UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Memorandum

Date: August 5, 2020

Subject: Olin Chemical Superfund Site
Updates to Draft 2019 OU3 RI Report Conclusions

To: File

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PURPOSE AND BACKGROUND

The purpose of this Memorandum is to update the conclusions and findings presented in the Operable Unit (OU) 3 Revised Draft Remedial Investigation (RI) Report, dated June 2019 (Draft 2019 OU3 RI Report),[1] for the Olin Chemical Superfund Site (Site)[2] specifically as relates to information needed to support the evaluation of remedial alternatives considered in the Interim Action Feasibility Study (IAFS). The Draft 2019 OU3 RI Report is not final at this time and is subject to revision as a result of the ongoing Remedial Investigation/Feasibility Study (RI/FS) process for OU3. There are various conclusions presented in the Draft 2019 OU3 RI Report that must be verified or re-considered through further investigations to close data gaps. As such, this memorandum is intended to address those conclusions that pertain directly to an interim OU3 remedy.

EPA concurs with Olin Corporation's (Olin's) conclusion that the current Conceptual Site Model (CSM) demonstrates existing, ongoing and uncontrolled sources of contamination. However, there are aspects of the historical CSM that have been developed using a scarcity of data that EPA believes does not allow for robust remedial design, although EPA and Olin agree that there is sufficient data to evaluate source control remedial alternatives appropriately. The IAFS Report

[1] *Revised Draft Remedial Investigation Report OU3, Olin Chemical Superfund Site, Wilmington, Massachusetts*, Wood Environment & Infrastructure Solutions, June 2019 (Draft 2019 OU3 RI Report).
[2] EPA has also prepared a companion document to this Memorandum, updating the conclusions and findings presented in the *Final Remedial Investigation Report, Operable Unit 1 & Operable Unit 2, Olin Chemical Superfund Site, Wilmington, Massachusetts,* AMEC, July 24, 2015. This companion document is entitled, Memorandum, *Olin Chemical Superfund Site, Updates to OU1/OU2 RI Report Conclusions,* EPA, August 5, 2020.

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is intended to provide an evaluation of remedial alternatives to address sources of contamination such as Dense Aqueous Phase Liquid (DAPL), Light Non-Aqueous Phase Liquid (LNAPL), and areas of elevated groundwater impacts (groundwater hot spots). The RI concludes, and EPA agrees, that DAPL and LNAPL are present at the Site, and that there are areas of groundwater where concentrations of Site-related constituents are high enough to result in continued downgradient mass transport.

While the existing OU3 data set does not allow for EPA to set Remedial Action Objectives (RAOs) for groundwater restoration, enough data exists such that RAOs for source control were able to be established in order to allow for the development of alternatives in the IAFS Report. An OU3 FS Report will be developed to evaluate groundwater restoration scenarios once source control measures are in place and functioning and following completion of the OU3 RI. In the meantime, EPA and Olin are working to develop work plans that will build significantly on the existing data set in a way that will allow a clearer understanding of bedrock characteristics, groundwater flow, etc., which will allow for completion of the OU3 RI.

Section I of this Memorandum discusses the key concepts relating to the CSM and discusses areas where some additional work must be completed to gain consensus on outstanding CSM uncertainties. Section II discusses the mass of contamination in DAPL and groundwater hot spots. Section III defines and explains the general basis for an interim remedy approach to groundwater remediation and summarizes the RAOs. Section IV provides a list of acronyms. Finally, Attachment A provides a series of figures and Attachment B provides output calculations from EPA's Regional Screening Level (RSL) calculator for EPA's risk-based screening level for n-nitrosodimethylamine (NDMA) in residential tapwater.

I. CONCEPTUAL SITE MODEL FOR GROUNDWATER

A. Background Information Regarding the CSM

A CSM provides a data-driven interpretation of the fate and transport dynamics that govern the nature and extent of contaminants at a particular site. The CSM can be presented as a textual description, a flow chart, or a pictorial representation. The CSM identifies and describes the source(s) of contamination, the physical and chemical fate and transport mechanisms, information on groundwater-surface water interactions, and potential routes of contaminant migration. CSMs are considered to be iterative products; updated and modified as additional data from the site is collected and interpreted.

The historical CSM for the Site is presented in Section 5 of the Draft 2019 OU3 RI Report. While EPA agrees with the general outline and some components of the CSM, EPA has developed a differing opinion with certain interpretations and conclusions drawn by Olin from the CSM. These differences in interpretation are discussed further in this memorandum.

EPA concurs with Olin's conclusion that the current CSM demonstrates existing, ongoing and uncontrolled sources of contamination. Additionally, EPA agrees that there is

sufficient data to conceptualize and evaluate a range of alternatives in the IAFS Report to address these sources. EPA believes that a higher resolution CSM is a critical project objective for the pre-design investigation (PDI) component of the Interim Action Remedial Design (RD).

B. General Summary of the CSM for the Olin Site

The primary source of groundwater contamination at the Site was the historical release of process waste waters to unlined lagoons (pits and surface impoundments), identified as Lake Poly, the East and West Pits under the East and West Warehouses, and the Acid Pits within the footprint of the Containment Area (see Section I(C), below) between the 1950s and 1970s. The lagoons were constructed in native soils consisting of sandy glacial outwash deposits. Exfiltration from these lagoons resulted in the formation of DAPL that migrated to topographic low points along the bedrock surface (see **Figure 1**, *Olin's Conceptual Site Model (CSM) for the Olin Site*; **Figure 2**, *EPA's Supplemental Conceptual Site Model;*[3] **Figure 3**, *EPA's Supplemental Conceptual Site Model – Main Street DAPL Pool*; and further discussion, below).

Diffuse material, which is less dense and less concentrated than the DAPL, is believed to have flowed advectively (through physical groundwater movement) from the original source areas and the DAPL pools (see below). Additional sources of impacts to groundwater included releases of LNAPL in the vicinity of Plant B and waste materials placed in a feature identified as the "Calcium Sulfate Landfill," or CSL.[4] Sludges were occasionally removed from the lagoons and placed in the CSL, located on the southernmost edge of the Olin property. The CSL was permitted and closed under Massachusetts solid waste regulations.[5] Overflow from the unlined pits and surface impoundments is also believed to have discharged into the upper portions of On-Property West Ditch Stream and South Ditch Stream.

Many of the discharged chemicals were dense in nature and, as DAPL, sunk through the aquifer to the top of bedrock. DAPL pooled in a bedrock depression beneath the Olin property (the On-Property DAPL Pool) and eventually migrated via gravity flow, independent of the overlying groundwater, into a lower depression immediately to the west of the Olin property (the Jewel Drive DAPL Pool or Off-Property West Ditch DAPL Pool). The DAPL filled this second depression and migrated into a third, lower elevation depression further to the west (the Main Street DAPL Pool). This third depression

[3] The transect D-D' shown in **Figure 2**, *EPA's Supplemental Conceptual Site Model* is similar to the transect shown in **Figure 1**, *Olin's Conceptual Site Model (CSM) for the Olin Site.*

[4] EPA does not consider the Calcium Sulfate Landfill (CSL) to be a significant source of contaminant impacts to hot spot groundwater, given that levels of n-nitrosodimethylamine (NDMA) in wells closest to the CSL are lower compared to other areas of the Olin property and do not indicate significant impacts from this potential source area. However, EPA plans to explore the CSL further as part of the ongoing Operable Unit 3 (OU3) Remedial Investigation (RI).

[5] Final closure certification of the CSL and approval of a post-construction monitoring plan in accordance with Massachusetts Solid Waste Management Regulations (310 CMR 19.000) was issued by the Massachusetts Department of Environmental Protection (MassDEP) on January 9, 2009, then modified on March 3, 2011.

eventually overtopped, releasing DAPL into the Maple Meadow Brook (MMB) wetland complex to the northwest. It is hypothesized that DAPL sunk into the large fracture network beneath the MMB wetlands – the volume of DAPL in these and other bedrock fractures beneath the DAPL pools is currently unknown.

