UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NEW ENGLAND REGION
FIVE POST OFFICE SQUARE, SUITE 100, BOSTON, MA 02109

October 8, 2020

Bruce Thompson
de maximis, inc.
200 Day Hill Road, Suite 200
Windsor, CT 06095

Re: Approval of de maximis inc. report titled *Remedial Design Work Plan – Appendix E In Situ Sequestration Treatability Study Work Plan* (the "TSWP"), dated September 2020.

Nuclear Metals, Inc. Superfund Site

Dear Mr. Thompson:

EPA, in consultation with the Massachusetts Department of Environmental Protection, has completed its review of the TSWP, dated September 2020. The TSWP was revised in response to EPA comments dated July 13, 2020, and United States Geological Survey (USGS) comments dated August 2020. The TSWP is subject to the terms and conditions specified in the Consent Decree (CD) for Remedial Design / Remedial Action (RD/RA) for the Nuclear Metals, Inc. Site, which has an effective Date of December 6, 2019.

EPA has reviewed the revisions to the TSWP and finds that they are acceptable. Therefore, EPA approves the TSWP.

If there is any conflict between the Performance Standards as stated in the Work Plan and the Performance Standards as stated in the CD and statement of work (SOW), the CD and SOW shall control.

Please do not hesitate to contact me at (617) 918-1339 or at smith.christopher@epa.gov should you have any questions in this regard.

Sincerely,

Christopher Smith
Project Manager

Response To Comments

EPA-Nuclear Metals: Campbell comments August 2020

I have reviewed Appendix E of the Remedial Design Work Plan, AECOM's comments, and the responses to those comments. Please find comments outlined below. The proposed experiments are well-designed, detailed, and a scientifically compelling set of tests that will answer the key questions of which amendments and what dose should be considered for the three *in situ* treatment zones (holding basin, overburden, bedrock). I also think that these tests would be very interesting to the greater scientific community (e.g., presented in a journal article form). There may be a few additional or specialized analyses needed, but the work as described has potential to be written up as a paper. I'm happy to discuss further if this is of interest to the team.

1. **AECOM comments**
    a. AECOM comment 2: AECOM recommended a possible alternative amendment (Calcium chloride, trisodium citrate, dibasic sodium phosphate amendment) for this system. Although this approach in many treatment environments has merit, it may not be ideal for NMI. As described in the responses to comments, calcium citrate is mainly used to amend the groundwater aquifer with calcium, so that the phosphate addition creates an apatite (or other Ca-phosphate mineral) barrier that reacts with uranium. Given the concentrations of Ca at the site, additional amendment of Ca is not likely to be needed. In addition, citrate forms complexes with metals, including iron and uranium, which may substantially alter the solubility of uranium, also mentioned in the responses. The complexation of uranium with citrate may potentially decrease the effectivity of the phosphate treatments. Francis et al. (1991) found that U-citrate complexes are resistant to microbial degradation, while Huang et al. (1998) found that microbial degradation of uranium-citrate complexes is pH dependent; however, both studies suggest that microbial degradation is likely to be limited at the pH of the aquifer. The literature on this subject is slightly outdated, given relatively new information about U-carbonato ternary complexes (ca., 2008-9), which are undoubtably important in this context. Some geochemical aqueous speciation modeling could be relatively easily used to determine the expected speciation of uranium in the presence of a citrate amendment under groundwater conditions. Generally, although an interesting approach to creating U-reactive Ca-phosphate precipitates in situ, it is not likely to be the best option for the NMI site.

        RESPONSE: We agree that the in-situ approach proposed by AECOM is not the best option for the NMI site.

    b. AECOM comment 4: Gamma spectrometry is an acceptable method for screening U concentrations. An alternate approach (mainly for future reference and which may have already been considered) is handheld XRF. Although it needs to be calibrated specifically for the matrix to be analyzed, it has the advantage of screening multiple elements simultaneously on a semi-quantitative to quantitative basis.

