN SUPPLY WELL
	PUMP



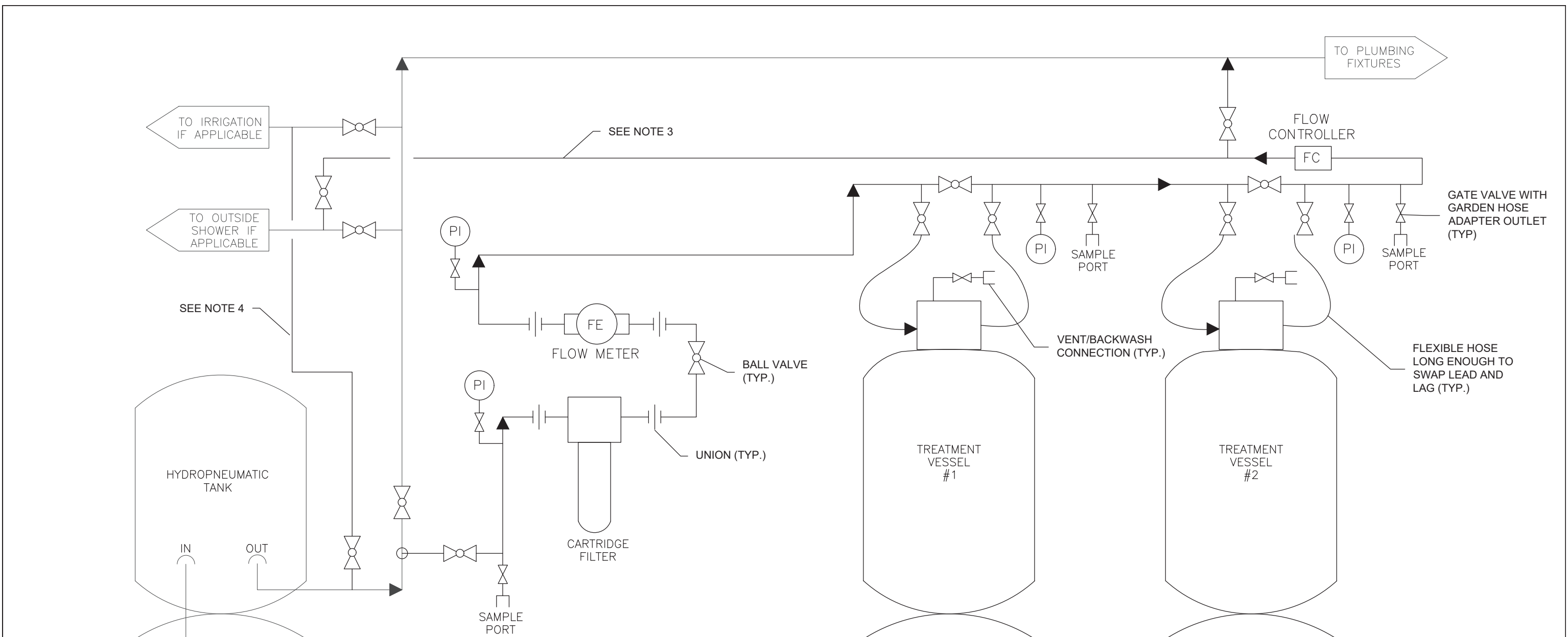
**NOTES**

- All dimensions and locations are approximate.
- Well locations surveyed in 2016 and 2021, some older wells were digitized from a drawing titled "Monitoring Locations and Total Volatile Organic Concentrations, May 2008" by Cannons Engineering, Roux Associates, Inc.
- Groundwater samples collected by Eastern Analytical in May and June 2021, samples analyzed by Alpha Analytical, Inc. Quality Monitoring Report 2023).
- Select CVOCs = select Chlorinated Volatile Organic Compounds (Values taken from the Haley & Aldrich Annual Water Quality Monitoring Report 2023).
- AGQS = Ambient Groundwater Quality Standards.
- Select CVOCs:  
 PCE = Tetrachloroethene (AGQS=5)  
 TCE = Trichloroethene (AGQS=5)  
 cis-1,2-DCE = cis-1,2-Dichloroethene (AGQS=70)  
 VC = Vinyl Chloride (AGQS=2)  
 1,2-DCA = 1,2-Dichloroethane
- Parcel address source: Town of Londonderry GIS
- Parcel boundary and road centerline source: NH Granit GIS Clearinghouse ([www.granit.unh.edu](http://www.granit.unh.edu)).
- Listed concentrations of select CVOCs were obtained from reported values of May 2023. Otherwise, reported concentrations represent most recent sampling round on record.
- Results posted in parts per billion (ppb).
- 1.7 - Select CVOc concentration (ppb)
- ND - Not detected
- NS - Not sampled

REPORT DATE: March 2025	PROJECT MANAGER: J. Soukup	DRAWING TITLE:  <b>SUM OF SELECT CVOCS IN DEEP BEDROCK THROUGH NOVEMBER 2023 TINKHAM GARAGE SITE LONDONDERRY, NH</b>	
SAVED DATE: March 2025	REVIEWER: W. Tift		
PROJECT: Tinkham Garage	CLIENT NAME: NHDES	SCALE: 1:8,700	FIGURE NO: 12B
		SPATIAL REFERENCE: NAD 1983 StatePlane New Hampshire FIPS 2800 Feet	

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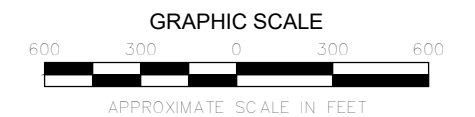
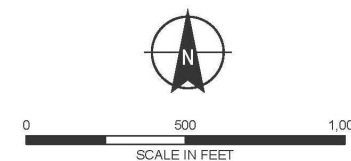
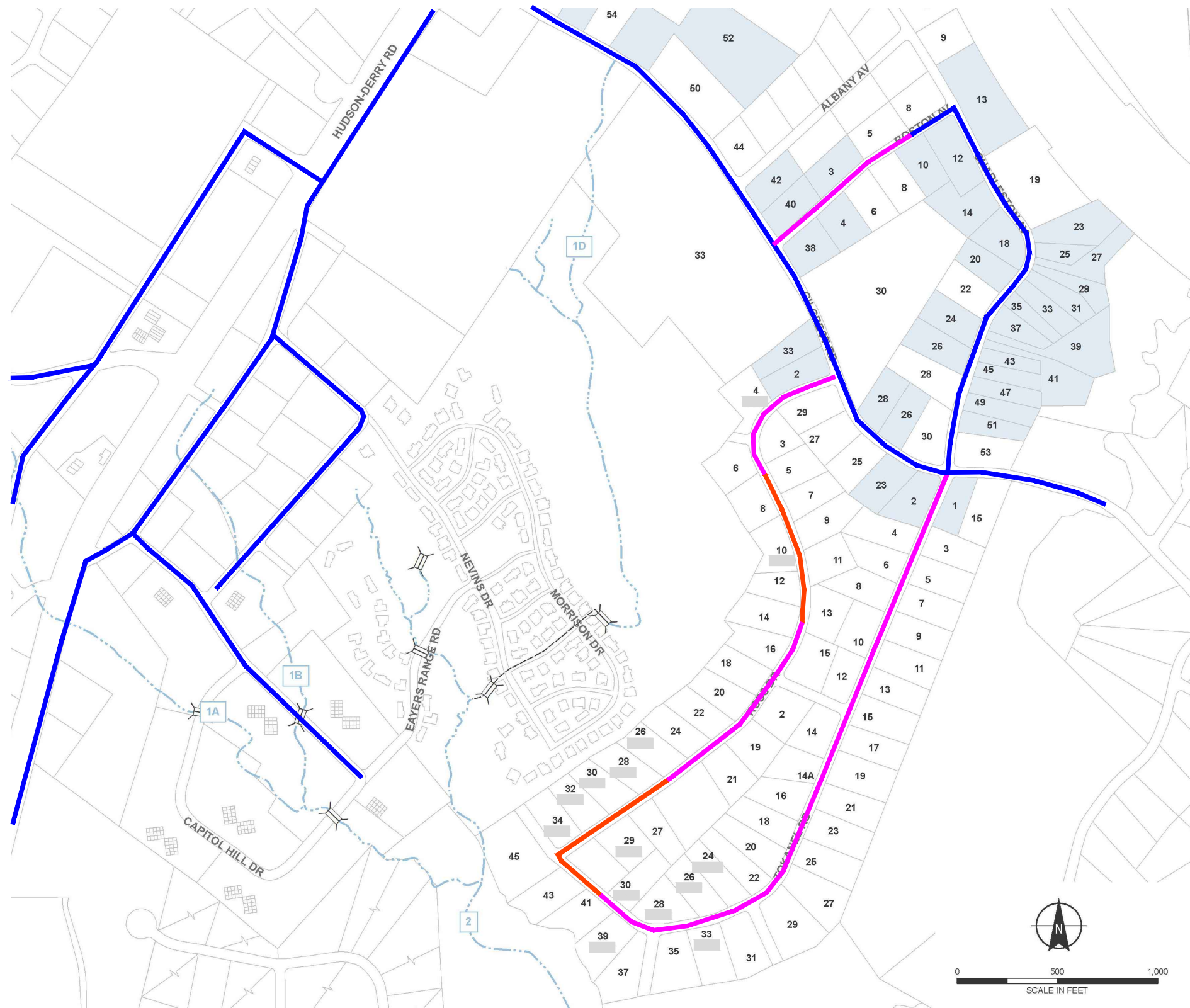
**NOTES**

1. BASE POETS TO HAVE ONE CARTRIDGE FILTER, FLOW METER, FLOW REGULATOR AND TWO TREATMENT VESSELS.
2. EACH TREATMENT VESSEL TO HAVE BYPASS AND BACKWASHING HEAD TO ENABLE BACKWASHING.
3. IF OWNER HAS OUTSIDE SHOWER, THE SHOWER SHALL BE CONNECTED TO THE POETS EFFLUENT. A SEPARATE SERVICE MAY BE REQUIRED AS SHOWN.
4. IF OWNER DOES NOT WANT TO CONNECT IRRIGATION TO POETS EFFLUENT, A NEW SERVICE FEED MAY BE REQUIRED AS SHOWN.

**LEGEND**

- EXISTING
- NEW

		<b>TYPICAL POINT OF ENTRY TREATMENT SYSTEM (POETS) SCHEMATIC</b>				
CONCORD	NEW HAMPSHIRE	DRAWN DCH	DATE JAN 2023	DES. ENG.	DATE	W.O. NO. 20139.007.002
TINKHAM GARAGE SITE LONDONDERRY, NEW HAMPSHIRE		CHECKED NW	DATE JAN 2023	SCALE AS SHOWN	REVISION	FIGURE NO. 113



LEGEND

- EXISTING WATER LINE
- NEW WATER LINE
- NEW WATER LINE REQUIRING BEDROCK BLASTING



CONCORD NEW HAMPSHIRE

TINKHAM GARAGE SITE  
LONDONDERRY, NEW HAMPSHIRE

PROPOSED WATER LINE

DRAWN DCH	DATE JAN 2023	DES. ENG.	DATE	W.O. NO. 20139.007.002
CHECKED NW	DATE JAN 2023	SCALE AS SHOWN	REVISION	FIGURE NO. 14

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## TABLES

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**Table 1**  
**General Response Actions and Technologies**  
**Tinkham Garage Superfund Site**  
**Londonderry, New Hampshire**

General Response Action	Technology	Process Options	
No Action	None	Not Applicable	
Alternate Water Supply	New Water Supply	Bottled Water	
		Water Line Extension	
	Residential Well Treatment	Point of Entry Water Treatment Systems	
Limited Action	Monitoring	Sampling and analysis	
	Institutional Controls	Deed Notice	
		Covenants	
		Town Ordinance	
Hydraulic Containment	Groundwater Withdrawal with Ex Situ Treatment	Pumping with Granular Activated Carbon Treatment	
		Pumping with Advanced Oxidation Treatment System	
	Slurry Wall	Injected Bentonite Grout Curtain	
Physical Containment	Vertical and Horizontal Barriers	Vertical Barrier - Grout injected into borings in bedrock under pressure.	
		Horizontal Barrier - Low permeability clay cap	
		Horizontal Barrier - Synthetic Geotextile Cap	
In Situ Treatment	In Situ Chemical Oxidation (ISCO)	Sodium Permanganate	
		Potassium Permanganate	
		Peroxide/Ozone	
		Sodium Persulfate	
	In Situ Chemical Reduction (ISCR)	Nano or Micro-Scale Zero Valent Iron (ZVI)	
		Calcium Polysulfate	
	In Situ Biological Treatment (ISB)	Commercially available oil or carbohydrate based amendments.	
	In Situ Thermal Treatment		Thermal Conductivity Heating (TCH)
			Electrical Resistivity Heating (ERH)
			Steam Injection