DAPL migration is generally influenced by the density of the fluid. There is evidence that DAPL and/or DAPL-related constituents migrated (and perhaps is/are migrating) into fractured bedrock. However, information regarding the nature of fractured bedrock at the Site is not adequate to fully understand this portion of the CMS currently, and significant work will be required to gain a working understanding for remedial purposes. As such, the IAFS report does not directly address bedrock impacts, however the IAFS will evaluate eliminating the DAPL pools as potential ongoing source of DAPL and dissolve-phase contamination into bedrock. EPA and Olin are working concurrently with the IAFS process to close these data gaps, ultimately inform a revised OU3 RI, and then develop an appropriate OU3 FS Report.

The term *diffuse groundwater* (or *diffuse groundwater layer*, *diffuse layer*, *diffuse layer material*, or *diffuse layer groundwater*) refers to the groundwater immediately surrounding DAPL and downgradient of the DAPL pools which exhibit some of the muted physical properties of DAPL. Under current hydrogeological conditions, the primary transfer of Site contaminants from DAPL to overlying groundwater occurs via chemical diffusion, resulting in the presence of a diffuse layer of groundwater contamination, also known as the diffuse groundwater plume (see **Figure 4**, *DAPL Pools and Extent of Diffuse Groundwater Plume in Overburden Groundwater*, below). Diffuse material may also be migrating into bedrock.

Diffuse groundwater has a specific gravity of just over 1.0,[6] is slightly acidic (pH around 6.0), and is typically light green in color. The diffuse groundwater layer is typically 3 to 5 feet (ft) in thickness and contains many of the same chemical compounds identified within DAPL, but at concentrations that, while generally lower than concentrations in DAPL, are still elevated. The diffuse groundwater layer is generally identified as the portion of groundwater that has a specific conductance of between 3,000 and 20,600 microohms per centimeter (µmhos/cm). Similar to DAPL, the concentration of NDMA within the diffuse groundwater plumes is highly variable. Therefore, it is not possible to prepare concentration-based contour maps for NDMA within the diffuse layers of groundwater.

As Site contaminants migrated via chemical diffusion from the DAPL pools into the overlying diffuse groundwater layer, these constituents were determined to be influenced by the Town of Wilmington's five municipal wells, located in the aquifer underlying the MMB wetlands to the northwest of the Olin property. These wells pulled the plume in a

[6] For comparison, the specific gravity of freshwater is 1.0, while the specific gravity of ocean salt water is typically 1.025.

westerly/northwesterly direction. For a time, two operational wells at the former Altron/Sanmina facility, located closer to the Olin property at 1 Jewel Drive (which is above the Main Street DAPL Pool), also exerted an influence on the plume.

The municipal wells operated at a rate of approximately 2.5 million gallons per day until they were shut down by the Town of Wilmington in 2003 due to the detection of NDMA in four of the five wells. The municipal wells in the MMB aquifer are located approximately three quarters of a mile from the Olin property, within the Ipswich River watershed (see **Figure 5,** *Watershed Map,* below). The production wells at the former Altron/Sanmina facility were shut down in 2004. The former unlined pits and surface impoundments are located within the Aberjona River watershed. This suggests that Site contaminants moved across the groundwater divide due to the gravity-based migration of DAPL, and possibly in conjunction with the combined pumping influence of the former municipal and Sanmina wells. This information is presented to provide an understanding of the locations of the DAPL pools and groundwater hot spots.

C. Definition of DAPL

The working definition for the term *DAPL* is: a dense, acidic, chromium-containing waste material with a high concentration of dissolved solids that has come to be located in the subsurface at the top of the bedrock surface – pooling in bedrock depressions – at locations under the former Olin facility and areas immediately west and northwest of the Olin property (see **Figure 1**, *Olin's Conceptual Site Model (CSM) for the Olin Site*, below). The DAPL areas are identified as the Upper DAPL Pool, the Main Street DAPL Pool, and the Western Bedrock Valley DAPL area. The portion of the Upper DAPL Pool under the Olin property that is within the same hydrologic regime as the slurry wall[7] is referred to as the Containment Area DAPL Pool (see Section I(B), above). The western slurry wall partitions the Upper DAPL Pool, resulting in its division into on-property (the Containment Area DAPL Pool) and off-property (the Jewel Drive DAPL Pool) portions. Immediately west of Jewel Drive and extending beyond Main Street to the edge of the MMB wetland complex is the largest of the DAPL pools – the Main Street DAPL Pool.

The DAPL source material is a highly acidic brine that is dark green in color with a specific gravity greater than or equal to 1.025. Inorganic compounds detected in DAPL at high concentrations include dissolved sulfate, sodium, chloride, ammonia, chromium, iron, aluminum, and manganese. Organic compounds detected in DAPL include phenol, acetone, 2-hexanone, bromoform, methylethylketone (MEK), bis-2-ethylhexylphthalate

[7] The Containment Area feature, which includes a concrete slurry wall that was installed in a trench excavated into the top of weathered bedrock, was constructed in an attempt to contain the DAPL pool on the Olin property. EPA believes the weathered bedrock underlying the Containment Area DAPL Pool is not competent. Given the weathered nature of the bedrock surface and based on a preliminary review of hydraulic data collected from inside and outside the Containment Area that indicates groundwater elevation changes that are regional and unabated by the slurry wall, leakage through the bedrock/slurry wall interface appears possible, resulting in some degree of communication between the interior of the Containment Area and the exterior environment.

(BEHP), toluene, trimethylpentenes (TMPs), 4-bromophenyl-phenylether, naphthalene, benzoic acid, n-nitrosodiphenylamine (NDPA), and NDMA. The major risk drivers for DAPL (contaminants which are present at least two orders of magnitude above their corresponding human health-protective screening values) include NDMA, 1,1-dimethylhydrazine, hexavalent chromium, trivalent chromium, cobalt, dibromochloromethane, manganese, chloroform, iron, silver, 1,2-dichloroethane, and napthalene. Among these, NDMA stands out as the largest risk contributor.

The simplest method to identify DAPL is to determine whether a groundwater sample has a specific gravity equal to or greater than 1.025. However, a number of physical and chemical parameters have been correlated with specific gravity. The following constituents, when taken together at the referenced concentrations, can be used to define DAPL empirically in the absence of reliable specific gravity measurements:

- Ammonia concentration greater than 1,250 milligrams per Liter (mg/L);
- Chloride concentration greater than 2,800 mg/L;
- Magnesium concentration greater than 270 mg/L;
- Sodium concentration greater than 1,700 mg/L;
- Sulfate concentration greater than 16,000 mg/L; or
- Specific conductance greater than 20,600 µmhos/cm.

DAPL is also acidic with a pH of less than 5.0 (typically around 3.5), and where present in the overburden, is typically several feet thick. Within the DAPL layer, the density and concentrations of DAPL constituents increase with depth. Most recently, Olin has estimated a total volume of DAPL of approximately 15 million gallons (see Sections I(E)(i) and II(A), below).

D. Definition of Highly Contaminated Groundwater/Groundwater Hot Spots

For the purposes of the IAFS Report, the term *highly contaminated groundwater* (also used interchangeably with the term *groundwater hot spots*) is defined as groundwater containing a large portion of the overall mass of contaminants relative to the overall plume, the removal of which would facilitate remediation of the entire plume by reducing the extent and further migration of the plume (see Section II(B), below). Groundwater hot spots contain significantly elevated concentrations of NDMA and other Site contaminants. EPA does not consider the entire overburden groundwater plume nor the entire network of impacted bedrock fractures to be groundwater hot spots.

E. Key Issues that Guide EPA's Interpretations of the CSM

Although EPA has determined that there is sufficient data to conceptualize and evaluate a range of alternatives in the IAFS Report to address the existing, uncontrolled sources of

contamination at the Site – DAPL and groundwater hot spots – there are issues regarding the adequacy of data and resulting uncertainties:

i. Data Density and Spatial Resolution (Lateral and Vertical)

There is a general lack of spatial resolution for much of the Site data. The current groundwater study area is large – approximately 1,450 acres (see **Figure 8**, *Operable Unit 3 (OU3) Groundwater Study Area*, below). But, in most areas, the density of characterization data (borings, seismic data, etc.) is sparse, particularly in bedrock. The degree of spatial resolution must be commensurate with the complexity of the Site's subsurface, due in part to the high degree of folding and faulting and changes in bedrock elevation in the area surrounding the Olin property. As such, elements of the CSM that rely on trend comparisons or other comparative means to draw conclusions, such as relative to the two areas discussed above, may be incomplete.