RESPONSE: Thank you for the recommendation.

c. AECOM comment 5: I would like to second this comment – vacuum sealing in the field is easy, inexpensive, and reliable when a double bag method is used. It is worth considering. Refrigeration of core is also highly recommended.

   RESPONSE: Preservation of the in-situ redox conditions of soil samples is not a priority for the soil sampling protocol since the soils will be exposed to oxygenated solutions during the batch and column tests. Based on this consideration, we believe that double bagging the soil in zip top bags and expelling ambient air within the bags will be sufficient to preserve the geochemistry of the samples. Additionally, soil samples will be packed on ice during transport to the lab to limit geochemical alteration.

d. AECOM comment 6: I agree that a consistent panel of metal(loids) should be analyzed throughout. Al, Ca, Mn, Fe, As, U – it looks like this was corrected in the edits. Consider also any other potential metals of concern (e.g., Sb, Ba, Be, Cd, Cr, Co, Cu, Pb, Mo, Ni, Se, Ag, Tl, Th, V, Zn – measured in GW) at this stage.

   RESPONSE: Concerning the other potential metals of concern: Sb, Be, Cd, Pb, Ni, Se, Ag, Tl, V, and Zn are not on the EPA Groundwater Cleanup List for the site. Ba, Cr, Co, Cu, have not been detected at levels of concern. Th has been detected in overburden groundwater above the cleanup level, but at locations far away from the uranium plume. Mo has been detected in groundwater at elevated levels in the upgradient portion of the uranium plume in overburden and has been added to the analyte list. Similar to arsenic, molybdenum will be measured in select batch reactor and column effluent samples at a frequency less than uranium.

e. AECOM comment 10: An important point is to have background phosphate and nitrate data in the baseline data.

   RESPONSE: We agree that background phosphate concentrations are important for evaluating the results of the study; phosphate is measured during background characterization of all soil and groundwater. Nitrate has been measured throughout the site in groundwater, and we have added nitrate to the baseline groundwater characterization and select batch reactor and column effluent samples in each treatability study.

f. AECOM comment 11: I definitely agree that Fe(II) data will be important to these studies. Phenanthroline or FerroZine are both relatively easy colorimetric methods for this determination.

   RESPONSE: We agree on the importance of measuring Fe(II) during the column study. We will consult with the laboratory on the use of colorimetric methods to directly measure Fe(II).

g. AECOM comment 18: Regarding solubility of apatite II, hydroxyapatite: Some experiments in my lab (unpublished, as of yet) found a poorly crystalline Ca-P-U precipitate that had a higher solubility than both apatite II and hydroxyapatite, and which slowly recrystallized into U-substituted hydroxyapatite over time. It may or may not be directly applicable to this situation, but this kind of phase may precipitate in the phosphate amended experiments. I am happy to discuss further if it would be helpful, or if you see evidence of it in the experiments.

   RESPONSE: Thank you for this insight. We will consider the possibility of this phase during evaluation of the treatability study results.

2. General comments

a. Analytical comments
   i. Consistency: The document still has a few incontinences with analytes. It might be good to double check the analytical parameters. I tried to point out many of them in the specific comments below.
   ii. Mineralogy
      1. Pre-reaction sediments: consider including particle size (PSA), XRD, sequential extractions to understand the baseline sediments.

         RESPONSE: During the Remedial Investigation (RI), soil cores were collected from the uranium plume in overburden. Analyses of these cores included particle size determinations using a Beckman-Coulter laser coulter counter (LS-230), XRD for major constituent minerals, and sequential extractions to qualitatively determine iron mineralogy and concentrations of uranium associated with different mineral fractions. Results can be found in Appendix G of the RI Report (de maximis, Geosyntec, 2011[1]). This document has been included with the response to comments transmittal.

         In general, the study found that the relative importance of system variables on uranium transport included: 1) sediment specific surface area; 2) solution alkalinity; 3) solution pH; and 4) calcium concentration.