**Table 2**  
**Process Option Screening**  
**Tinkham Garage Superfund Site**  
**Londonderry, New Hampshire**

General Response Action/ Technology	Description	Process Options	Retained as Representative Process Option?	Alternative for Initial Screening
No Action	No Action must be considered to provide a base-line for comparison	Not Applicable	Yes	Provided as a stand-alone alternative to provide a baseline for comparison of other alternatives.
Alternate Water Supply: New Water Supply and Residential Well Treatment	Prevent resident exposure from ingestion of contaminated groundwater used as drinking water by providing an alternate source of water	Bottled Water	Yes	Provision of bottled water to residents within target neighborhoods to minimize exposure.
		Point of Entry Treatment (POET)	Yes	Installation of POETs at households within target neighborhoods to treat well water; Paired with monitoring to monitor the effectiveness of the treatment system and to determine media replenishment schedules.
		Municipal Water Line Extension	Yes	Extension of an existing waterline and connection of households within the target neighborhoods; Paired with future ICs to manage use of groundwater within the Groundwater Management Zone (GMZ) until the cleanup goals are achieved.
<b>Limited Action:</b> Monitoring	Sampling of residential wells and/or treatment system influent/effluent	Collection of samples with analysis for site contaminants at an analytical laboratory	Yes	To be included as a component in the POET alternative to monitor effectiveness and ensure risk mitigation.
Institutional Controls (IC)	Must be included to prevent incidental or continued use of groundwater	Deed Notice	Yes	ICs are a component of the current remedy; ICs will be used in the future to manage the use of groundwater within the GMZ until drinking water standards are attained. Deed notices, legal covenant, or town ordinance would all be effective.
		Legal Covenant	Yes	
		Town Ordinance	Yes	

**Table 3**  
**Summary of Comparative Analysis of Alternatives**  
**Tinkham Garage Superfund Site**  
**Londonderry, New Hampshire**

<b>EVALUATION CRITERIA</b>	<b>ALT 1 – NO ACTION</b>	<b>ALT 2 – BOTTLED WATER</b>	<b>ALT 3 – POET SYSTEMS</b>	<b>ALT 4 – WATER LINE EXTENSION</b>
<b>Overall Protection of Human Health and the Environment</b>	Will not provide any protection and would not mitigate risk to human health. No Action alone would not meet the threshold criterion of protectiveness.	Will partially mitigate risk to human health by providing an alternate source of drinking water. Will not prevent exposure to contaminants via other exposure pathways (e.g., incidental ingestion of contaminated groundwater) as households will continue to rely on groundwater for other household uses. Protectiveness may wane over time due to residents' fatigue with using bottled water. Bottled water is considered temporary until a permanent alternative water source is provided or groundwater is restored. Five-Year Reviews would be performed to verify protectiveness.	Will mitigate risk to human health by providing a source of clean water by treating groundwater as it enters the home. Concentrations in groundwater would be treated to below drinking water standards although some risk will remain if POET systems are not properly operated and maintained. Monitoring of the system will assess attainment of performance standards. Continued monitoring would allow for an assessment of groundwater concentrations over time and the continued need for treatment. Five-Year Reviews would be performed to verify protectiveness.	Will mitigate risk to human health from contaminated groundwater by providing an alternative source of water that is maintained and monitored by an independent water purveyor. Provides a permanent public water supply (which has mandated monitoring requirements for the water provider) to residents limiting all potential exposure to groundwater via household use. Five-Year Reviews would be performed to verify protectiveness.
<b>Compliance with ARARs</b>	There are no ARARs associated with this alternative.	Will comply with ARARs, as a temporary measure (e.g., while a final groundwater remedy is in progress). No chemical-specific ARARs are selected for this alternative because groundwater is not being restored for this interim remedy.	Will comply with ARARs. Monitoring would be performed to assess groundwater and treatment to ensure attainment of drinking water quality post treatment, which will have to comply with chemical-specific ARARs. Chemical-specific ARARs are not being selected for Site groundwater itself for this interim remedy.	Will comply with ARARs. This action is considered to provide a permanent alternative water supply. No chemical-specific ARARs are selected for this alternative because groundwater is not being restored for this interim remedy.
<b>Long-Term Effectiveness and Permanence</b>	The remedy will have no long-term effectiveness because it does nothing to mitigate documented risk to receptors from ingestion of contaminated groundwater.	Provision of bottled water to mitigate ingestion of contaminated groundwater is considered a short-term (temporary) remedy and has limited long-term effectiveness. Over time, reliance on bottled water may be an inconvenience to residents and the reliability of using the supplied water over time may be reduced. Because the provision of bottled water does not measurably minimize stresses on the aquifer, migration from the Site may continue to expand the plume and the timeframe for restoration.	POET systems can be a long-term remedy for risk mitigation if they are properly operated and maintained. However, they are considered to be a temporary alternative. Because use of POETS does not minimize stresses on the aquifer, continued migration from the Site may continue to expand the plume and the timeframe to restore groundwater. Routine monitoring must be performed to monitor system performance and the treatment media changed regularly. Failure to properly maintain the POET systems could result in unacceptable risk.	Connection of all homes to a municipal water line would permanently prevent contact with contaminated groundwater for all residents in the target neighborhoods. Long term O&M is provided by the water purveyor and funded through water fees, ensuring that it will be done. Use of a water line would remove stresses on the aquifer from continued pumping and minimize potential migration of contaminants in groundwater within and from the Site into the neighborhoods.
<b>Reduction of Toxicity, Mobility, or Volume through Treatment</b>	There would be no reduction of toxicity, mobility, or volume through treatment as this alternative does not treat contaminants in groundwater; groundwater restoration will be addressed in a future ROD.	There would be no reduction of toxicity, mobility or volume through treatment, as this alternative does not treat contaminants in groundwater; groundwater restoration will be addressed in a future ROD.	There would be a small reduction in toxicity, mobility, or volume of groundwater contaminants within the neighborhood as a result of water treated through the POET systems. Site groundwater restoration will be addressed in a future ROD.	There would be no reduction of toxicity, mobility, and volume through treatment, as this alternative does not treat contaminants in groundwater; groundwater will be addressed in a future ROD.

**Table 3**  
**Summary of Comparative Analysis of Alternatives**  
**Tinkham Garage Superfund Site**  
**Londonderry, New Hampshire**

EVALUATION CRITERIA	ALT 1 – NO ACTION	ALT 2 – BOTTLED WATER	ALT 3 – POET SYSTEMS	ALT 4 – WATER LINE EXTENSION
<b>Short-Term Effectiveness</b>	There are no short-term risks associated with this alternative, and it is not expected to be effective in the short-term. No action would be taken to address exposure as this alternative does not involve any site work.	Implementation of this alternative would provide good short-term effectiveness because it can be implemented very quickly and in fact is already being used at the Site. The short-term risks involve increased truck traffic in the neighborhoods for delivery of the bottled water.	This alternative presents limited short-term effectiveness because it will take a year or more to design and install the POET systems within these neighborhoods. Short-term risks related to installation of the systems include increased truck traffic associated with contractor installation and O&M of the POET systems.	This alternative would have limited short-term effectiveness because it will take a year or more to complete pre-design investigations, design, and construction of the water line extension with connections to households. No impacts are predicted after installation. Short-term risks related to installation of the water line include worker contact with contaminated soil and groundwater, increased truck traffic, construction equipment, and noise.
<b>Implementability</b>	No implementation required.	Provision of bottled water have been ongoing at the Site for several years. The services, expertise, and materials needed are locally available. As a result, this is considered a proven technology and there are no concerns with regard to implementation.	The expertise, services, and materials needed to design and install the POET systems is locally available and relies on off-the-shelf technology. Implementation of this alternative would require time because each home would require its own engineered system based on specific home plumbing system and preferences of the owner. There are no concerns with regard to implementation of this alternative.	The expertise, services, and materials needed to design and install the water line extension is locally available and relies on off-the-shelf technology. Implementation of this alternative would be complicated by the presence of shallow bedrock in some areas of the proposed alignment, but removal of bedrock is routinely performed and the equipment and expertise needed to do so is available locally. Some residents may be hesitant to connect to the water line due to the future cost of water service.
<b>Cost</b>	Capital Cost: \$0 Annual O&M Cost: \$0 O&M NPV: \$0  <b>Rounded Total Present Value: \$0</b>	Capital Cost: \$0 Annual O&M Cost: \$172,800 O&M NPV: \$2,814,720  <b>Rounded Total Present Value: \$2,800,000</b>	Capital Cost: \$892,492 Annual O&M Cost: \$436,850 O&M NPV: \$7,115,801  <b>Rounded Total Present Value: \$8,000,000</b>	Capital Cost: \$6,832,000 Annual O&M Cost: \$0 O&M NPV: \$0  <b>Total Present Value: \$6,800,000</b>

Notes:  
 ARAR = Applicable or Relevant and Appropriate Requirements  
 NHDES = New Hampshire Department of Environmental Services  
 PFAS = Per- and Polyfluoroalkyl Substances  
 AGQS = Ambient Groundwater Quality Standards  
 TMV = Toxicity, mobility, and volume  
 O&M = Operation & maintenance  
 NPV = Net Present Value

**Table 4**

**Summary of Estimated Costs for Remedial Alternatives  
Tinkham's Garage Superfund Site  
Londonderry, New Hampshire**

<b>Alternative:</b>	<b>1- No Action</b>	<b>2-Bottled Water</b>	<b>3-POET Systems</b>	<b>4- Water Line Extension</b>
<b>Summary of Costs</b>				
Capital Cost	\$0	\$0	\$892,492	\$6,832,000
Annual O&M Cost	\$0	\$172,800	\$436,850	\$0
Net Present Value of 30 Years of O&M	\$0	\$2,814,720	\$7,115,801	\$0
Total 30-Year Net Present Value (rounded)	\$0	\$2,800,000	\$8,000,000	\$6,800,000

Notes:

O&M = Operation and maintenance

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**APPENDIX A**

**EPA RISK EVALUATION MEMORANDUM**

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**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**

**Region 1**

**5 Post Office Square, Suite 100**

**BOSTON, MA 02109-3912**

To: Cheryl Sprague

From: Courtney Carroll

Date: December 16, 2024

RE: Risk evaluation of PFAS and 1,4-dioxane concentrations in residential wells for Tinkham Garage NPL Site

Per request, this memorandum provides a risk evaluation for PFAS and 1,4-dioxane concentrations in residential drinking water wells located in proximity to the Tinkham Garage NPL Site in Londonderry, NH. The risk evaluation is performed for private well data for approximately 80 residences collected between 2014 and 2023 for 1,4-dioxane and for selected PFAS compounds including Perfluorooctanoic acid (PFOA), Perfluorooctane sulfonate (PFOS), Perfluorononanoic acid (PFNA), Perfluorobutanesulfonic Acid (PFBS), Perfluorobutanoic Acid (PFBA), Perfluorohexanesulfonic Acid (PFHxS), and Perfluorohexanoic Acid (PFHxA). Private well data is unavailable for Perfluorodecanoic acid (PFDA); therefore, it is not included in the risk evaluation. Additionally, EPA does not currently have toxicity values available for Perfluoropentanoic Acid (PFPeA) or Perfluoroheptanoic Acid (PFHpA), therefore risks for these compounds could not be estimated.

A residential tapwater scenario was used for the risk evaluation which assumes potable uses of water such as drinking and bathing and that a person may be exposed to contaminants through ingestion, dermal and inhalation routes. There is currently limited dermal toxicity data for PFAS compounds. Additionally, EPA does not currently have inhalation toxicity data available for PFAS compounds, therefore there is potential for risks to be underestimated due to limited toxicity information for the dermal and inhalation pathways.

Estimation of Exposure

In risk assessment, to evaluate the magnitude of potential human exposures, the concentrations of contaminants must be estimated. An estimate of this concentration is referred to as an Exposure Point Concentration (EPC). EPA guidance recommends calculation of the 95% UCL on the arithmetic mean concentration for estimation of risk. The 2014 OSWER Directive on Determining Groundwater EPCs generally recommends that data for private wells be evaluated on an individual basis because there may be limited availability of construction information to determine if wells are comparable. However, for the Tinkham Garage site, an approach to combine the extensive volume of residential data from all individual residential wells was used in order to calculate the 95% UCLs for 1,4-dioxane and the selected PFAS compounds for this risk evaluation. While it is noted that the approach of evaluating an exposure scenario by combining residential well data may increase uncertainty about representativeness of the EPC, this method was determined to be a reasonable approach for this risk evaluation for residential receptors. As documented in the RISM, contaminant migration in fractured bedrock is driven by both the hydraulic gradient and the orientation of the fractures. The residential wells in this data set are comparable in that they are all located within the bedrock aquifer and hydraulically downgradient of the Tinkham garage Site or along predominant fracture orientation which has been mapped at the Site. Patterns for the migration of contaminants have been noted for Site contaminants, including 1,4-

dioxane and PFAS, which have raised concerns about the uncontrolled migration of site contaminants, the continued use of private wells and the further pulling of Site contamination toward residences.