It is EPA's observation that the bedrock surface is highly complex at the Site. Where data density is low, resolution of second-order features on the top of rock (TOR) surface is limited. This suggests that lateral variations of bedrock elevation on a similar scale (or finer) could be inferred from the lateral spacing of the characterization data points. This will be verified upon completion of the data gaps investigation and PDI.

A more resolved depiction of the TOR surface at the Site is needed, as well as the elevations, thicknesses, and lateral extent of all three DAPL pools, to understand the bedrock topography underlying the DAPL pools. This knowledge is necessary to inform the locations of extraction and monitoring wells for source control remediation. Higher resolution bedrock data is also important to understand the nature and extent of preferential migration pathways between the overburden aquifer and bedrock fractures.

EPA notes that data sparseness and low spatial resolution may result in the CSM omitting significant preferential pathways that may exist along the bedrock surface. Additionally, Olin has agreed with EPA that the existing data are insufficient to pinpoint the locations of the deepest portions of the DAPL pools – which is an important consideration in designing the number, location, and depth of well screens for DAPL source control, and if an interim remedy for DAPL is selected, that additional data will be collected during the PDI component of the RD to address this issue. DAPL volumes presented in the Draft 2019 RI and the IAFS Reports are roughly estimated due to this lack of information. However, the estimates are close enough to allow a comparative analysis of alternatives.

ii. Temporal Variability vs. Measurement Frequency of Key Parameters

Consistent with EPA guidance, the OU3 RI required two rounds of groundwater data collection. These collection efforts were completed, but the nature of groundwater contamination at this Site is unusually complex, and updated information is required to understand current conditions, which relates more to the locations of groundwater hot spots. EPA and Olin have agreed on a quarterly groundwater sampling program to monitor current conditions and groundwater/mass transport dynamics. The information generated from these efforts will provide an enhanced understanding of the extent and location of groundwater hot spots.

iii. Measurement Uncertainty for a Range of Variables

As EPA has revisited the underlying data used to update the CSM for the Site, it has become apparent that while the various approaches used to measure DAPL are acceptable for providing rough volume estimates, the measurement techniques being used may have accuracy limitations (see **Table 1**, *Measurement Uncertainties*, below). EPA believes that reliable measurement techniques are essential to understand the amount of DAPL present at the Site and the location(s) of DAPL, and to be able to monitor source control remediation efforts with an eye towards future remedial performance and optimization.

Ultimately, additional approaches will need to be employed as part of the PDI component of the RD following the interim action remedy selection, as well as in follow-up efforts, to further characterize OU3 including DAPL.

iv. Determining DAPL Pool Configurations

As noted above, there is insufficient information to fully describe the overall geometry of the DAPL pools. For example, in the Main Street area, only one multi-port (MP) well (well MP-03) exists, located at the edge of the Main Street DAPL pool. A singular MP well is insufficient by itself to adequately monitor a study area as large (approximately 20 acres) as the Main Street DAPL pool. While there are several monitoring wells nearby, these wells (wells GW-45S/D, GW-44S/D, GW-59S/D, and GW-70S/D) are constructed with 10-ft well screens, limiting the accuracy of DAPL measurements. Moreover, the full geometry (areal extent, depth, etc.) of all three DAPL pools should be more fully understood to provide appropriate design parameters for any remedy that will be implemented to remove these sources of contamination. The pending data gaps investigations (see the following section) and the PDI following the interim action remedy selection that Olin has agreed to undertake will be designed to answer remaining questions.

v. Additional Data Collection Efforts to Refine the CSM

Identification of the limitations on data resolution and the uncertainties in the CSM presented in the Draft 2019 OU3 RI Report point to specific recommendations for follow-up actions, such as additional data collection and/or analysis efforts that will improve the resolution of critical aquifer features and refine the CSM in key locations. EPA expects this data to be collected through the implementation of the ongoing OU3 RI, which includes the OU3 Data Gaps Work Plan.[8] However, it must be emphasized that refinement of the CSM is not needed for the purposes of developing and evaluating alternatives in the IAFS Report for source control because EPA and Olin believe that sufficient data exists to support an interim cleanup action to address the major, uncontrolled sources of groundwater contamination at the Site – DAPL and groundwater hot spots. However, the PDI component of the RD phase to implement a source control remedy (the selected interim remedy for DAPL and groundwater hot spots) should include efforts to evaluate well numbers and placement, screen lengths, and other key remedial components.

II. EVALUATION OF NDMA MASS IN DAPL AND GROUNDWATER

While DAPL contains a number of primary Site contaminants, NDMA contributes the most exposure risk, is more mobile than the other Site contaminants, and is therefore the primary Site contaminant that is the focus of the source control action (interim remedy for DAPL and groundwater hot spots) evaluated in the IAFS Report.

A. NDMA Mass in DAPL

The highest concentrations of NDMA detected to date, up to 54,000 nanograms per Liter (ng/L), are located within the DAPL pools. Yet, there does not appear to be any correlation between NDMA concentrations in DAPL and between specific gravity and/or the other designated DAPL parameters (see Section I(C), above). While there is no minimum cut-off concentration for NDMA in DAPL, concentrations are generally over 1,000 ng/L.

Calculations of NDMA mass within DAPL are based on the volume of DAPL present. However, as explained above, the volume estimates for DAPL vary due to the uncertainty of the bedrock geometry including topography and the exact elevation of the DAPL pools. Based on the available data, the range of NDMA mass estimates developed by EPA and Olin range from 996 to 2,573 grams (g). Even though this range of estimates is wide, these estimates at either end of the range are sufficient for the consideration of remedial alternatives as source control measures.

B. NDMA Mass in Groundwater Hot Spots

[8] *Data Gaps Work Plan*, Geomega, Inc., August 2, 2019.

In addition to being elevated within the DAPL pools, concentrations of NDMA are elevated in surrounding groundwater. In order to evaluate whether interim source control actions in groundwater should be limited to just DAPL, EPA and Olin calculated estimates of the mass of NDMA contained within certain concentration contours in overburden groundwater.

Because there is no Safe Drinking Water Act Maximum Contaminant Level (MCL) for NDMA, EPA established contours at orders of magnitude above the RSL for NDMA in groundwater, 11 ng/L[9], and calculated NDMA mass within such contours. NDMA concentration contours of 1,100 ng/L and 11,000 ng/L were used. Based on the broad NDMA mass difference between the 1,100 and 11,000 ng/L contours (2,000 g per EPA estimates and of more than 3,000 g per Olin's estimates), a third mass estimate was calculated based on the 5,000 ng/L median contour (see **Figure 6**, *N-nitrosodimethylamine (NDMA) Concentrations in Shallow Overburden Groundwater* and **Figure 7**, *N-nitrosodimethylamine (NDMA) Concentrations in Deep Overburden Groundwater,* below). Based on the available data, EPA estimates the mass of NDMA within the three concentration contours as follows:

- Within the 11,000 ng/L NDMA contour = **1,361 g NDMA**
- Within the 5,000 ng/L NDMA contour = **3,129 g NDMA**
- Within the 1,100 ng/L NDMA contour = **3,599 g NDMA**

Olin estimates the mass of NDMA within the three concentration contours as follows:

- Within the 11,000 ng/L NDMA contour = **1,715 g NDMA**
- Within the 5,000 ng/L NDMA contour = **4,440 g NDMA**
- Within the 1,100 ng/L NDMA contour = **4,747 g NDMA**

Differences between EPA's and Olin's NDMA mass calculations within the various NDMA concentration contours are not significant enough to change the general approach to conceptualizing alternatives in the IAFS Report to address DAPL and groundwater hot spots. Applying any of the above three concentration contours, EPA's estimates show significant NDMA mass in groundwater that exceeds the combined NDMA mass of 996 g within the three DAPL pools. Similarly, Olin's estimates show significant NDMA mass in overlying groundwater (above NDMA concentrations of either 5,000 ng/L or 1,100 ng/L) that exceed their estimate of 2,573 g of NDMA within the three DAPL pools.

Both EPA's and Olin's calculations of NDMA mass within the aforementioned concentration contours show a significant increase in NDMA mass removal if remediation were to occur down to the 5,000 ng/L contour as compared to the 11,000 ng/L contour, but only a modest increase in NDMA mass removal if remediation were to

[9] EPA's health-protective risk-based screening level of 11 nanograms per Liter (ng/L) for n-nitrosodimethylamine (NDMA) in residential tapwater corresponds to a cancer risk of one in ten thousand, or $1x10^{-4}$. See EPA's Regional Screening Level (RSL) Calculator, available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables, output available in Attachment B, below.

occur at or below the 1,100 ng/L contour. Therefore, the IAFS Report conceptualizes a range of alternatives to control the further migration of uncontrolled groundwater hot spots and reduce the mass of NDMA in groundwater hot spots.