      2. Homogeneity: It would be good to clarify how the homogeneity of the sediments used in the experiments will be ensured.

         RESPONSE: Soil samples will be homogenized by the laboratory prior to baseline characterization and column packing. Additional details regarding the soil homogenization procedure have been added throughout the text:

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[1] *de maximis*, Geosyntec, 2011, Remedial Investigation Report (Appendix G: Dartmouth College Uranium Adsorption Study - Nielsen, L.C.., and Bostick, B.C., *Integrating Variable Aquifer Geochemistry and Sediment Properties into Models of Uranium Retention at the Nuclear Meals Incorporated Superfund Site.*

Loose or sandy soil will be blended via cloth blending, use of a V-blender, or cone-and-quartering techniques. Following homogenization, representative sub-samples will be collected for use in the batch and column tests based on visual inspection.

3. Bicarbonate extraction: Kohler et al. (Environ. Sci. Technol. 2004, 38, 240-247) developed an extraction with bicarbonate at pH ~9 that estimates desorbable U. It is no harder to do than the modified Tessier extractions. Consider incorporating this method.

   RESPONSE: We appreciate this suggestion. The Kohler et al. work employs a 1,500 mg/L bicarbonate/carbonate extraction fluid at pH 9.45 to quantitatively desorb uranium from sediment surfaces by strong aqueous complexation of U(VI) in order to develop a distribution coefficient for uranium partitioning between sediment and aqueous phases. We propose two extraction steps that target adsorbed uranium (weakly sorbed and strongly sorbed), which we believe are sufficient to quantify the fraction of uranium sorbed to soils. Additionally, we propose a bicarbonate extraction as part of the evaluation of the leachability of immobilized uranium after the column tests using a 70 mg/L bicarbonate solution adjusted to pH 7 to represent site groundwater conditions. We believe this to be more relevant to the site than the higher concentrations of bicarbonate used by Kohler et al.

iii. Alkalinity. This measurement is generally absent from the groundwater sampling, but this is a key measurement. Groundwater in ambient atmosphere will likely degas CO_2, changing the pH and potentially precipitating calcite. Also, microbial activity will generate CO_2, so monitoring alkalinity is part of understanding the redox question (see below) as well as affecting uranium speciation. In addition, phosphate amendments may change the alkalinity as well. Good alkalinity and pH measurements will be a key part of having enough geochemistry to interpret changes between amendment and control batch reactors and columns.

RESPONSE: We agree alkalinity is an important parameter to assess and monitor; we propose in the workplan to use inorganic carbon measurements (by coulometry) for baseline groundwater characterization and during batch and column tests to determine inorganic carbon concentration, which is the primary component of alkalinity that affects uranium mobility and is equivalent to alkalinity measurements. Phosphorus measurements during the column study will allow us to evaluate the effect of phosphate-based treatments on alkalinity. Directly measuring inorganic carbon and phosphorus provides more information and is more practical than alkalinity titrations.

iv. Consider following nitrate, Fe(II), and sulfide in addition to total Al, Ca, Mn, Fe, As, and U

RESPONSE: We will measure nitrate (colorimetry), Fe(II) (colorimetry, or indirectly by dissolved iron), and sulfide (by zinc acetate/turbidimetric method) in select samples as redox indicators. These analytes have also been added to the baseline characterization.

b. Redox: As we are all well-aware, reduction can be beneficial for U in short term (insoluble U(IV) precipitates) but the extent of reduction can also be hard to control. If U reduction is a mode of removal, the extent of U reduction and co-precipitation of "redox buffers" (e.g., FeS) need to be considered and matched as closely as possible to what is achievable *in situ*, especially during reduction/reoxidation tests for the holding basin.

i. How reducing should each batch/column test go (how is the system poised in Eh space)? How will it be monitored? With different treatments will come different redox conditions (especially since Apatite II has organic carbon residual in it). Do the redox conditions in the experiments mimic what is expected in the aquifer during treatment?