The 95% UCLs for PFOA, PFOS, PFNA, PFBA, PFBS, PFHxS, PFHxA, and 1,4-dioxane were calculated using ProUCL (version 5.2) and are displayed in Table 1 below.

**Table 1 – Exposure Point Concentrations (EPCs)**

PFOA	PFOS	PFNA	PFBA	PFBS	PFHxS	PFHxA	1,4-dioxane
13.08 ng/L	4.74 ng/L	1.72 ng/L	2.94 ng/L	4.28 ng/L	2.36 ng/L	3.76 ng/L	0.197 µg/L

Calculation of Risk

The EPCs obtained for the PFAS compounds and 1,4-dioxane representing the 95% UCLs were used in the EPA RSL calculator to generate estimates of risk for residential tap water use. For comparison, estimations of risk are also provided using the minimum concentrations detected for PFAS and 1,4-dioxane, and estimations of risk are provided using the maximum concentrations detected for PFAS and 1,4-dioxane. All default exposure parameters were used to estimate risks for the resident. The exposure parameters used are listed below in Table 2. Additionally, Table 3 below provides the formulas used in the RSL calculator and Table 4 below provides the most current toxicity values available for 1,4-dioxane and the selected PFAS compounds. Output files from the RSL calculator are also included as attachments.

Estimates of ILCR represent the lifetime incremental risk of cancer from the Site. Hazard quotient (HQ) estimates represent the risk of health effects other than cancer from exposure to Site contaminants. A hazard index (HI) is obtained by summing HQs for individual contaminants. The risk calculations using the 95 UCLs are shown in Table 5 for estimates of ILCR and Table 6 for non-cancer hazard. Risk estimates for ICLR and non-cancer hazard using the minimum detected concentrations are provided in Tables 7 and 8. Table 9 provides the risk estimates for ILCR using the maximum concentrations while Table 10 provides estimates of non-cancer hazard using the maximum concentrations. The risk estimates for the minimum detected concentrations and the maximum concentrations are provided for comparison only. Risk managers will use the results for the 95 UCLs to base the risk management decision.

**Table 2 – Exposure Parameters**

Receptor	Body weight (kg)	Exposure Duration (years)	Exposure Frequency (days/year)	Exposure Time Dermal (hours/event)	Exposure Time Inhalation (hours/event)	Events per day	Ingestion Rate Water (Liters per day)	Skin Surface Area (cm <sup>2</sup> )
Child	15	6	350	0.54	24	1	0.78	6365
Adult	80	20	350	0.71	24	1	2.5	19652

Table 3 – Formulas

<p>Non-carcinogenic Child Resident Ingestion</p>	$SL_{res-sol-ingnc} \left( \frac{mg}{kg} \right) = \frac{THQ \times AT_{res-c} \left( \frac{365 \text{ days}}{yr} \times ED_{res-c} (6 \text{ yr}) \right) \times BW_{res-c} (15 \text{ kg})}{\left( \frac{RBA}{RfDo} \left( \frac{mg}{kg-day} \right) \right) \times \left( \frac{10^{-6} \text{ kg}}{mg} \right) \times EF_{res-c} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-c} (6 \text{ yr}) \times IRS_{res-c} \left( \frac{200 \text{ mg}}{day} \right)}$
<p>Non-carcinogenic Child Resident Dermal*</p>	$SL_{res-sol-dernc} \left( \frac{mg}{kg} \right) = \frac{THQ \times AT_{res-c} \left( \frac{365 \text{ days}}{yr} \times ED_{res-c} (6 \text{ yr}) \right) \times BW_{res-c} (15 \text{ kg})}{\left( \frac{1}{RfDo} \left( \frac{mg}{kg-day} \right) \times GIABS \right) \times \left( \frac{10^{-6} \text{ kg}}{mg} \right) \times EF_{res-c} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-c} (6 \text{ yr}) \times SA_{res-c} \left( \frac{2,373 \text{ cm}^2}{day} \right) \times AF_{res-c} \left( \frac{0.2 \text{ mg}}{\text{cm}^2} \right) \times ABS_d}$
<p>Non-carcinogenic Child Resident Inhalation**</p>	$SL_{res-sol-inhnc} \left( \frac{mg}{kg} \right) = \frac{THQ \times AT_{res-c} \left( \frac{365 \text{ days}}{yr} \times ED_{res-c} (6 \text{ yr}) \right)}{\left( \frac{1}{RfC} \left( \frac{mg}{m^3} \right) \right) \times EF_{res-c} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-c} (6 \text{ yr}) \times ET_{res-c} \left( \frac{24 \text{ hrs}}{day} \right) \times \left( \frac{1 \text{ day}}{24 \text{ hrs}} \right) \times \left( \frac{1}{VF_{ulim}} \left( \frac{m^3}{kg} \right) + \frac{1}{PEF} \left( \frac{m^3}{kg} \right) \right)}$
<p>Non-carcinogenic Child Resident Total</p>	$SL_{res-sol-totnc} \left( \frac{mg}{kg} \right) = \frac{1}{\frac{1}{SL_{res-sol-ingnc}} + \frac{1}{SL_{res-sol-inhnc}} + \frac{1}{SL_{res-sol-dernc}}}$
<p>Non-carcinogenic Risk Calculation</p>	<p>Hazard Quotient = (Exposure Point Concentration × Target Hazard Quotient) / Regional Screening Level</p>
<p>Carcinogenic Ingestion</p>	$SL_{res-sol-ingc} \left( \frac{mg}{kg} \right) = \frac{TR \times AT_{res} \left( \frac{365 \text{ days}}{yr} \times LT (70 \text{ yrs}) \right)}{CSF_o \left( \frac{mg}{kg-day} \right)^{-1} \times \left( \frac{10^{-6} \text{ kg}}{mg} \right) \times RBA \times IFS_{res-adj} \left( \frac{36,750 \text{ mg}}{kg} \right)}$ <p>where:</p> $IFS_{res-adj} \left( \frac{36,750 \text{ mg}}{kg} \right) = \left[ \frac{EF_{res-c} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-c} (6 \text{ yr}) \times IRS_{res-c} \left( \frac{200 \text{ mg}}{day} \right)}{BW_{res-c} (15 \text{ kg})} + \frac{EF_{res-a} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-a} (20 \text{ yr}) \times IRS_{res-a} \left( \frac{100 \text{ mg}}{day} \right)}{BW_{res-a} (80 \text{ kg})} \right]$
<p>Carcinogenic Dermal*</p>	$SL_{res-sol-derc} \left( \frac{mg}{kg} \right) = \frac{TR \times AT_{res} \left( \frac{365 \text{ days}}{yr} \times LT (70 \text{ yrs}) \right)}{\left( \frac{CSF_o \left( \frac{mg}{kg-day} \right)^{-1}}{GIABS} \right) \times \left( \frac{10^{-6} \text{ kg}}{mg} \right) \times DFS_{res-adj} \left( \frac{103,390 \text{ mg}}{kg} \right) \times ABS_d}$ <p>where:</p> $DFS_{res-adj} \left( \frac{103,390 \text{ mg}}{kg} \right) = \left[ \frac{EF_{res-c} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-c} (6 \text{ yr}) \times SA_{res-c} \left( \frac{2,373 \text{ cm}^2}{day} \right) \times AF_{res-c} \left( \frac{0.2 \text{ mg}}{\text{cm}^2} \right)}{BW_{res-c} (15 \text{ kg})} + \frac{EF_{res-a} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res-a} (20 \text{ yr}) \times SA_{res-a} \left( \frac{6,032 \text{ cm}^2}{day} \right) \times AF_{res-a} \left( \frac{0.07 \text{ mg}}{\text{cm}^2} \right)}{BW_{res-a} (80 \text{ kg})} \right]$

Carcinogenic Inhalation**	$SL_{res-sol-inhc} \left( \frac{mg}{kg} \right) = \frac{TR \times AT_{res} \left( \frac{365 \text{ days}}{yr} \times LT(70 \text{ yrs}) \right)}{IUR \left( \frac{\mu g}{m^3} \right)^{-1} \times \left( \frac{1000 \mu g}{mg} \right) \times EF_{res} \left( \frac{350 \text{ days}}{yr} \right) \times ED_{res} (26 \text{ yr}) \times ET_{res} \left( \frac{24 \text{ hrs}}{\text{day}} \right) \times \left( \frac{1 \text{ day}}{24 \text{ hrs}} \right) \times \left( \frac{1}{VF_{ulim} \left( \frac{m^3}{kg} \right)} + \frac{1}{PEF \left( \frac{m^3}{kg} \right)} \right)}$
Carcinogenic Total	$SL_{res-sol-totc} \left( \frac{mg}{kg} \right) = \frac{1}{\frac{1}{SL_{res-sol-ingc}} + \frac{1}{SL_{res-sol-inhc}} + \frac{1}{SL_{res-sol-derc}}}$
Carcinogenic Risk Calculation	Carcinogenic Risk = (Exposure Point Concentration × Target Risk) / Regional Screening Level

\*Dermal toxicity limited for PFAS compounds

\*\*No inhalation tox for PFAS compounds, only applies to 1,4-dioxane

Table 4 – Toxicity Values

<u>Chemical</u>	<u>Oral Slope Factor</u> (mg/kg-day) <sup>-1</sup>	<u>Inhalation Unit Risk</u> (μg/m <sup>3</sup> ) <sup>-1</sup>	<u>Chronic Oral Reference Dose</u> (mg/kg-day)	<u>Chronic RfD target organ</u>	<u>Chronic Inhalation Reference Concentration</u> (mg/m <sup>3</sup> )	<u>Chronic RfC target organ</u>
PFOA	2.93E+04	-	3.00E-08	Developmental	-	-
PFOS	3.95E+01	-	1.00E-07	Developmental	-	-
PFNA	-	-	3.00E-06	Developmental	-	-
PFBS	-	-	3.00E-04	Thyroid	-	-
PFBA	-	-	1.00E-03	Liver and Thyroid	-	-
PFHxA	-	-	5.00E-04	Developmental	-	-
PFHxS	-	-	2.00E-05	Endocrine	-	-
1,4-Dioxane	1.00E-01	5.00E-06	3.00E-02	Liver and Kidney	3.00E-02	Nasal cavity

Table 5 – ILCR Estimates for PFAS and 1,4-Dioxane using 95 UCLs as EPCs

Chemical	Exposure Point Concentration	Ingestion Risk	Dermal Risk	Inhalation Risk	Incremental Lifetime Cancer Risk (ILCR)
PFOA	13.08 ng/L	<b>4.92E-03</b>	8.97E-06	-	<b>4.93E-03</b>
PFOS	4.74 ng/L	2.40E-06	-	-	2.40E-06
PFNA	1.72 ng/L	-	-	-	-
PFBA	2.94 ng/L	-	-	-	-
PFBS	4.28 ng/L	-	-	-	-
PFHxS	2.36 ng/L	-	-	-	-
PFHxA	3.76 ng/L	-	-	-	-
1,4-Dioxane	0.197 μg/L	2.53E-07	8.66E-10	1.75E-07	4.29E-07

<b>Total Risk</b>		<b>4.92E-03</b>	8.97E-06	1.75E-07	<b>4.93E-03</b>

Table 6 – Non-cancer Hazard Estimates for PFAS and 1,4-Dioxane using 95 UCLs as EPCs

Chemical	Exposure Point Concentration	Ingestion HQ	Dermal HQ	Inhalation HQ	Non-cancer hazard quotient (HQ)
PFOA	13.08 ng/L	<b>2.17E+01</b>	3.65E-02	-	<b>2.18E+01</b>
PFOS	4.74 ng/L	<b>2.36E+00</b>	-	-	<b>2.36E+00</b>
PFNA	1.72 ng/L	2.86E-02	6.09E-04	-	2.92E-02
PFBA	2.94 ng/L	1.47E-04	1.27E-05	-	1.59E-04
PFBS	4.28 ng/L	7.11E-04	5.10E-07	-	7.12E-04
PFHxS	2.36 ng/L	5.88E-03	1.08E-04	-	5.99E-03
PFHxA	3.76 ng/L	3.75E-04	4.10E-06	-	3.79E-04
1,4-Dioxane	0.197 µg/L	3.27E-04	1.03E-06	3.15E-03	3.48E-03
<b>Total Hazard</b>		<b>2.41E+01</b>	3.72E-02	3.15E-03	<b>2.42E+01</b>
Developmental HI <b>2.42E+01</b> Kidney HI 3.48E-03 Liver HI 3.48E-03 Thyroid HI 8.71E-04 Endocrine HI 5.99E-03 Nasal HI 3.15E-03					