III. INTERIM REMEDY APPROACH AND REMEDIAL ACTION OBJECTIVES FOR THE IAFS REPORT

The term *interim action* means a cleanup effort that is limited in scope that is taken while EPA gathers additional information to inform a final remedial action. Interim actions can include measures to stabilize a site and prevent the further migration of contaminants. The remedial actions evaluated in the IAFS Report for DAPL and groundwater hot spots are interim measures until the full nature and extent of the contamination in groundwater is understood, resulting in the identification of additional alternatives for evaluation that address the full extent of contamination, ultimately resulting in the future selection of a final groundwater remedy for the Site.

The interim actions evaluated in the IAFS Report are necessary to begin restoration of groundwater and to prevent unacceptable risks from future exposure to Site groundwater while EPA continues to gather additional information to select a final cleanup plan. Accordingly, the cleanup objectives for the interim action have been developed to prioritize reduction of exposure risk and reduction of contaminant mass through treatment. The objectives do not include attainment of specific cleanup levels. Final cleanup levels will be selected as part of the final remedy determination for Site groundwater (OU3).

As documented in the Draft 2019 OU3 RI Report, and as supplemented by this Memorandum, the potential for unacceptable human health exposures exist within OU3 that warrant the development of remedial alternatives for an interim action. The following RAOs have been established to address the Site contaminants and unacceptable exposure pathways. These RAOs form the basis for the remedial alternatives screened, developed, and evaluated in the IAFS Report.

- DAPL
    - Reduce, to the extent practicable, the volume of DAPL and mass of Site contaminants in DAPL that represent a source to groundwater, surface water, and sediments.
    - Reduce, to the extent practicable, the horizontal and vertical migration of DAPL acting as a source of Site contaminants, including penetration into bedrock.
    - Prevent potential human exposure by a future resident to DAPL containing Site contaminants at levels that pose an unacceptable risk.

- Groundwater Hot Spots

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- Reduce, to the extent practicable, the mass of Site contaminants in highly contaminated groundwater (groundwater hot spots).
- Reduce, to the extent practicable, the further horizontal and vertical migration of Site contaminants in groundwater hot spots, including penetration into bedrock.
- Prevent potential human exposure by a future resident to groundwater containing Site contaminants at levels that pose an unacceptable risk.

IV. ACRONYMS

BEHP	bis-2-ethylhexylphthalate
CSL	Calcium Sulfate Landfill
CSM	Conceptual Site Model
DAPL	Dense Aqueous Phase Liquid
EPA	United States Environmental Protection Agency
ft	foot
g	grams
IAFS	Interim Action Feasibility Study
LNAPL	Light Non-Aqueous Phase Liquid
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MEK	methylethylketone
mg/L	milligrams per Liter
MMB	Maple Meadow Brook
MP	multi-port
µmhos/cm	microohms per centimeter
NDMA	n-nitrosodimethylamine
NDPA	n-nitrosodiphenylamine
ng/L	nanograms per Liter
OU	Operable Unit
PDI	pre-design investigation
RAO	Remedial Action Objective
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RSL	Regional Screening Level
TOR	top of rock
TMPs	trimethylpentenes

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Attachment A

Figures

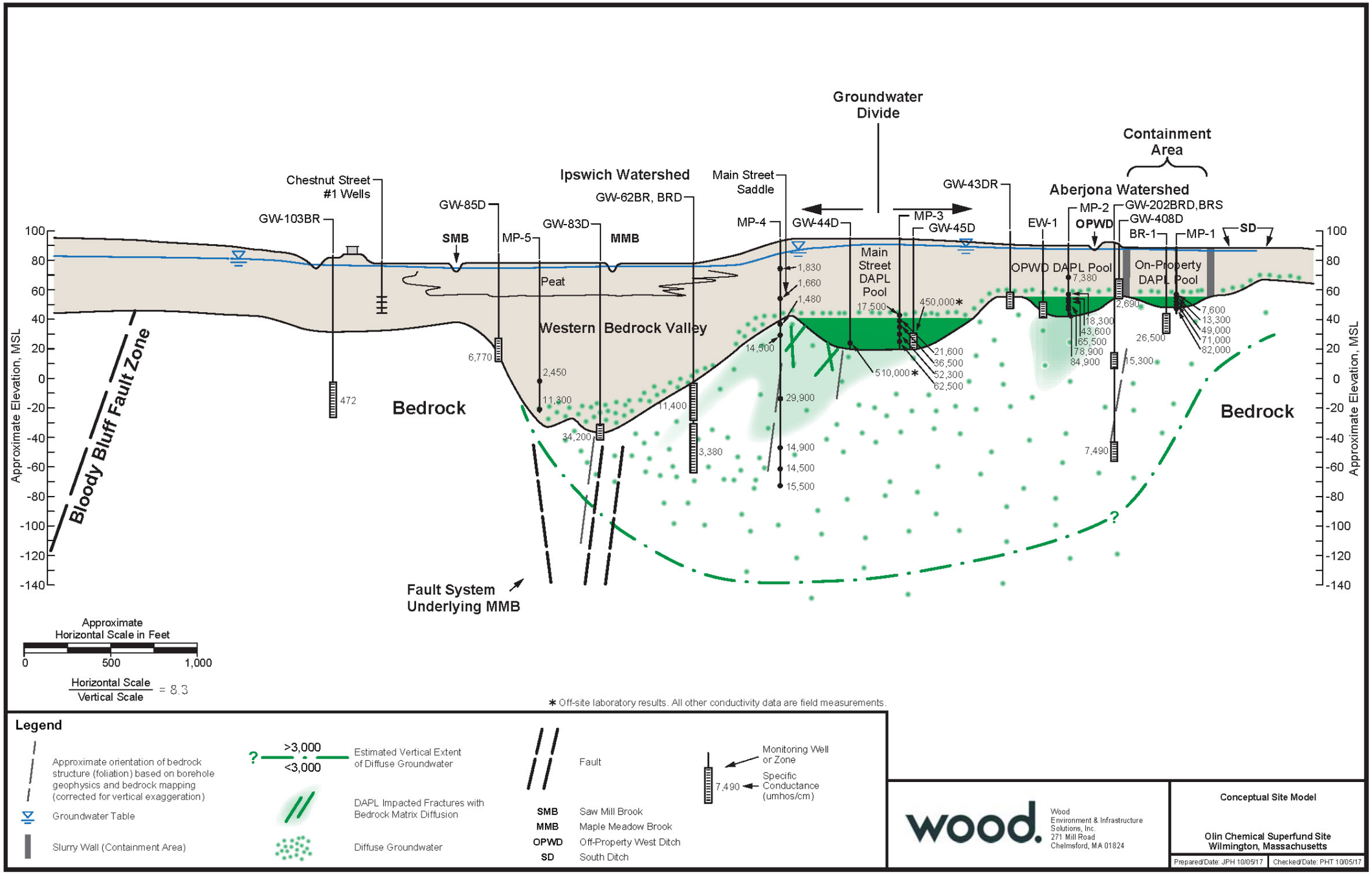

Figure 1. Olin's Conceptual Site Model (CSM) for the Olin Site. Dense Aqueous Phase Liquid (DAPL) shown in green, pooled in bedrock depressions in the subsurface. Diffuse groundwater shown as green dots.