RESPONSE: The only test in which we are manipulating the redox conditions will be for the holding basin (HB) soil in TS ISS-1; we expect that field conditions in the HB will be anaerobic after capping and vertical barrier wall installation. We will simulate these conditions in the lab by amending the column influent with glucose and ammonium chloride to stimulate consumption of dissolved oxygen and nitrate and to achieve iron reducing/fermentative conditions. We will monitor the change in redox conditions via measurement of DO, ORP, nitrate, Fe(II) (directly, or as dissolved iron), and sulfide in select column effluent samples. The goal will then be to reintroduce oxidizing conditions to simulate a breach in the HB containment, to evaluate uranium dissolution and to determine which amendment works best to prevent resolubilizaiton of the uranium. It is possible that the reducing conditions in the TS ISS-1 tests will lead to uranium reduction and formation of uraninite. We may add QEMSCAN analysis of selected samples to determine the mineralogical distribution of solid-associated uranium.

We will not seek to lower the ORP in the overburden groundwater study outside the Holding Basin (ISS-2) since the groundwater system is generally oxidizing, however, changes in redox conditions may occur due to the amendment. We have revised the work plan to monitor redox indicator species (nitrate, iron, sulfide) concentrations throughout the batch and column tests to evaluate if we see development of reducing conditions.

ii. Glucose: this will drive fermentative microbial pathways. I would think you would be more interested in dissimilatory metal reduction, so lactate or acetate may be an alternative electron donor.

RESPONSE: Glucose fermentation will produce lactate and acetate and associated iron reduction, so we believe this will stimulate a range of microbial activity relevant in the HB. We hope to avoid promoting dissimilatory uranium reduction with the redox amendment in the Treatability Study. Dissimilatory uranium reduction is not a primary sequestration mechanism of any of our proposed in situ amendments, and reduced uranium is susceptible to reoxidation and remobilization even when reducing conditions are maintained.[2]

iii. Question of long-term stability: One of the big questions is if aquifer returns to oxic conditions and the reduced U reoxidizes, is the Ca-phosphate sufficient to sequester U? If the experiments are too reducing and the reoxidation test indicates no pulse of U because of the “redox buffering”, there is the possibility that the phosphate question will not quite be answered. Just something to think about – this does not change the experimental design fundamentally. Also, maybe this is made clear in the larger document (my apologies if I’ve missed it), but what is the decision tree for whether possible follow-up injection may be needed if oxidation of reduced U becomes an issue in the aquifer?

RESPONSE: We agree that a return to oxic conditions within the columns during TS ISS-1 will be necessary to evaluate whether the amendments prevent remobilization of oxidized U(IV) minerals. Section 3.2.4 states that “if by week 4 the effluent is not indicative of a return to oxidizing conditions within the column (return to baseline ORP and dissolved iron concentrations), this phase of the column test will continue.”

Injection remedies rely on contact with impacted groundwater and are a function of distribution, seepage rates, and hydraulic gradients. Whatever amendment and dose are selected for the final remedy in overburden outside the Holding Basin, groundwater in and downgradient of the current plume area will be monitored closely. If uranium concentrations do not decline significantly or decline and rebound, then follow-up injections will be implemented.

c. Column experiments

i. Tracers: Consider monitoring/adding a tracer. You will need it to determine porosity of the column (so results can be translated to pore volumes). Also, a tracer is needed for any geochemical modeling efforts. E.g., Br addition to influent. This would also add an additional analyte.

RESPONSE: Thank you for this suggestion; we agree that addition of a conservative tracer to the column tests will provide valuable information. We have revised the text to state that bromide (or a suitable tracer based on laboratory analytical

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[2] Wan et al., 2005. *Reoxidation of bioreduced uranium under reducing conditions.* Environmental Science and Technology.

capabilities) will be added to the column influent solution and measured in the column effluent.

d. Arsenic. It is clear this team is well-aware of likelihood of arsenic release from sediments, especially with high levels of phosphate competitively desorbs arsenic from the sediments, along with the arsenic introduced with amendments. It is not clear to me exactly what the plan is to deal with arsenic – it sounds like there may be enough Fe-oxide content downstream of treatment to re-adsorb the arsenic, but it would be worth adding modeling or other planning tools for understanding arsenic mobility during and after treatment. The comments about redox state also applies to arsenic, as strongly sulfidic conditions in a column may sequester As in sulfide precipitates, but is the aquifer expected to go that reducing during treatment conditions?