Table 7 – ILCR Estimates for PFAS and 1,4-Dioxane using minimum detected concentrations as EPCs

Chemical	Exposure Point Concentration	Ingestion Risk	Dermal Risk	Inhalation Risk	Incremental Lifetime Cancer Risk (ILCR)
PFOA	1.80 ng/L	<b>6.77E-04</b>	1.23E-06	-	<b>6.78E-04</b>
PFOS	1.82 ng/L	9.23E-07	-	-	-
PFNA	1.77 ng/L	-	-	-	-
PFBA	1.79 ng/L	-	-	-	-
PFBS	1.84 ng/L	-	-	-	-
PFHxS	1.77 ng/L	-	-	-	-
PFHxA	1.77 ng/L	-	-	-	-
1,4-Dioxane	0.133 µg/L	1.71E-07	5.85E-10	1.23E-06	2.90E-07
<b>Total Risk</b>		<b>6.78E-04</b>	1.24E-06	1.18E-07	<b>6.79E-04</b>

Table 8 – Non-cancer Hazard Estimates for PFAS and 1,4-Dioxane using minimum detected concentrations as EPCs

Chemical	Exposure Point Concentration	Ingestion HQ	Dermal HQ	Inhalation HQ	Non-cancer hazard quotient (HQ)
PFOA	1.80 ng/L	<b>2.99E+00</b>	5.02E-03	-	<b>3.00E+00</b>
PFOS	1.82 ng/L	9.08E-01	-	-	9.08E-01
PFNA	1.77 ng/L	2.94E-02	6.27E-04	-	3.00E-02
PFBA	1.79 ng/L	8.93E-05	7.74E-06	-	9.70E-05
PFBS	1.84 ng/L	3.06E-04	2.19E-07	-	3.06E-04
PFHxS	1.77 ng/L	4.41E-03	8.07E-05	-	4.49E-03
PFHxA	1.77 ng/L	1.77E-04	1.93E-06	-	1.78E-04
1,4-Dioxane	0.133 µg/L	2.21E-04	6.96E-07	2.13E-03	2.35E-03
<b>Total Hazard</b>		<b>3.93E+00</b>	5.74E-03	2.13E-03	<b>3.94E+00</b>
Developmental HI <b>3.94E+00</b> Kidney HI 2.35E-03 Liver HI 2.45E-03 Thyroid HI 4.03E-04 Endocrine HI 4.49E-03 Nasal HI 2.13E-03					

Table 9 – ILCR Estimates for PFAS and 1,4-Dioxane using maximum detected concentrations as EPCs

Chemical	Exposure Point Concentration	Ingestion Risk	Dermal Risk	Inhalation Risk	Incremental Lifetime Cancer Risk (ILCR)
PFOA	831 ng/L	<b>2.68E-01</b>	<b>5.70E-04</b>	-	<b>2.69E-01</b>
PFOS	67 ng/L	3.40E-05	-	-	3.40E-05
PFNA	3.61ng/L	-	-	-	-
PFBA	35 ng/L	-	-	-	-
PFBS	32.4 ng/L	-	-	-	-
PFHxS	12 ng/L	-	-	-	-
PFHxA	42 ng/L	-	-	-	-
1,4-Dioxane	1.65 µg/L	2.12E-06	7.25E-09	1.47E-06	3.59E-06
<b>Total Risk</b>		<b>2.68E-01</b>	<b>5.70E-04</b>	1.47E-06	<b>2.69E-01</b>

Table 10 – Non-cancer Hazard Estimates for PFAS and 1,4-Dioxane using maximum detected concentrations as EPCs

Chemical	Exposure Point Concentration	Ingestion HQ	Dermal HQ	Inhalation HQ	Non-cancer hazard quotient (HQ)
PFOA	831 ng/L	<b>1.38E+03</b>	<b>2.32E+00</b>	-	<b>1.38E+03</b>

PFOS	67 ng/L	<b>3.34E+01</b>	-	-	<b>3.34E+01</b>
PFNA	3.61 ng/L	6.00E-02	1.28E-03	-	3.34E+01
PFBA	35 ng/L	1.75E-03	1.51E-04	-	1.90E-03
PFBS	32.4 ng/L	5.39E-03	3.86E-06	-	5.39E-03
PFHxS	12 ng/L	2.99E-02	5.47E-04	-	3.05E-02
PFHxA	42 ng/L	4.19E-03	4.58E-05	-	4.23E-03
1,4-Dioxane	1.65 µg/L	2.74E-03	8.64E-06	2.64E-02	2.91E-02
<b>Total Hazard</b>		<b>1.41E+03</b>	<b>2.32E+00</b>	2.64E-02	<b>1.42E+03</b>
			Developmental HI <b>1.41E+03</b>		
			Kidney HI 2.91E-02		
			Liver HI 3.10E-02		
			Thyroid HI 7.29E-03		
			Endocrine HI 3.05E-02		
			Nasal HI 2.64E-02		

Risk results shown in Table 5 which use the 95 UCLs indicate that the total ILCR exceeds the EPA target cancer risk range of  $10^{-4}$  to  $10^{-6}$  due to concentrations of PFOA and 1,4-dioxane. The results for non-cancer hazard shown in Table 6 using 95 UCLs indicate that the total non-cancer HI exceeds a target limit of 1; therefore, non-cancer hazard was then broken down by target organ to determine if organ specific HIs exceed the target limit of 1. The breakdown by target organ indicates that the HI for developmental effects exceeds the target limit of 1 due to concentrations of PFOA, PFOS, PFNA and PFHxA.

For comparison, risk results were also calculated using minimum detected concentrations of PFAS and 1,4-dioxane. The risk results using minimum detected concentrations show that minimum detected concentrations of PFAS and 1,4-dioxane also result in cancer risk exceeding the target risk range and non-cancer hazard exceeding the target limit of 1 for developmental effects. Additionally, risks were calculated using maximum detected PFAS and 1,4-dioxane which showed significantly increased risks from cancer and non-cancer effects.

The results of the risk evaluation indicate that cancer and non-cancer risks are exceeded for the residential well data.

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# ATTACHMENTS

Site-specific  
Resident Risk for Tap Water

Chemical	SF <sub>6</sub> (mg/kg-day) <sup>1</sup>	SF <sub>6</sub> Ref	IUR (ug/m <sup>3</sup> ) <sup>1</sup>	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m <sup>3</sup> )	RfC Ref	GIABS	K <sub>0</sub> (cm/hr)	MW	B (unitless)	t (hr)	T <sub>1/2</sub> (hr)(vev)	FA (unitless)	In EPD?	DA <sub>vent (inc child)</sub>	DA <sub>vent (inc adult)</sub>	MCL (ug/L)	Concentration (ug/L)	Ingestion Risk	Dermal Risk	Inhalation Risk	Carcinogenic Risk	Ingestion Child HQ	Dermal Child HQ	Inhalation Child HQ	Noncarcinogenic Child HI	Ingestion Adult HQ	Dermal Adult HQ	Inhalation Adult HQ	Noncarcinogenic Adult HI	
Dioxane, 1,4-	1.00E-01	I	5.00E-06	I	3.00E-02	I	3.00E-02	I	1.00E+00	3.32E-04	#####	1.20E-03	7.86E-01	3.28E-01	1.00E+00	Yes	9.79E-05	7.37E-03	1.27E-02	-	1.97E-01	2.53E-07	8.66E-10	1.75E-07	4.29E-07	3.27E-04	1.03E-06	3.15E-03	3.48E-03	1.97E-04	6.84E-07	3.15E-03	3.35E-03
Perfluorobutanesulfonic acid (PFBS)	-	-	-	-	3.00E-04	P	-	-	1.00E+00	1.93E-05	#####	1.28E-04	1.21E+01	5.04E+00	1.00E+00	Yes	-	7.37E-05	1.27E-04	-	4.28E-03	-	-	-	7.11E-04	5.10E-07	-	7.12E-04	4.28E-04	3.39E-07	-	4.28E-04	3.35E-03
Perfluorobutanoic acid (PFBA)	-	-	-	-	1.00E-03	I	-	-	1.00E+00	4.06E-03	#####	2.29E-02	3.99E+00	1.66E+00	1.00E+00	Yes	-	2.46E-04	4.25E-04	-	2.94E-03	-	-	-	1.47E-04	1.27E-05	-	1.59E-04	8.81E-05	8.44E-06	-	9.65E-05	3.35E-03
Perfluorohexanesulfonic acid (PFHxS)	-	-	-	-	2.00E-05	A	-	-	1.00E+00	2.58E-04	#####	1.99E-03	4.39E+01	1.83E+01	1.00E+00	Yes	-	4.92E-06	8.49E-06	1.00E-02	2.36E-03	-	-	-	5.88E-03	1.08E-04	-	5.99E-03	3.54E-03	7.15E-05	-	3.61E-03	3.35E-03
Perfluorohexanoic acid (PFHxA)	-	-	-	-	5.00E-04	I	-	-	1.00E+00	2.69E-04	#####	1.83E-03	1.45E+01	6.04E+00	1.00E+00	Yes	-	1.23E-04	2.12E-04	-	3.76E-03	-	-	-	3.75E-04	4.10E-06	-	3.79E-04	2.25E-04	2.72E-06	-	2.28E-04	3.35E-03
Perfluorononanoic acid (PFNA)	-	-	-	-	3.00E-06	A	-	-	1.00E+00	1.99E-04	#####	1.65E-03	1.00E+02	4.18E+01	1.00E+00	Yes	-	7.37E-07	1.27E-06	1.00E-02	1.72E-03	-	-	-	2.86E-02	6.09E-04	-	2.92E-02	1.72E-02	4.04E-04	-	1.76E-02	3.35E-03
Perfluorooctanesulfonic acid (PFOS)	3.95E+01	D	-	-	1.00E-07	D	-	-	1.00E+00	4.69E-07	#####	4.03E-06	1.59E+02	6.64E+01	1.00E+00	No	-	-	-	4.00E-03	4.74E-03	2.40E-06	-	-	2.40E-06	2.36E+00	-	-	2.36E+00	1.42E+00	-	-	1.42E+00
Perfluorooctanoic acid (PFOA)	2.93E+04	D	-	-	3.00E-08	D	-	-	1.00E+00	2.16E-05	#####	1.69E-04	5.28E+01	2.20E+01	1.00E+00	Yes	3.34E-10	7.37E-09	1.27E-08	4.00E-03	1.31E-02	4.92E-03	8.97E-06	-	4.93E-03	2.17E+01	3.65E-02	-	2.18E+01	1.31E+01	2.42E-02	-	1.31E+01
<b>Total Risk/HI</b>																					<b>4.92E-03</b>	<b>8.97E-06</b>	<b>1.75E-07</b>	<b>4.93E-03</b>	<b>2.41E+01</b>	<b>3.72E-02</b>	<b>3.15E-03</b>	<b>2.42E+01</b>	<b>1.45E+01</b>	<b>2.47E-02</b>	<b>3.15E-03</b>	<b>1.45E+01</b>	