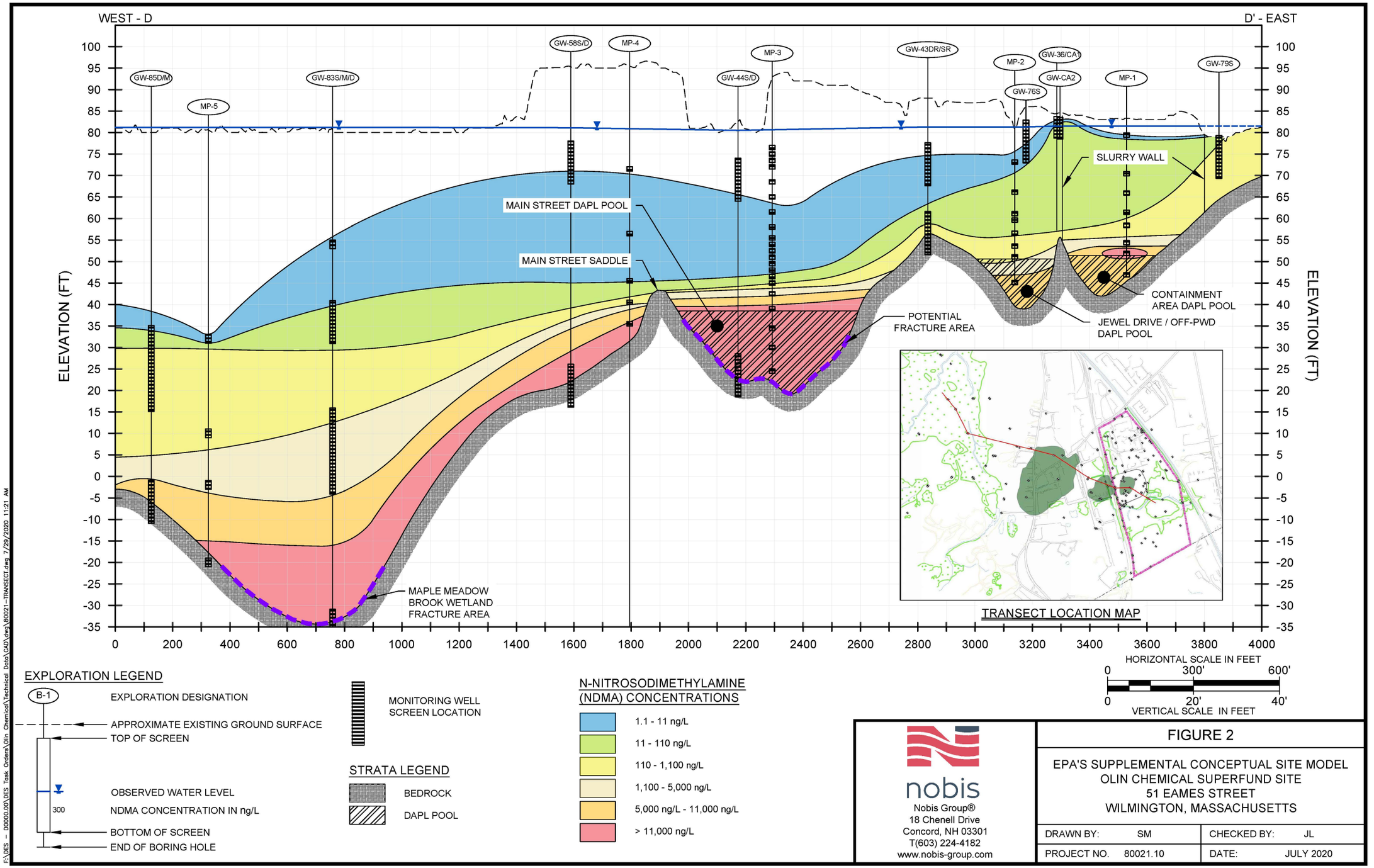

Figure 2. EPA's Supplemental Conceptual Site Model.

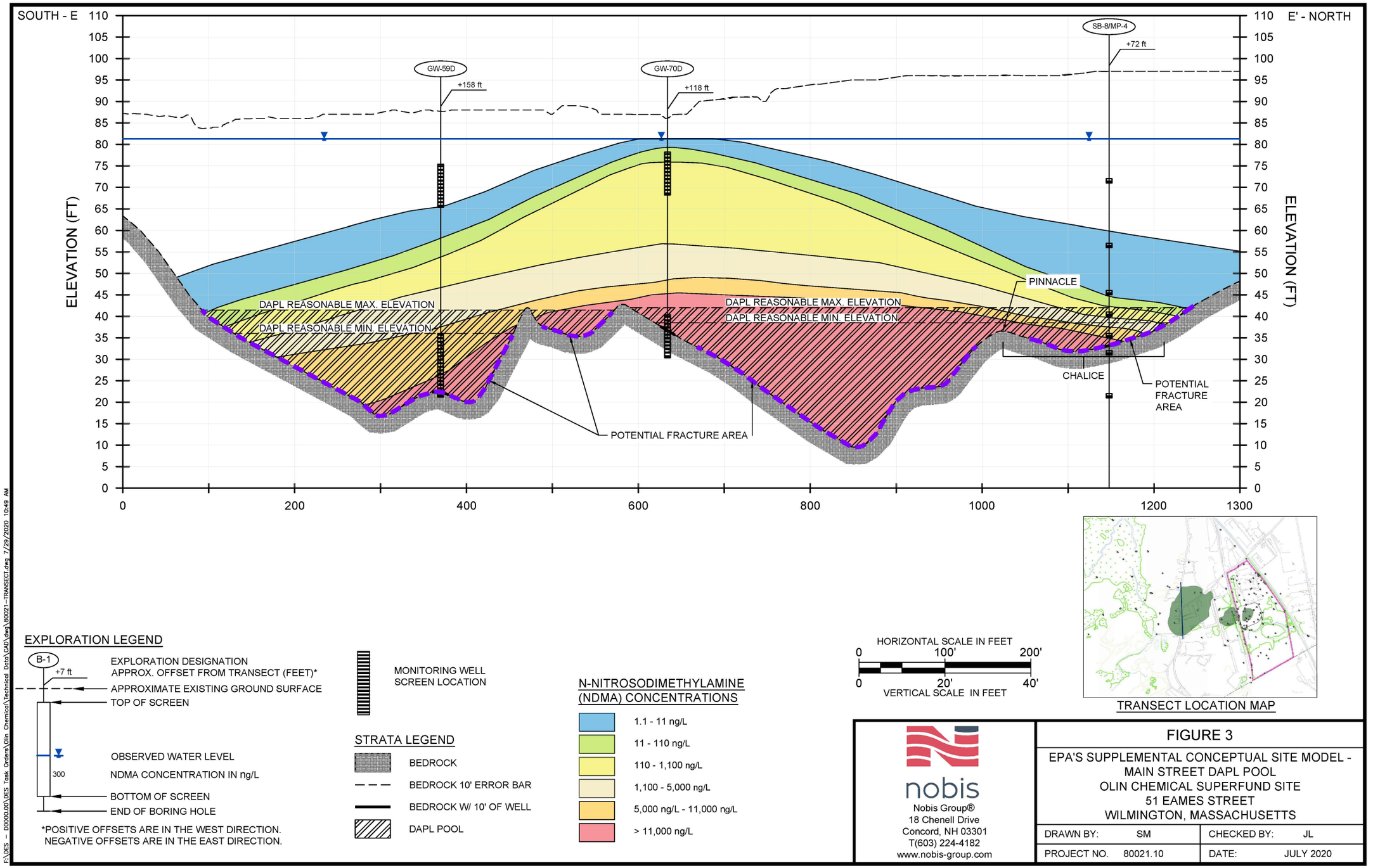

Figure 3. EPA's Supplemental Conceptual Site Model – Main Street DAPL Pool.

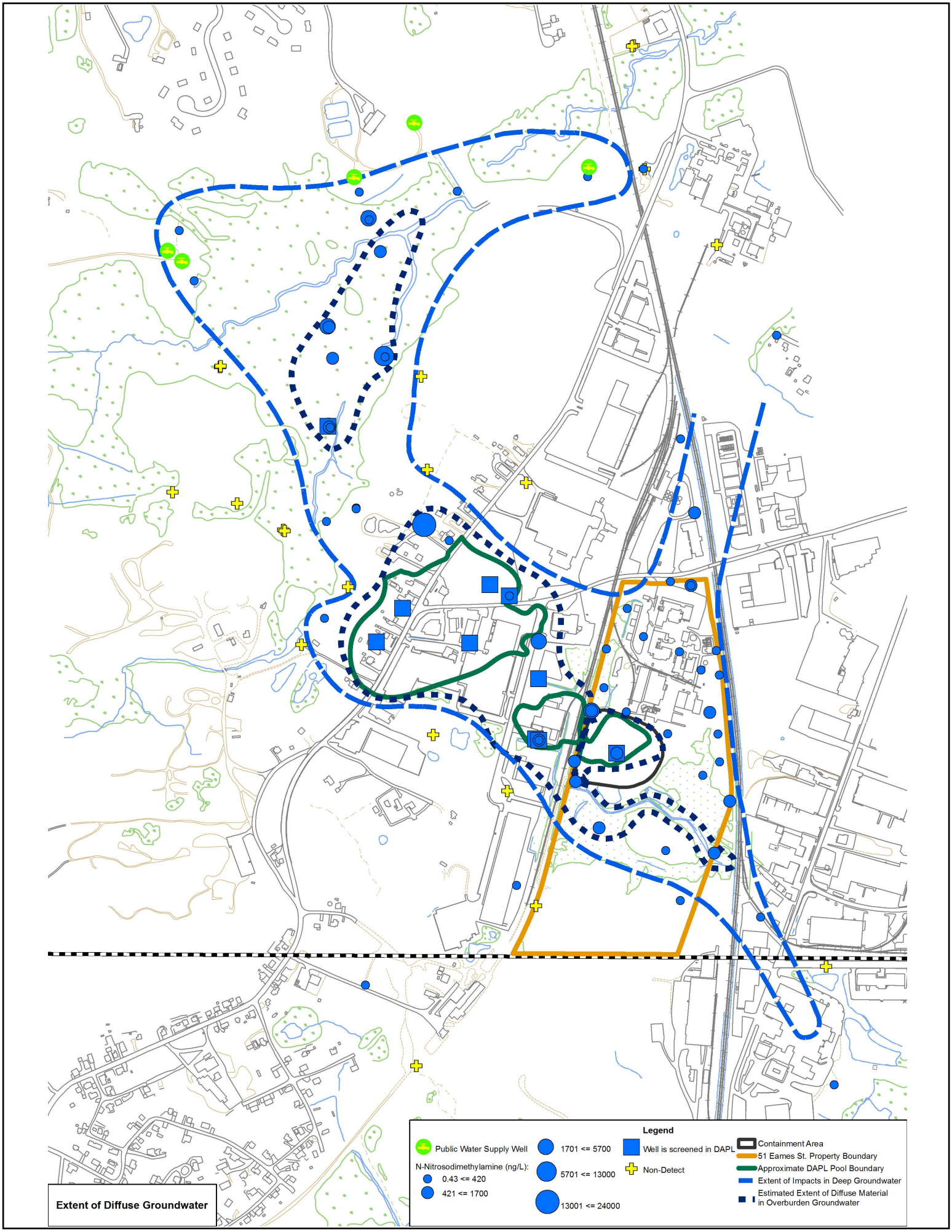

Figure 4. Dense Aqueous Phase Liquid (DAPL) Pools and Extent of Diffuse Groundwater Plume in Overburden Groundwater. Diffuse groundwater plume depicted by NDMA concentrations in the deep overburden aquifer.

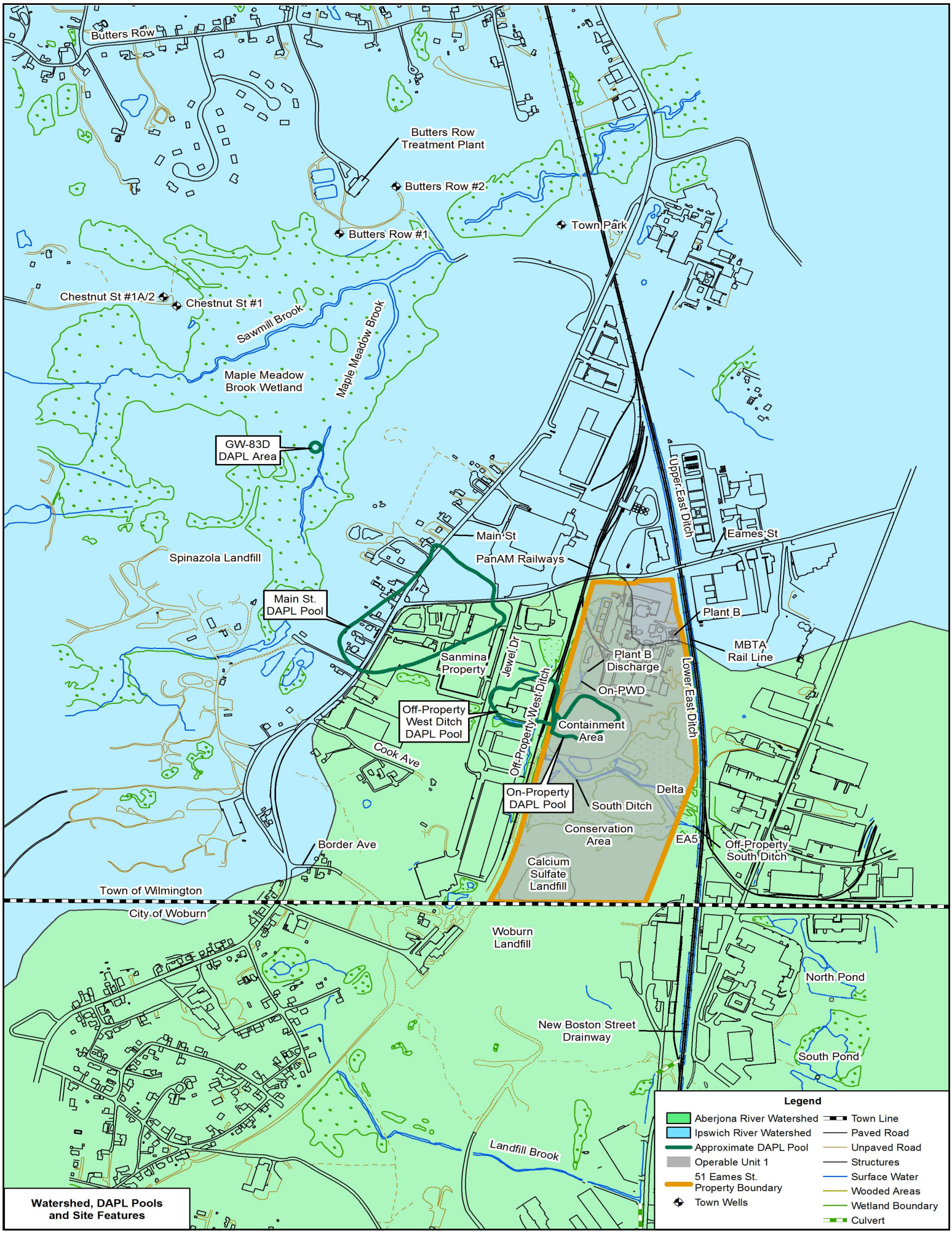

Figure 5. Watershed Map. Site straddles two watersheds – the Ipswich River Watershed to the north and west (in blue) and the Aberjona River Watershed to the south and east (in green). The location of the divide based on Massachusetts Geographic Information System watershed mapping conducted in 1990. Visible also are the subsurface pools of DAPL (shown in green outline), located in depressions on the top of bedrock.