Site-specific  
Resident Risk for Tap Water

Chemical	SF <sub>6</sub> (mg/kg-day) <sup>1</sup>	SF <sub>6</sub> Ref	IUR (ug/m <sup>3</sup> ) <sup>1</sup>	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m <sup>3</sup> )	RfC Ref	GIABS	K <sub>0</sub> (cm/hr)	MW	B (unitless)	t (hr)	T <sub>1/2</sub> (hr/veve nt)	FA (unitless)	In EPD?	DA <sub>vent (inc child)</sub>	DA <sub>vent (inc adult)</sub>	MCL (ug/L)	Concentration (ug/L)	Ingestion Risk	Dermal Risk	Inhalation Risk	Carcinogenic Risk	Ingestion Child HQ	Dermal Child HQ	Inhalation Child HQ	Noncarcinogenic Child HI	Ingestion Adult HQ	Dermal Adult HQ	Inhalation Adult HQ	Noncarcinogenic Adult HI	
Dioxane, 1,4-	1.00E-01	I	5.00E-06	I	3.00E-02	I	3.00E-02	I	1.00E+00	3.32E-04	#####	1.20E-03	7.86E-01	3.28E-01	1.00E+00	Yes	9.79E-05	7.37E-03	1.27E-02	-	1.65E+00	2.12E-06	7.25E-09	1.47E-06	3.59E-06	2.74E-03	8.64E-06	2.64E-02	2.91E-02	1.65E-03	5.73E-06	2.64E-02	2.80E-02
Perfluorobutanesulfonic acid (PFBS)	-	-	-	-	3.00E-04	P	-	-	1.00E+00	1.93E-05	#####	1.28E-04	1.21E+01	5.04E+00	1.00E+00	Yes	-	7.37E-05	1.27E-04	-	3.24E-02	-	-	-	5.39E-03	3.86E-06	-	5.39E-03	3.24E-03	2.58E-06	-	3.24E-03	
Perfluorobutanoic acid (PFBA)	-	-	-	-	1.00E-03	I	-	-	1.00E+00	4.06E-03	#####	2.29E-02	3.99E+00	1.66E+00	1.00E+00	Yes	-	2.46E-04	4.25E-04	-	3.50E-02	-	-	-	1.75E-03	1.51E-04	-	1.90E-03	1.05E-03	1.01E-04	-	1.15E-03	
Perfluorohexanesulfonic acid (PFHxS)	-	-	-	-	2.00E-05	A	-	-	1.00E+00	2.58E-04	#####	1.99E-03	4.39E+01	1.83E+01	1.00E+00	Yes	-	4.92E-06	8.49E-06	1.00E-02	1.20E-02	-	-	-	2.99E-02	5.47E-04	-	3.05E-02	1.80E-02	3.63E-04	-	1.83E-02	
Perfluorohexanoic acid (PFHxA)	-	-	-	-	5.00E-04	I	-	-	1.00E+00	2.69E-04	#####	1.83E-03	1.45E+01	6.04E+00	1.00E+00	Yes	-	1.23E-04	2.12E-04	-	4.20E-02	-	-	-	4.19E-03	4.58E-05	-	4.23E-03	2.52E-03	3.04E-05	-	2.55E-03	
Perfluorononanoic acid (PFNA)	-	-	-	-	3.00E-06	A	-	-	1.00E+00	1.99E-04	#####	1.65E-03	1.00E+02	4.18E+01	1.00E+00	Yes	-	7.37E-07	1.27E-06	1.00E-02	3.61E-03	-	-	-	6.00E-02	1.28E-03	-	6.13E-02	3.61E-02	8.48E-04	-	3.69E-02	
Perfluorooctanesulfonic acid (PFOS)	3.95E+01	D	-	-	1.00E-07	D	-	-	1.00E+00	4.69E-07	#####	4.03E-06	1.59E+02	6.64E+01	1.00E+00	No	-	-	-	4.00E-03	6.70E-02	3.40E-05	-	-	3.40E-05	3.34E+01	-	-	3.34E+01	2.01E+01	-	-	2.01E+01
Perfluorooctanoic acid (PFOA)	2.93E+04	D	-	-	3.00E-08	D	-	-	1.00E+00	2.16E-05	#####	1.69E-04	5.28E+01	2.20E+01	1.00E+00	Yes	3.34E-10	7.37E-09	1.27E-08	4.00E-03	8.31E-01	2.68E-01	5.70E-04	-	2.69E-01	1.38E+03	2.32E+00	-	1.38E+03	8.30E+02	1.54E+00	-	8.32E+02
<b>Total Risk/HI</b>																					<b>2.68E-01</b>	<b>5.70E-04</b>	<b>1.47E-06</b>	<b>2.69E-01</b>	<b>1.41E+03</b>	<b>2.32E+00</b>	<b>2.64E-02</b>	<b>1.42E+03</b>	<b>8.30E+02</b>	<b>1.54E+00</b>	<b>2.64E-02</b>	<b>8.32E+02</b>	

Site-specific  
Resident Risk for Tap Water

Chemical	SF <sub>6</sub> (mg/kg-day) <sup>1</sup>	SF <sub>6</sub> Ref	IUR (ug/m <sup>3</sup> ) <sup>1</sup>	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m <sup>3</sup> )	RfC Ref	GIABS	K <sub>0</sub> (cm/hr)	MW	B (unitless)	t (hr)	T <sub>1/2</sub> (hr/vev)	FA (unitless)	In EPD?	DA <sub>vent (inc child)</sub>	DA <sub>vent (inc adult)</sub>	MCL (ug/L)	Concentration (ug/L)	Ingestion Risk	Dermal Risk	Inhalation Risk	Carcinogenic Risk	Ingestion Child HQ	Dermal Child HQ	Inhalation Child HQ	Noncarcinogenic Child HI	Ingestion Adult HQ	Dermal Adult HQ	Inhalation Adult HQ	Noncarcinogenic Adult HI	
Dioxane, 1,4-	1.00E-01	I	5.00E-06	I	3.00E-02	I	3.00E-02	I	1.00E+00	3.32E-04	#####	1.20E-03	7.86E-01	3.28E-01	1.00E+00	Yes	9.79E-05	7.37E-03	1.27E-02	-	1.33E-01	1.71E-07	5.85E-10	1.18E-07	2.90E-07	2.21E-04	6.96E-07	2.13E-03	2.35E-03	1.33E-04	4.62E-07	2.13E-03	2.26E-03
Perfluorobutanesulfonic acid (PFBS)	-	-	-	-	3.00E-04	P	-	-	1.00E+00	1.93E-05	#####	1.28E-04	1.21E+01	5.04E+00	1.00E+00	Yes	-	7.37E-05	1.27E-04	-	1.84E-03	-	-	-	3.06E-04	2.19E-07	-	3.06E-04	1.84E-04	1.46E-07	-	1.84E-04	
Perfluorobutanoic acid (PFBA)	-	-	-	-	1.00E-03	I	-	-	1.00E+00	4.06E-03	#####	2.29E-02	3.99E+00	1.66E+00	1.00E+00	Yes	-	2.46E-04	4.25E-04	-	1.79E-03	-	-	-	8.93E-05	7.74E-06	-	9.70E-05	5.36E-05	5.14E-06	-	5.88E-05	
Perfluorohexanesulfonic acid (PFHxS)	-	-	-	-	2.00E-05	A	-	-	1.00E+00	2.58E-04	#####	1.99E-03	4.39E+01	1.83E+01	1.00E+00	Yes	-	4.92E-06	8.49E-06	1.00E-02	1.77E-03	-	-	-	4.41E-03	8.07E-05	-	4.49E-03	2.65E-03	5.36E-05	-	2.71E-03	
Perfluorohexanoic acid (PFHxA)	-	-	-	-	5.00E-04	I	-	-	1.00E+00	2.69E-04	#####	1.83E-03	1.45E+01	6.04E+00	1.00E+00	Yes	-	1.23E-04	2.12E-04	-	1.77E-03	-	-	-	1.77E-04	1.93E-06	-	1.78E-04	1.06E-04	1.28E-06	-	1.07E-04	
Perfluorononanoic acid (PFNA)	-	-	-	-	3.00E-06	A	-	-	1.00E+00	1.99E-04	#####	1.65E-03	1.00E+02	4.18E+01	1.00E+00	Yes	-	7.37E-07	1.27E-06	1.00E-02	1.77E-03	-	-	-	2.94E-02	6.27E-04	-	3.00E-02	1.77E-02	4.16E-04	-	1.81E-02	
Perfluorooctanesulfonic acid (PFOS)	3.95E+01	D	-	-	1.00E-07	D	-	-	1.00E+00	4.69E-07	#####	4.03E-06	1.59E+02	6.64E+01	1.00E+00	No	-	-	-	4.00E-03	1.82E-03	9.23E-07	-	-	9.23E-07	9.08E-01	-	-	9.08E-01	5.45E-01	-	-	5.45E-01
Perfluorooctanoic acid (PFOA)	2.93E+04	D	-	-	3.00E-08	D	-	-	1.00E+00	2.16E-05	#####	1.69E-04	5.28E+01	2.20E+01	1.00E+00	Yes	3.34E-10	7.37E-09	1.27E-08	4.00E-03	1.80E-03	6.77E-04	1.23E-06	-	6.78E-04	2.99E+00	5.02E-03	-	3.01E+00	1.80E+00	3.33E-03	-	1.80E+00
<b>Total Risk/HI</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<b>6.78E-04</b>	<b>1.24E-06</b>	<b>1.18E-07</b>	<b>6.78E-04</b>	<b>3.93E+00</b>	<b>5.74E-03</b>	<b>2.13E-03</b>	<b>3.94E+00</b>	<b>2.36E+00</b>	<b>3.61E-03</b>	<b>2.13E-03</b>	<b>2.37E+00</b>	

Site-specific  
Resident Tap Water Inputs

/HTML"<a href=/tmp/Resident\_chem\_rsl\_19NOV2024\_prg3184322.xlsx class=button>Output to XLS</a>

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Variable	Resident Tap Water Default Value	Site-Specific Value
BW <sub>0-2</sub> (mutagenic body weight) kg	15	15
BW <sub>2-6</sub> (mutagenic body weight) kg	15	15
BW <sub>6-16</sub> (mutagenic body weight) kg	80	80
BW <sub>16-26</sub> (mutagenic body weight) kg	80	80
BW <sub>res-a</sub> (body weight - adult) kg	80	80
BW <sub>res-c</sub> (body weight - child) kg	15	15
DFW <sub>res-adj</sub> (age-adjusted dermal factor) cm <sup>2</sup> -event/kg	2610650	2610650
DFWM <sub>res-adj</sub> (mutagenic age-adjusted dermal factor) cm <sup>2</sup> -event/kg	8191633	8191633
ED <sub>res</sub> (exposure duration - resident) years	26	26
ED <sub>0-2</sub> (mutagenic exposure duration first phase) years	2	2
ED <sub>2-6</sub> (mutagenic exposure duration second phase) years	4	4
ED <sub>6-16</sub> (mutagenic exposure duration third phase) years	10	10
ED <sub>16-26</sub> (mutagenic exposure duration fourth phase) years	10	10
ED <sub>res-a</sub> (exposure duration - adult) years	20	20
ED <sub>res-c</sub> (exposure duration - child) years	6	6
EF <sub>res</sub> (exposure frequency) days/year	350	350
EF <sub>0-2</sub> (mutagenic exposure frequency first phase) days/year	350	350
EF <sub>2-6</sub> (mutagenic exposure frequency second phase) days/year	350	350
EF <sub>6-16</sub> (mutagenic exposure frequency third phase) days/year	350	350
EF <sub>16-26</sub> (mutagenic exposure frequency fourth phase) days/year	350	350
EF <sub>res-a</sub> (exposure frequency - adult) days/year	350	350
EF <sub>res-c</sub> (exposure frequency - child) days/year	350	350
ET <sub>res</sub> (exposure time) hours/day	24	24
ET <sub>event-res-adj</sub> (age-adjusted exposure time) hours/event	0.67077	0.67077
ET <sub>event-res-madj</sub> (mutagenic age-adjusted exposure time) hours/event	0.67077	0.67077
ET <sub>0-2</sub> (mutagenic dermal exposure time first phase) hours/event	0.54	0.54
ET <sub>2-6</sub> (mutagenic dermal exposure time second phase) hours/event	0.54	0.54
ET <sub>6-16</sub> (mutagenic dermal exposure time third phase) hours/event	0.71	0.71
ET <sub>16-26</sub> (mutagenic dermal exposure time fourth phase) hours/event	0.71	0.71
ET <sub>res-a</sub> (dermal exposure time - adult) hours/event	0.71	0.71
ET <sub>res-c</sub> (dermal exposure time - child) hours/event	0.54	0.54
ET <sub>0-2</sub> (mutagenic inhalation exposure time first phase) hours/day	24	24
ET <sub>2-6</sub> (mutagenic inhalation exposure time second phase) hours/day	24	24
ET <sub>6-16</sub> (mutagenic inhalation exposure time third phase) hours/day	24	24
ET <sub>16-26</sub> (mutagenic inhalation exposure time fourth phase) hours/day	24	24
ET <sub>res-a</sub> (inhalation exposure time - adult) hours/day	24	24
ET <sub>res-c</sub> (inhalation exposure time - child) hours/day	24	24
EV <sub>0-2</sub> (mutagenic events) per day	1	1
EV <sub>2-6</sub> (mutagenic events) per day	1	1
EV <sub>6-16</sub> (mutagenic events) per day	1	1
EV <sub>16-26</sub> (mutagenic events) per day	1	1
EV <sub>res-a</sub> (events - adult) per day	1	1
EV <sub>res-c</sub> (events - child) per day	1	1
THQ (target hazard quotient) unitless	0.1	0.1
IFW <sub>res-adj</sub> (adjusted intake factor) L/kg	327.95	327.95
IFWM <sub>res-adj</sub> (mutagenic adjusted intake factor) L/kg	1019.9	1019.9
IRW <sub>0-2</sub> (mutagenic water intake rate) L/day	0.78	0.78
IRW <sub>2-6</sub> (mutagenic water intake rate) L/day	0.78	0.78
IRW <sub>6-16</sub> (mutagenic water intake rate) L/day	2.5	2.5
IRW <sub>16-26</sub> (mutagenic water intake rate) L/day	2.5	2.5
IRW <sub>res-a</sub> (water intake rate - adult) L/day	2.5	2.5
IRW <sub>res-c</sub> (water intake rate - child) L/day	0.78	0.78
K (volatilization factor of Andelman) L/m <sup>3</sup>	0.5	0.5
LT (lifetime) years	70	70
SA <sub>0-2</sub> (mutagenic skin surface area) cm <sup>2</sup>	6365	6365
SA <sub>2-6</sub> (mutagenic skin surface area) cm <sup>2</sup>	6365	6365
SA <sub>6-16</sub> (mutagenic skin surface area) cm <sup>2</sup>	19652	19652
SA <sub>16-26</sub> (mutagenic skin surface area) cm <sup>2</sup>	19652	19652
SA <sub>res-a</sub> (skin surface area - adult) cm <sup>2</sup>	19652	19652
SA <sub>res-c</sub> (skin surface area - child) cm <sup>2</sup>	6365	6365
l <sub>sc</sub> (apparent thickness of stratum corneum) cm	0.001	0.001
TR (target risk) unitless	0.000001	0.000001