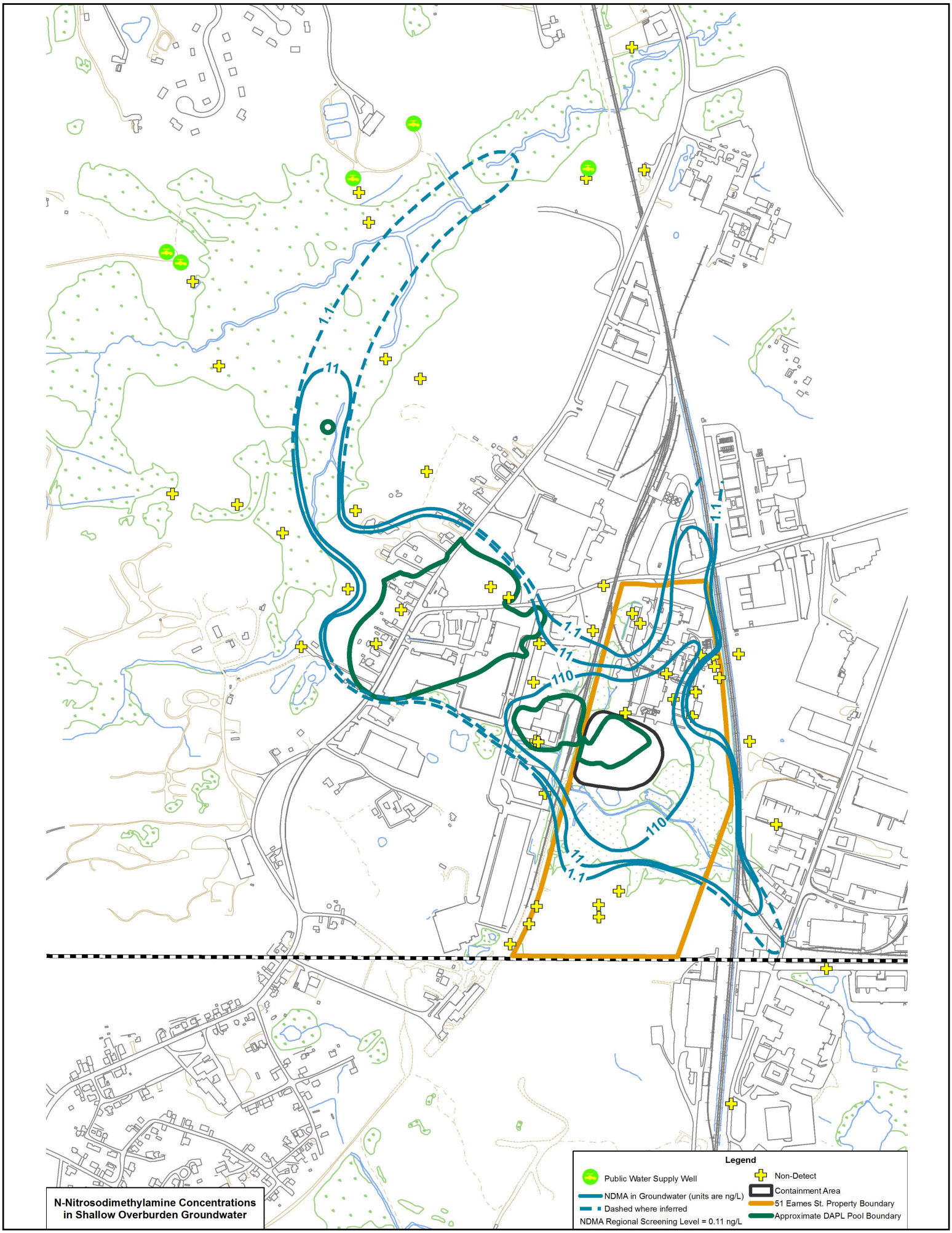

Figure 6. N-nitrosodimethylamine (NDMA) Concentrations in Shallow Overburden Groundwater.

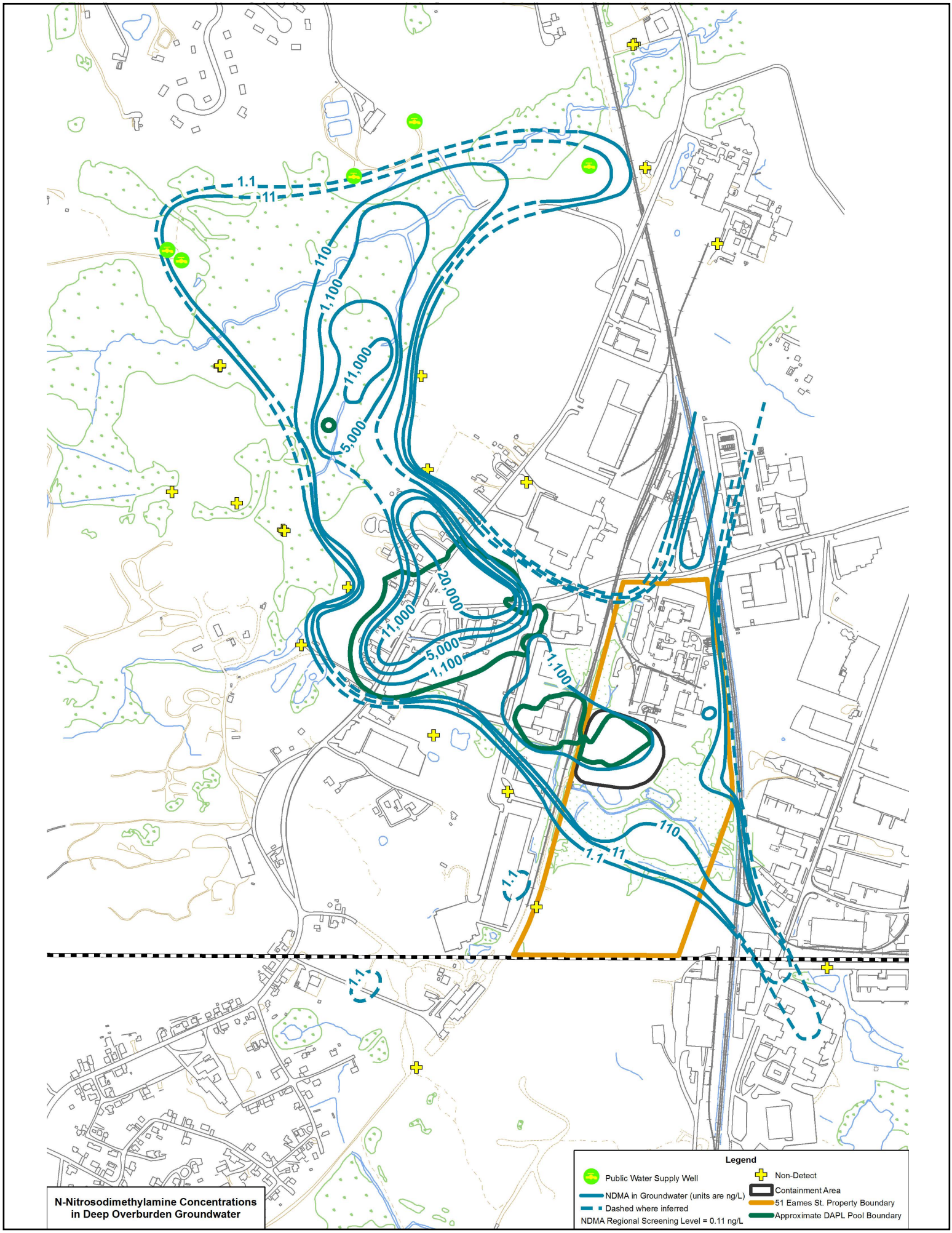

Figure 7. N-nitrosodimethylamine (NDMA) Concentrations in Deep Overburden Groundwater.