Site-specific

Resident Risk-Based Regional Screening Levels (RSL) for Tap Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; T = ATSDR DRAFT; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = OW; R = ORD; N = WI; W = TEF applied; E = RPF applied; G = see user guide; U = user provided; ca = cancer; nc = noncancer; \* = where: nc SL < 100X ca SL; \*\* = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF <sub>6</sub> (mg/kg-day) <sup>1</sup>	SF <sub>R</sub> ef	IUR (ug/m <sup>3</sup> ) <sup>1</sup>	IUR Ref	RID (mg/kg-day)	RID Ref	RIC (mg/m <sup>3</sup> )	RIC Ref	GIABS	K <sub>p</sub> (cm/hr)	MW	B (unitless)	t (hr)	T <sub>max</sub> (hr/rev) nt	FA (unitless)	In EPD?	DA <sub>non-cancer</sub>	DA <sub>cancer</sub>	DA <sub>non-cancer</sub>	MCL (ug/L)	Ingestion SL T10=1E-06 (ug/L)	Dermal SL T10=1E-06 (ug/L)	Inhalation SL T10=1E-06 (ug/L)	Carcinogenic SL T10=1E-06 (ug/L)	Ingestion SL Child T10=1 (ug/L)	Dermal SL Child T10=1 (ug/L)	Inhalation SL Child T10=1 (ug/L)	Noncarcinogenic SL Child T10=1 (ug/L)	Ingestion SL Adult T10=1 (ug/L)	Dermal SL Adult T10=1 (ug/L)	Inhalation SL Adult T10=1 (ug/L)	Noncarcinogenic SL Adult T10=1 (ug/L)	Screening Level (ug/L)
Dioxane, 1,4-	123-91-1	No	Yes	Organics	1.00E-01	I	5.00E-06	I	3.00E-02	I	3.00E-02	I	#####	3.32E-04	#####	1.20E-03	7.86E-01	3.26E-01	1.00E+00	Yes	9.79E-05	7.37E-03	1.27E-02	-	7.79E-01	2.28E+02	4.59E-01	6.02E+01	1.91E+04	6.26E+00	5.67E+00	1.00E+00	2.88E+04	6.26E+00	5.89E+00	4.59E-01 ca	
Perfluorobutanesulfonic acid (PFBS)	375-73-5	No	No	Organics	-	-	-	-	3.00E-04	P	-	-	#####	1.93E-05	#####	1.28E-04	1.21E+01	5.04E+00	1.00E+00	Yes	-	7.37E-05	1.27E-04	-	-	-	-	6.02E-01	8.39E+02	-	6.01E-01	1.00E+00	1.26E+03	-	1.00E+00	6.01E-01 nc	
Perfluorobutanoic acid (PFBA)	375-22-4	No	Yes	Organics	-	-	-	-	1.00E-03	I	-	-	#####	4.08E-03	#####	2.29E-02	3.99E+00	1.66E+00	1.00E+00	Yes	-	2.46E-04	4.25E-04	-	-	-	-	2.01E+00	2.31E+01	-	1.85E+00	3.34E+00	3.48E+01	-	3.05E+00	1.85E-00 nc	
Perfluorohexanesulfonic acid (PFHS)	355-46-4	No	No	Organics	-	-	-	-	2.00E-05	A	-	-	#####	2.58E-04	#####	1.99E-03	4.39E+01	1.83E+01	1.00E+00	Yes	-	4.90E-06	8.49E-06	1.00E-02	-	-	-	4.01E-02	2.19E+00	-	3.94E-02	6.67E-02	3.30E+00	-	6.54E-02	3.94E-02 nc	
Perfluorohexanoic acid (PFHA)	307-34-4	No	No	Organics	-	-	-	-	6.00E-04	I	-	-	#####	2.99E-04	#####	1.83E-03	1.45E+01	6.04E+00	1.00E+00	Yes	-	1.25E-04	2.12E-04	-	-	-	-	1.00E-03	6.17E+01	-	9.92E-01	1.67E+00	3.36E+02	-	1.65E+00	9.92E-01 nc	
Perfluorononanoic acid (PFNA)	375-96-1	No	No	Organics	-	-	-	-	3.00E-06	A	-	-	#####	1.99E-04	#####	1.65E-03	1.00E+02	4.18E+01	1.00E+00	Yes	-	7.37E-07	1.27E-06	1.00E-02	-	-	-	6.02E-03	2.83E-01	-	5.89E-03	1.00E-02	4.26E-01	-	9.78E-03	5.89E-03 nc	
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	No	No	Organics	3.9E-01	D	-	-	1.00E-07	D	-	-	#####	4.89E-07	#####	4.03E-06	1.59E+02	6.64E+01	1.00E+00	No	-	-	-	4.00E-03	1.97E-03	-	-	1.97E-03	2.01E-04	-	-	2.01E-04	3.34E-04	-	-	3.34E-04	2.01E-04 nc
Perfluorooctanoic acid (PFOA)	335-67-1	No	No	Organics	2.93E+04	D	-	-	3.00E-08	D	-	-	#####	2.16E-05	#####	1.69E-04	5.28E+01	2.20E+01	1.00E+00	Yes	3.34E-10	7.37E-09	1.27E-08	4.00E-03	2.66E-06	1.46E-03	-	2.65E-06	6.02E-05	3.99E-02	-	6.01E-05	1.00E-04	5.40E-02	-	9.99E-05	2.65E-06 ca

Inhalation Unit Risk Toxicity Metadata

Chemical	CAS Number	Chemical Type	IUR (ug/m <sup>3</sup> ) <sub>1</sub>	Toxicity Source	EPA Cancer Classification	IUR Tumor Type	IUR Target Organ	IUR Species	IUR Method	IUR Route	IUR Treatment Duration	IUR Study Reference	IUR Notes
Dioxane, 1,4-	123-91-1	Organics	0	IRIS	Likely to be carcinogenic to humans	multiple	multiple	rat	Multi-tumor dose-response model with linear extrapolation from the POD (BMDL10HED) associated with 10% extra cancer risk.	NA	NA	Kasai et al. 2009	NA
Perfluorobutanesulfonic acid (PFBS)	375-73-5	Organics	-										
Perfluorobutanoic acid (PFBA)	375-22-4	Organics	-										
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	Organics	-										
Perfluorohexanoic acid (PFHxA)	307-24-4	Organics	-										
Perfluorononanoic acid (PFNA)	375-95-1	Organics	-										
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	Organics	-										
Perfluorooctanoic acid (PFOA)	335-67-1	Organics	-										

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Oral Slope Factor Toxicity Metadata

Chemical	CAS Number	Chemical Type	SF <sub>o</sub> (mg/kg-day) <sup>-1</sup>	Toxicity Source	EPA Cancer Classification	SF <sub>o</sub> Tumor Type	SF <sub>o</sub> Target Organ	SF <sub>o</sub> Species	SF <sub>o</sub> Method	SF <sub>o</sub> Route	SF <sub>o</sub> Treatment Duration	SF <sub>o</sub> Study Reference	SF <sub>o</sub> Notes
Dioxane, 1,4-	123-91-1	Organics	0.1	IRIS	Likely to be carcinogenic to humans	Hepatocellular adenoma and carcinoma	Liver	mouse	Log-logistic model with linear extrapolation from the POD (BMDL50HED) associated with 50% extra cancer risk.	NA	NA	Kano et al. 2009	NA
Perfluorobutanesulfonic acid (PFBS)	375-73-5	Organics	-										
Perfluorobutanoic acid (PFBA)	375-22-4	Organics	-										
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	Organics	-										
Perfluorohexanoic acid (PFHxA)	307-24-4	Organics	-										
Perfluorononanoic acid (PFNA)	375-95-1	Organics	-										
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	Organics	39.5	DWSHA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Perfluorooctanoic acid (PFOA)	335-67-1	Organics	29300	DWSHA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Chemical	CAS Number	Chemical Type	Chronic RfD (mg/kg-day)	Toxicity Source	Chronic RfD Basis	Chronic RfD Confidence Level	Chronic RfD Critical Effect	Chronic RfD Target Organ	Chronic RfD Modifying Factor	Chronic RfD Uncertainty Factor	Chronic RfD Species	Chronic RfD Route	Chronic RfD Study Duration	Chronic RfD Study Reference	Chronic RfD Notes
Dioxane, 1,4-	123-91-1	Organics	0.03	IRIS	NOAEL: 9.6 mg/kg-day	Medium	Liver and kidney toxicity	Liver and Kidney	1	300	Rat	NA	NA	Kociba et al. 1974	NA
Perfluorobutanesulfonic acid (PFBS)	375-73-5	Organics	0.0003	PPRTV	BMDL: .095 mg/kg-day	Low	Decreased serum total T4 in newborn (PND1) mice	Thyroid	NA	300	Mouse	Oral	GD 1-20	Feng et al 2017	The RfD was calculated from the RfD for Potassium Perfluorobutane Sulfonate using molecular weight comparison.
Perfluorobutanoic acid (PFBA)	375-22-4	Organics	0.001	IRIS	NOAEL(HED): 1.27 mg/kg-day	Medium	Increased hepatocellular hypertrophy and decreased total T4	Liver and Thyroid	1	1000	Rat	NA	NA	Butenhoff et al. 2012a	NA
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	Organics	0.00002	ATSDR PFAS	NOAEL: 1 mg/kg-day	NA	Hypertrophy and hyperplasia of thyroid follicular cells in males	Endocr.	NA	30	Rat	Endocr.	42-56 days	Butenhoff et al. 2009a; Hoberman and York 2003	The MRL was derived based on a measured serum PFHxS level of 89.12 ug/mL at the NOAEL dose and an empirical clearance model to estimate a HED
Perfluorohexanoic acid (PFHxA)	307-24-4	Organics	0.0005	IRIS	BMD(HED): .048	Medium	Decreased F1 body weight at PND0	Developmental	1	100	Rat	NA	NA	Loveless et al. 2009	NA
Perfluorononanoic acid (PFNA)	375-95-1	Organics	0	ATSDR PFAS	NOAEL: 1 mg/kg-day	NA	Delayed postnatal development [eye opening, preputial separation and vaginal opening] and decreased body weight gain in males; decreased postnatal survival; full litter resorptions at 10 mg/kg/day	Develop.	NA	30	Mouse	Develop.	GDs 1-17	Das et al. 2015	The MRL was derived based on a measured serum PFNA level of 8.91 ug/mL at the NOAEL dose and an empirical clearance model to estimate a HED
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	Organics	0	DWSHA	NOAEL: 0.1 mg/kg-day	NA	Delayed eye opening and transient decrease in F2 pup body weight (13%) on LDs 7-14 at greater or equal to 4 mg/kg/day; decreased pup survival to postpartum day 21 at greater than or equal to 1.6 mg/kg/day	Develop.	NA	30	Rat	Develop.	84 days	Luebker et al. 2005a	The MRL was derived based on the predicted TWA serum PFOA level of 29.7 ug/mL at the NOAEL dose and an empirical clearance model to estimate a HED
Perfluorooctanoic acid (PFOA)	335-67-1	Organics	0	DWSHA	LOAEL: 0.3 mg/kg-day	NA	Altered femur and tibial bone morphology, decreased tibial mineral density; Increased locomotor activity in adult offspring	Develop.	NA	300	Mouse	Develop.	GDs 1-21	Koskela et al. 2016; Onishchenko et al. 2011	The MRL was derived based on the predicted TWA serum PFOA level of 8.29 ug/mL at the LOAEL dose and an empirical clearance model to estimate a HED

Inhalation Chronic Toxicity Metadata

Chemical	CAS Number	Chemical Type	Chronic RfC (mg/m <sup>3</sup> )	Toxicity Source	Chronic RfC Basis	Chronic RfC Confidence Level	Chronic RfC Critical Effect	Chronic RfC Target Organ	Chronic RfC Modifying Factor	Chronic RfC Uncertainty Factor	Chronic RfC Species	Chronic RfC Route	Chronic RfC Study Duration	Chronic RfC Study Reference	Chronic RfC Notes
Dioxane, 1,4-	123-91-1	Organics	0.03	IRIS	LOAEL (HEC): 32.2 mg/m3	Medium	Atrophy and respiratory metaplasia of the olfactory epithelium	Nasal cavity	1	1000	rat	NA	NA	Kasai et al. 2009	NA
Perfluorobutanesulfonic acid (PFBS)	375-73-5	Organics	-												
Perfluorobutanoic acid (PFBA)	375-22-4	Organics	-												
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	Organics	-												
Perfluorohexanoic acid (PFHxA)	307-24-4	Organics	-												
Perfluorononanoic acid (PFNA)	375-95-1	Organics	-												
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	Organics	-												
Perfluorooctanoic acid (PFOA)	335-67-1	Organics	-												

## **Tinkham Garage Neighborhood UCL Estimates**

Data on groundwater concentrations of 1,4-dioxane and selected PFAS analytes from samples of multiple residential wells collected between April 2014 and November 2023 were combined to calculate 95% upper confidence limits of the mean (UCL) estimates of these contaminants in the Tinkham Garage neighborhood groundwater. Data were analyzed using the EPA software ProUCL v. 5.2.0 (EPA, 2022). Summary statistics and the UCL estimates are provided in Table 1. Outputs of summary statistics, distribution goodness-of-fit testing outcomes, and UCL estimation are attached.

The estimated UCL for 1,4-dioxane is 0.197 µg/L (parts per billion; ppb). With the exception of PFOA with an estimated UCL of 13.1 ng/L (parts per trillion; ppt), the UCL estimates for PFAS constituents with sufficient detections ranged from 1.72 ng/L (PFNA) to 4.74 ng/L (PFOS).

### **Reference:**

EPA. 2022. ProUCL: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. Version 5.2. <https://www.epa.gov/land-research/proucl-software>.

**Table 1****Tinkham Garage Neighborhood UCL Estimates**

Analyte	Units	NumObs	Num Ds	NumNDs	% NDs	Min ND	Max ND	Minimum D	Maximum D	Median <sup>1</sup>	KM Mean	KM SD	KM CV	UCL
1,4-Dioxane	µg/L	697	247	450	64.56%	0.0144	0.2	0.133	1.65	0.15	0.17	0.25	1.46	0.197
9-Chlorohexadecafluoro-3-Oxanone-1-Sulfonic Acid (9Cl-PF3ONS)	ng/L	43	1	42	97.67%	2	2	12.5	12.5	2.00	2.24	1.58	0.71	--
N-ethyl perfluorooctane sulfonamido acetic acid (EtFOSAA)	ng/L	42	0	42	100.00%	2	2	--	--	2.00	--	--	--	--
Perfluorobutanesulfonic Acid (PFBS)	ng/L	707	460	247	34.94%	1.7	4.1	1.84	32.4	3.00	4.06	3.56	0.88	4.28
Perfluorobutanoic Acid (PFBA)	ng/L	706	346	360	50.99%	1.7	4.1	1.79	35	2.00	2.79	2.41	0.86	2.94
Perfluoroheptanoic Acid (PFHpA)	ng/L	705	214	491	69.65%	1.7	4.1	1.75	18	1.85	2.32	1.65	0.72	2.42
Perfluorohexanesulfonic Acid (PFHxS)	ng/L	696	287	409	58.76%	1.7	4.1	1.77	12	1.90	2.29	1.19	0.52	2.36
Perfluorohexanoic Acid (PFHxA)	ng/L	703	370	333	47.37%	1.7	4	1.77	42	2.00	3.53	3.62	1.02	3.76
Perfluorononanoic Acid (PFNA)	ng/L	702	11	691	98.43%	1.7	4.1	1.77	3.61	1.81	1.71	0.13	0.07	1.72
Perfluoropentanoic Acid (PFPeA)	ng/L	707	366	341	48.23%	1.7	4	1.77	52	2.00	3.42	3.63	1.06	3.65
Perfluorooctanesulfonic Acid (PFOS)	ng/L	670	390	280	41.79%	1.7	4.1	1.82	67	2.34	4.38	5.72	1.31	4.74
Perfluorooctanoic Acid (PFOA)	ng/L	678	521	157	23.16%	1.72	2	1.8	831	4.71	10.28	44.29	4.31	13.1

**Notes:**

D = detect

ND = nondetect

UCL = 95% upper confidence limit of the mean

KM = Kaplan-Meier method

KM (t) UCL values presented for all constituents on the basis of the updated ProUCL v.5.2.0 decision matrix (Neptune and Company, Inc.).

<sup>1</sup>Median value of all data (including NDs)

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**APPENDIX B**

**APPLICABLE OR RELEVANT AND  
APPROPRIATE REQUIREMENTS (ARARS) TABLES**

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**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
<b><u>Chemical-Specific ARARs</u></b>				
<b><u>Federal Requirements</u></b>				
Maximum Contaminant Levels (MCLs) promulgated under the Safe Drinking Water Act (42 U.S.C. § 300f <i>et seq.</i> ); National Primary Drinking Water Regulations	40 C.F.R. 141.61	Relevant and Appropriate for Alternative 3	Establishes maximum contaminant levels (MCLs) for common organic and inorganic contaminants applicable to public drinking water supplies. These levels regulate the concentration of contaminants in public drinking water supplies.	POET Systems (Alternative 3) would be required to treat groundwater coming into a water supply well to meet these requirements for Site COCs prior to use as drinking water.
Safe Drinking Water Act (42 U.S.C. § 300f <i>et seq.</i> ); National primary drinking water regulations	40 C.F.R. 141.53	Relevant and Appropriate for Alternative 3	Establishes maximum contaminant level goals (MCLGs) for public water supplies for disinfection byproducts. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	POET Systems (Alternative 3) would be required to treat groundwater coming into a water supply well to meet the MCLG for chloroform (0.07 mg/L) prior to use as drinking water.
EPA Risk Reference Dose (RfDs)	EPA Integrated Risk Information System (IRIS) <a href="https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system">https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system</a>	To Be Considered for Alternatives 2, 3 and 4	Dose levels developed by EPA to protect sensitive individuals over the course of a lifetime. RfDs reflect a daily exposure level likely to be without appreciable risk of adverse health effects.	Potential risks posed by chemicals in groundwater at the Site were evaluated in accordance with this guidance.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

<b>Requirement</b>	<b>Citation</b>	<b>Status</b>	<b>Requirement Synopsis</b>	<b>Action to be Taken to Comply</b>
EPA Carcinogenicity Slope Factor	EPA Integrated Risk Information System (IRIS) <a href="https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system">https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system</a>	To Be Considered for Alternatives 2, 3 and 4	Slope factors are developed by EPA from Health Effects Assessments and present the most up-to-date information on cancer risk potency. Slope factors are developed by EPA from Health Effects Assessments by the Carcinogenic Assessment Group.	Potential risks posed by chemicals in groundwater at the Site were evaluated in accordance with this guidance.
Health Advisories (EPA Office of Drinking Water)	2018 Edition of the Drinking Water Standards and Health Advisories Tables	To Be Considered for Alternative 3	Health Advisories are estimates of risk due to consumption of contaminated drinking water; they consider non-carcinogenic effects only. To be considered for contaminants in groundwater that may be used for drinking water where the standard is more conservative than either federal or state statutory or regulatory standards.	Health Advisories will be considered in the design of POET Systems for treatment of groundwater (Alternative 3) for each household.
<b><u>State Requirements</u></b>				
New Hampshire Groundwater Protection Act  Ambient Groundwater Quality Standards	RSA 485-C:6  NH Admin. Code Env-Or 603.03  Table 600-1	Relevant and Appropriate for Alternative, 3	Establishes ambient groundwater quality standards (AGQSs) for regulated contaminants, which result from human operations or activities. NH AGQSs are derived to be protective for drinking water uses and are equivalent to MCLs for contaminants that have MCLs. AGQS are considered drinking water standards if a New Hampshire MCL standard has not been developed for a particular compound.	For Site COCs for which there are no federal or state MCLs or non-zero MCLGs and for which a more stringent risk-based federal standard has not been selected, POET Systems (Alternative 3) would be required to treat groundwater coming into a water supply well to meet the NH AGQS prior to use as drinking water.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
<b><u>Action-Specific ARARs</u></b>				
<b><u>Federal Requirements</u></b>				
USEPA Guidance Document for Providing Alternate Water <b><u>Supplies</u></b>	EPA 540/G-87/006  OSWER Directive 9355.3-03 (February 1988) and its update for Providing Alternative Water Supply as part of Superfund Response Actions, OSWER Directive 9355.3-22 (September 2010)	To Be Considered for Alternatives 2, 3, and 4	Provides technical guidance on the evaluation and selection of alternate water supply remedies.	This guidance would be consulted when evaluating the need for and evaluation of options for alternative water supply at Superfund Sites.
Clean Air Act, Section 112(b)(1), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC 7412(b)(1)  40 CFR Part 61	Applicable for Alternative 4	Establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	Any monitoring of air emissions during remedial activities, including during excavation activities for installation of the water line extension and connection of homes to the water line, will be performed to assess compliance with the substantive requirements of these standards.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

<b>Requirement</b>	<b>Citation</b>	<b>Status</b>	<b>Requirement Synopsis</b>	<b>Action to be Taken to Comply</b>
Clean Water Act Section 402, Discharge of Pollutants	33 USC 1342; 40 CFR 122, 136, 450	Relevant and Appropriate for Alternative 4	These regulations establish standards for the control and discharge of stormwater from construction projects that exceed one acre.	Any remedial action, including the construction of the waterline, that will result in discharge to surface waters or that will disturb more than one acre will meet the substantive parts of these discharge and stormwater standards.
Resource Conservation and Recovery Act (RCRA) Subtitle C; Hazardous Waste Identification and Listing Regulations; Generator and Handler Requirements	40 CFR Parts 261 and 262	Applicable for Alternative 3	These regulations establish standards used to identify, manage, and dispose of hazardous waste and for generators of hazardous waste, as defined by 40 C.F.R. § 261.3. New Hampshire has been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State.	Any wastes generated by remedial activity will be analyzed by appropriate test methods. If found to be hazardous wastes, then they will be managed in accordance with the substantive requirements of the State hazardous waste regulations. Wastes that may be generated include investigation derived waste from monitoring activities and contaminated treatment media produced during O&M of the POET systems...
Guide to Management of Investigation-Derived Waste	EPA OSWER Publication 9345.3-05 FS (Jan. 1992)	To Be Considered for Alternatives 2, 3, and 4	Management of Investigation-Derived Waste (IDW) must ensure protection of human health and the environment.	This guidance will be considered to ensure IDW will be managed in a manner to protect human health and the environment.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
<b><u>State Requirements</u></b>				
Safe Alternate Water	NH Admin. Code Env-Or 603.04	Relevant and Appropriate for Alternatives 2, 3 and 4	<p>Mandates the provision of potable water to well owners impacted by contamination exceeding AGQs. Responsible parties (RPs) must provide bottled water as an interim measure until one of the two long-term alternative water supplies is established:</p> <ul style="list-style-type: none"> <li>• Installing, testing, and maintaining a point-of-entry water treatment system at each affected structure; or,</li> <li>• Connecting each affected structure to a public water system.</li> </ul> <p>Connection to a public water system is required whenever practicable and consistent with applicable laws and rules.</p>	The interim remedial action will comply with the substantive portions of these requirements until a final determination on Site groundwater is developed.
Identification and Listing of Hazardous Wastes	NH Admin Code Chapter Env-Hw 400	Applicable to Alternative 3	These standards list particular hazardous wastes and identify the maximum concentration of contaminants for which the waste would be a RCRA characteristic waste. The analytical test set out in Appendix II of 40 C.F.R. Part 261 is referred to as the Toxicity Characteristic Leaching Procedure (TCLP). The federal requirements 40 C.F.R. Part 261 are incorporated by reference.	Any wastes generated by remedial activities will be analyzed by appropriate test methods to determine if they are hazardous. If found to be hazardous waste, they will be managed in accordance with the substantive requirements of the State hazardous waste regulations. Wastes that may be generated include investigation derived waste from monitoring activities and contaminated treatment media produced during O&M of the POET systems.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