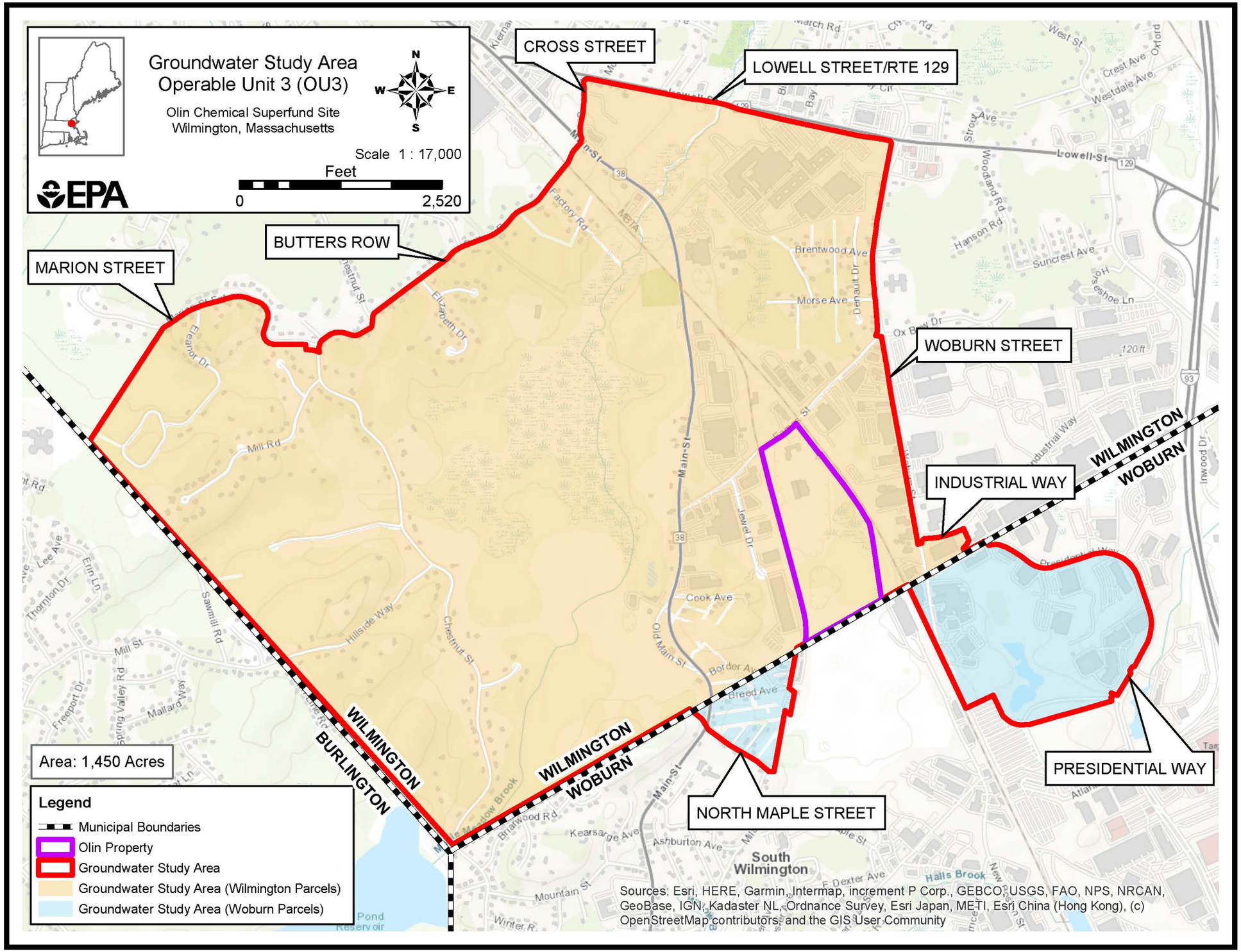

Figure 8. Operable Unit 3 (OU3) Groundwater Study Area.

Attachment B

Output Calculations from EPA's Regional Screening Level (RSL) Calculator

Risk-Based Screening Level for N-Nitrosodimethylamine (NDMA) in Residential Tapwater

RSL Calculator Available at

https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

Default
Resident Equation Inputs for Tap Water

Variable	Value
THQ (target hazard quotient) unitless	1
TR (target risk) unitless	0.0001
LT (lifetime) years	70
K (volatilization factor of Andelman) L/m^3	0.5
l_{sc} (apparent thickness of stratum corneum) cm	0.001
ED_{res} (exposure duration - resident) years	26
ED_{res-c} (exposure duration - child) years	6
ED_{res-a} (exposure duration - adult) years	20
ED_{0-2} (mutagenic exposure duration first phase) years	2
ED_{2-6} (mutagenic exposure duration second phase) years	4
ED_{6-16} (mutagenic exposure duration third phase) years	10
ED_{16-26} (mutagenic exposure duration fourth phase) years	10
EF_{res} (exposure frequency) days/year	350
EF_{res-c} (exposure frequency - child) days/year	350
EF_{res-a} (exposure frequency - adult) days/year	350
EF_{0-2} (mutagenic exposure frequency first phase) days/year	350
EF_{2-6} (mutagenic exposure frequency second phase) days/year	350
EF_{6-16} (mutagenic exposure frequency third phase) days/year	350
EF_{16-26} (mutagenic exposure frequency fourth phase) days/year	350
$ET_{event-res-adj}$ (age-adjusted exposure time) hours/event	0.67077
$ET_{event-res-madj}$ (mutagenic age-adjusted exposure time) hours/event	0.67077
ET_{res} (exposure time) hours/day	24
ET_{res-c} (dermal exposure time - child) hours/event	0.54
ET_{res-a} (dermal exposure time - adult) hours/event	0.71
ET_{res-c} (inhalation exposure time - child) hours/day	24
ET_{res-a} (inhalation exposure time - adult) hours/day	24
ET_{0-2} (mutagenic inhalation exposure time first phase) hours/day	24
ET_{2-6} (mutagenic inhalation exposure time second phase) hours/day	24
ET_{6-16} (mutagenic inhalation exposure time third phase) hours/day	24
ET_{16-26} (mutagenic inhalation exposure time fourth phase) hours/day	24
ET_{0-2} (mutagenic dermal exposure time first phase) hours/event	0.54
ET_{2-6} (mutagenic dermal exposure time second phase) hours/event	0.54
ET_{6-16} (mutagenic dermal exposure time third phase) hours/event	0.71

Default
Resident Equation Inputs for Tap Water

Variable	Value
ET_{16-26} (mutagenic dermal exposure time fourth phase) hours/event	0.71
BW_{res-a} (body weight - adult) kg	80
BW_{res-c} (body weight - child) kg	15
BW_{0-2} (mutagenic body weight) kg	15
BW_{2-6} (mutagenic body weight) kg	15
BW_{6-16} (mutagenic body weight) kg	80
BW_{16-26} (mutagenic body weight) kg	80
$IFW_{res-adj}$ (adjusted intake factor) L/kg	327.95
$IFW_{res-adj}$ (adjusted intake factor) L/kg	327.95
$IFWM_{res-adj}$ (mutagenic adjusted intake factor) L/kg	1019.9
$IFWM_{res-adj}$ (mutagenic adjusted intake factor) L/kg	1019.9
IRW_{res-c} (water intake rate - child) L/day	0.78
IRW_{res-a} (water intake rate - adult) L/day	2.5
IRW_{0-2} (mutagenic water intake rate) L/day	0.78
IRW_{2-6} (mutagenic water intake rate) L/day	0.78
IRW_{6-16} (mutagenic water intake rate) L/day	2.5
IRW_{16-26} (mutagenic water intake rate) L/day	2.5
EV_{res-a} (events - adult) per day	1
EV_{res-c} (events - child) per day	1
EV_{0-2} (mutagenic events) per day	1
EV_{2-6} (mutagenic events) per day	1
EV_{6-16} (mutagenic events) per day	1
EV_{16-26} (mutagenic events) per day	1
$DFW_{res-adj}$ (age-adjusted dermal factor) cm^2-event/kg	2610650
$DFWM_{res-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	8191633
SA_{res-c} (skin surface area - child) cm^2	6365
SA_{res-a} (skin surface area - adult) cm^2	19652
SA_{0-2} (mutagenic skin surface area) cm^2	6365
SA_{2-6} (mutagenic skin surface area) cm^2	6365
SA_{6-16} (mutagenic skin surface area) cm^2	19652
SA_{16-26} (mutagenic skin surface area) cm^2	19652

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

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's 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_o (mg/kg-day)$^{-1}$	SF_o Ref	IUR (ug/m^3)$^{-1}$	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	GIABS	K_p\ (cm/hr)
Nitrosodimethylamine, N-	62-75-9	Yes	Yes	Organics	5.10E+01	I	1.40E-02	I	8.00E-06	P	4.00E-05	X	1	2.51E-04

MW	B (unitless)	t^* (hr)	τ_{event} (hr/event)	FA (unitless)	In EPD?	$DA_{event\ (ca)}$	DA_{event} (nc child)	DA_{event} (nc adult)	MCL (ug/L)	Ingestion SL TR=0.0001 (ug/L)	Dermal SL TR=0.0001 (ug/L)	Inhalation SL TR=0.0001 (ug/L)	Carcinogenic SL TR=0.0001 (ug/L)
74.083	8.31E-04	6.56E-01	2.73E-01	1	Yes	6.12E-06	1.97E-05	3.40E-05	-	4.91E-02	2.00E+01	1.45E-02	1.12E-02

Ingestion SL Child THQ=1 (ug/L)	Dermal SL Child THQ=1 (ug/L)	Inhalation SL Child THQ=1 (ug/L)	Noncarcinogenic SL Child THI=1 (ug/L)	Ingestion SL Adult THQ=1 (ug/L)	Dermal SL Adult THQ=1 (ug/L)	Inhalation SL Adult THQ=1 (ug/L)	Noncarcinogenic SL Adult THI=1 (ug/L)	Screening Level (ug/L)
1.60E-01	7.38E+01	8.34E-02	5.48E-02	2.67E-01	1.08E+02	8.34E-02	6.35E-02	1.12E-02 ca