<b>Requirement</b>	<b>Citation</b>	<b>Status</b>	<b>Requirement Synopsis</b>	<b>Action to be Taken to Comply</b>
Requirements for Hazardous Waste Generators	NH Admin Code Chapter Env-Hw 500, including Part 507 Storage Requirements; Part 513 Emergency/ Remedial Actions	Applicable to Alternative 3	Requires a determination as to whether waste materials are hazardous and, if so, requirements for managing such materials on site prior to shipment off site. The federal requirements 40 C.F.R. Part 262 are incorporated by reference.	If any remedial activity generates hazardous wastes, then it will be managed in accordance with the substantive requirements of these regulations. Design of POET systems will comply with these requirements if the spent treatment media are determined to be hazardous.
New Hampshire Fugitive Dust Standards	RSA Ch. 125-C NH Admin Code Chapter Env-A 1002	Applicable to Alternative 4	Set requirements for the control of fugitive emissions and dust.	Compliance with these requirements will be required during excavation activities for installation of the water line extension and connection of homes to the water line.
New Hampshire Code of Administrative Rules We 600 Standards for Construction, Maintenance and Abandonment of Wells	RSA 482-B NH Admin. Code Chapter We 600	Applicable to Alternative 4	These rules provide standards for the construction, maintenance, and abandonment of water wells to ensure safety and environmental protection.	Decommissioning of former private water supply wells following construction of the waterline must comply with substantive portions of the decommissioning requirements.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
New Hampshire Administrative Rules for Public Water System Classification and Design	NH Admin. Code Env-Dw 402 – 404	Applicable for Alternative 4	Establishes standards for the classification, siting, and design of public water systems to ensure safe and reliable drinking water. It includes specific parts addressing well siting requirements, hydrogeologic studies, and design standards for public water supply systems. The chapter also covers prohibitions on lead, and the adoption of referenced standards to maintain water quality and system integrity.	The design and installation of the water line extension and connection of homes to the water line will comply with the substantive requirements of these standards.
<b><u>Location-Specific ARARs</u></b>				
<b><u>Federal Requirements</u></b>				
Clean Water Act Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Requirements	33 USC 1344 40 CFR 230; 33 CFR 320-323	Applicable for Alternative 4	Outlines requirements for the discharge of dredged or fill materials into surface waters including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impacts. If adverse impacts are unavoidable, action must be taken to restore or create alternative wetlands. EPA must determine which alternative is the least environmentally damaging practicable alternative to protect wetland and aquatic resources.	Jurisdictional waters may be present at the Site and within the nearby neighborhoods. Installation of wells, construction associated with the water line and household connections may be necessary in these areas. If avoidance of these areas is not feasible, appropriate actions will be taken to minimize or mitigate any project related impacts.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
Floodplain Management and Protection of Wetlands	44 C.F.R. § 9	Relevant and Appropriate for Alternative 4	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands). Prohibits activities that adversely affect a federally regulated wetland unless there is no practicable alternative, and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use. Requires the avoidance of impacts associated with the occupancy and modification of federally designated 100-year and 500-year floodplain and to avoid development within floodplain wherever there is a practicable alternative. An assessment of impacts to 500-year floodplain is required for critical actions. Requires public notice when proposing any action in or affecting floodplain or wetlands.	Portions of the proposed water line extension (within the neighborhoods) may be located within the 500-year floodplain of Beaver Brook. Given the current extent of residential development, it may be impracticable to avoid the siting for the waterline within the 500-year floodplain or relocate the water line; however, an assessment of impacts may be needed. Public comment will be solicited on the proposed impacts to federal floodplain and wetland resources.
Endangered Species Act	16 U.S.C. 1531-1544; 50 CFR 17.11 and 17.12; 50 CFR 402	Applicable for Alternative 4 if endangered species are identified	This statute requires that federal agencies avoid activities that jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized.	An evaluation into endangered or threatened species in the project area will be performed during remedial design. If present, actions will be taken to avoid impacts to these species or their habitats.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
National Historic Preservation Act	54 USC 306101 et seq.  36 CFR Part 800	Applicable for Alternative 4, if such resources are identified	Pursuant to Sections 106 and 110(f) of the NHPA, CERCLA response actions are required to take into account the effects of the response activities on any historic property included or eligible for inclusion on the national Register of Historic Places.	If protected resources are identified in the area, measures to avoid, minimize and/or mitigate any adverse effects to protected resources will be implemented in consultation with federal and state historic preservation officials.
Preservation of Historical and Archeological Data and regulations	54 USC § 312501 et seq.  43 CFR Part 7	Applicable for Alternative 4, if such data are identified	Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alterations of terrain as a result of a federal construction project or a federally licensed activity program.	If during the remedial action it is determined that this remedial action may cause irreparable loss or destruction of significant scientific, prehistorical, historical, or archeological data, EPA will notify state, tribal, or federal authorities and comply with the substantive requirements in the statute and regulations.
Fish and Wildlife Coordination Act	16 U.S.C 661-666c  40 CFR Part 6	Applicable for Alternative 4	Requires consideration of the effects of a proposed action on wetlands and areas affecting streams (including floodplains), as well as other protected habitats. Any action that affects species/habitat requires consultation with US DOI, USFWS, and/or state agencies, as appropriate, to ensure that proposed action does not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. Action must be taken to prevent, mitigate or compensate for project related damages or losses to fish and wildlife resources.	If this interim Remedy alters wildlife habitat, it will comply with this ARAR through appropriate consultation and implementation of measures to prevent, mitigate, or compensate for project related impacts to habitat and wildlife.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
<b><u>State Requirements</u></b>				
Wetlands Protection, Excavating and Dredging	RSA 482-A NH Admin. Code Env-Wt Parts 300-700	Relevant and Appropriate for Alternative 4, if remedial activities are conducted within RSA 482-A Fill and Dredge in Wetlands Act jurisdictional areas	Outlines the requirements necessary when conducting activities within New Hampshire wetlands jurisdictional areas.	Remedial activities including water line construction, well decommissioning activities, and other remedial activities in wetlands jurisdictional areas must comply with the substantive provisions of these wetlands protection requirements.
Alteration of Terrain Permits	RSA 485-A:17 NH Admin. Code Env-Wq 1500	Applicable for Alternative 4, if any remedial activities are in or on the border of a state surface water or would significantly alter the characteristics of the terrain	Establishes criteria for conducting any activity that involves dredging, excavation, mining, forest production transportation, or construction in or near state surface waters or which significantly alters terrain and impedes natural runoff or creates unnatural runoff activities.	If any remedial activities, including excavation and construction associated with the water line, borders the surface waters of a state or significantly alters the characteristics of the terrain in such a manner as to impede the natural runoff or create an unnatural runoff, activities will comply with the substantive requirements of these provisions.
Historic Preservation Act	NH RSA 227-C	Applicable for Alternative 4, if such data are identified	The Act regulates the archeological discovery, investigation, analysis, and disposition of human remains removed from unmarked burials in New Hampshire.	If unmarked human burials or human remains are identified, activities will comply with the substantive provisions of these requirements.

**Appendix B**  
**Potential Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Tinkham Garage Superfund Site**

Requirement	Citation	Status	Requirement Synopsis	Action to be Taken to Comply
New Hampshire Native Plant Protection Act	NH RSA 217-A NH Admin. Code Ncr 312	Applicable for Alternative 4, if protected species are present	Prohibits the taking, possession, selling, offer for sale, delivery, carrying, transport, or shipment of any protected species from public highways, public property, waters of the state or from property of another. Protected species are listed in Ncr 312.	Remedial activities should not jeopardize the continued existence of any protected plant species.
Endangered Species Conservation Act	NH RSA 212-A NH Admin. Code Chapter Fis 1000	Applicable for Alternative 4, if protected species are present	This chapter serves to protect species of wildlife that are threatened and endangered.	The New Hampshire Fish and Game Department should be consulted to determine if there are endangered or threatened species that exist at the site. Any recommendations from New Hampshire Fish and Game consistent with RSA 212-A should be implemented with respect to this remedial action alternative. Remedial activities should not jeopardize the continued existence of any protected species.

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**APPENDIX C**

**REMEDIAL ALTERNATIVE DETAILED COST ESTIMATES**

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**Table C-1  
Estimated Costs for Alternative 2 - Bottled Water**

	Item	Quantity	Unit	Unit Price	Cost	Subtotal	Present Value
<b>1</b>	<b>Capital Cost</b>						
	Bottled water dispensers are rented, so there are no capital costs associated with this Alternative.					\$0	\$0
<b>2</b>	<b>Operation &amp; Maintenance Cost</b>						
2.1	Water Delivery						
a	Water Delivery to 89 Residences (10 one gallon water cases per household)	12	Month	\$7,200	\$86,400		
b	Water Delivery to 89 Residences (10 half liter water cases per household)	12	Month	\$7,200	\$86,400		
	<b>Total Annual O&amp;M Costs</b>					<b>\$172,800</b>	<b>\$ 2,814,720</b>
<b>3</b>	<b>Summary</b>						
	Capital for Limited Action Response					\$0	\$0
	O&M for Alternative 2					\$172,800	\$2,814,720
<b>4</b>	<b>Total 30 Year Net Present Worth of Alternative 2 (rounded)</b>						<b>\$2,800,000</b>

**Notes**

- Present Value is calculated with a discount rate of 4.5%
- O&M - Operation and Maintenance

**Table C-2  
Estimated Costs for Alternative 3- POET System**

	Item	Quantity	Unit	Unit Price	Cost	Subtotals	Present Value
<b>1</b>	<b>Capital Cost</b>						
a	POET System Equipment	89	LS	\$4,800	\$427,200		
b	Miscellaneous plumbing, fittings, and modifications as needed	89	LS	\$1,200	\$106,800		
c	Planning and Design (6 hours per residence at \$120.00)	534	Hour	\$120	\$64,080		
d	Installation (20 hours per residence at \$100.00)	1780	Hour	\$100	\$178,000		
e	15% Contingency	1	LS	\$116,412	\$116,412		
	<b>POET System Total Capital Cost</b>					<b>\$892,492</b>	<b>\$892,492</b>
<b>2</b>	<b>Operation &amp; Maintenance Cost</b>						
<b>2.1</b>	<b>POET System Maintenance</b>						
a	Carbon Changeouts	89	Year	\$1,150	\$102,350		
b	Miscellaneous POET Repairs	89	Year	\$500	\$44,500		
<b>2.2</b>	<b>Monitoring</b>						
a	Semiannual sample collection from 89 POET systems (influent, mid-point, and effluent samples)	2	Year	\$18,000	\$36,000		
b	Sample Analysis (Method 8270E-SIM, Method 524, and Method 533)	2	Year	\$115,000	\$230,000		
c	Semiannual reporting after each sampling event (100 hours at \$120.00)	2	Year	\$12,000	\$24,000		
	<b>Total Annual O&amp;M Costs</b>					<b>\$436,850</b>	<b>\$ 7,115,801</b>
<b>3</b>	<b>Summary</b>						
a	Capital Cost for POET Systems					<b>\$892,492</b>	<b>\$892,492</b>
b	O&M Costs for Alternative 3					<b>\$436,850</b>	<b>\$7,115,801</b>
<b>4</b>	<b>Total 30 Year Net Present Worth of Alternative 3 (rounded)</b>						<b>\$8,000,000</b>

**Notes**

- Present Value is calculated with a discount rate of 4.5%  
 POET - Point of Entry Treatment  
 O&M - Operation and Maintenance

**Table C-3  
Estimated Costs for Alternative 4 - Waterline Extension**

	Item	Quantity	Unit	Unit Price	Cost	Subtotals	Present Value
<b>1</b>	<b>Capital Cost</b>						
1.1	Pipeline Extension						
a	Engineering design	1	LS	\$375,000	\$375,000		
b	Permits and Fees	1	LS	\$100,000	\$100,000		
c	Pipeline construction through bedrock (30% of the pipeline length)	2500	LF	\$590	\$1,475,000		
d	Pipeline construction through overburden (70% of the length)	5800	LF	\$380	\$2,204,000		
e	Waterline connections to residences (average distance from water main to house = 200 ft. Price includes planning, survey, installation, plumbing modifications for meter connection, and landscape restoration)	89	EA	\$23,500	\$2,091,500		
f	Construction oversight	6	Month	\$32,500	\$195,000		
g	Contingency (15% of construction cost)	1	LS	\$321,500	\$321,500		
1.2	Institutional Controls						
	Legal and administrative fees associated with establishing a town ordinance that prevents the use contaminated groundwater for drinking water or other domestic purposes.	200	Hours	\$350	\$70,000		
	<b>Pipeline Extension Total Capital Cost</b>					<b>\$6,832,000</b>	<b>\$6,832,000</b>
<b>2</b>	<b>Operation &amp; Maintenance Cost</b>						
a	There are no operations and maintenance costs for this alternative. Residents served by the public water supply will pay the fees for water service. Those fees will cover any maintenance of the pipeline that is necessary. No monitoring is necessary.					<b>\$0</b>	<b>\$0</b>
<b>3</b>	<b>Summary</b>						
a	Capital Cost for Waterline Extension					<b>\$6,832,000</b>	<b>\$6,832,000</b>
b	O&M for Alternative 4					<b>\$0</b>	<b>\$0</b>
<b>4</b>	<b>30 Year Net Present Worth Cost of Alternative 4 (rounded)</b>						<b>\$6,800,000</b>

**Notes**

1. Present Value is calculated with a discount rate of 4.5%
2. Engineering design and construction costs are based on preliminary estimates from Pennichuck Water Works.  
O&M - Operation and Maintenance