   RESPONSE: We do not expect sulfidic conditions to develop within the aquifer during treatment, especially if apatite or soluble phosphate is used, however, we will monitor redox conditions during the treatability tests to evaluate this. We expect there will be enough iron oxide mineral content in the aquifer downstream of the injections to sequester any arsenic that might be mobilized through phosphate emplacement. We will evaluate the iron content of the soil and the iron mineral phases through selective extractions as part of the TS. This information can be used to assess the sorptive capacity of the aquifer for arsenic.

3. Specific comments

[p2] Amendment selection Matrix:
#1: additional disadvantage: contains organic matter – reduction potential likely.
#4: additional advantage: As may be retained on ZVI; ZVI not likely to introduce As

RESPONSE: The amendment selection matrix has been updated to include these additional advantages and disadvantages.

[p3]. Other possibilities include U-substituted apatite, and possible poorly crystalline Ca-U-P precursor phases. There is uncertainty in the actual mineralogical products.

RESPONSE: The text has been updated to include these additional uranium sequestration products.

[p7 #8] I would think that mineralogy, particle size would be as important to this experiment as U concentration. How homogeneous are these cores expected to be?

RESPONSE: Soil samples will be collected over a 20-foot interval, which will likely include the range of grain sizes known to be present in the holding basin. Homogeneity in the lab will be achieved by mixing the soils in the laboratory prior to constructing the columns. Assessments of mineralogy and particle size within the depleted uranium plume have been performed previously.[3]

[p7 #10]
Particle size? XRD? Please see general comment about Mineralogy above. Sometimes the controlling phases are minor in content but key to overall geochemistry. E.g., Fe oxides.
Are there any other elements of concern that should be measured at this time? Co was mentioned in the call. How about Al, Sb, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Tl, Th, V, Zn, as for groundwater? Consider measuring in starting material.

RESPONSE: Mineralogy and particle size have been previously measured,[4] and results indicated that particle size and Fe oxides have strong controls on the magnitude of uranium sorption at the site. The target soil collection areas for the Holding Basin should have very representative particle size and Fe oxide concentrations, and therefore, particle size determination on the homogenized soils will not be critical for the study. We have added molybdenum to the list of metals for baseline characterization and select batch and column effluent samples; the remaining metals are not regulated at the site or have not been detected at levels of concern.

[p8 3.2.2] Raw and a 0.45um filtered sample at time of sampling would be useful. Although O2 will be minimized, as will CO2 degassing, you may want to know if calcite precipitated before starting your experiments. Calcite precipitation may also affect [U]. By having an initial acidified sample for analysis, you know how much your water changed. Also, measure alkalinity. Having a handle on the initial water conditions, including pCO2, calcite, and effect on U speciation and conc seems important. Add Mn to analyte list. Consider turbidity for consistency. Sample preservation protocols (e.g., acidification)?

RESPONSE: We added additional characterization of the groundwater at the time of sampling (unfiltered and 0.45 µm filtered) to identify potential changes in groundwater composition between sampling and initiation of the column and batch studies (baseline characterization). In addition, we added Mn to the analyte list and turbidity to the field measurements.

[p9 analytes] Sorry for nit-picking here, but As is not a cation. Also, Fe is not always reliable by ICP-MS. Many of these elements are better by ICP-OES, which is included in the rest of the document, so perhaps this is just a typo.

RESPONSE: Thank you for pointing out these typos. We have revised the text to add arsenic to the list of metals and to add ICP-OES as a potential analytical technique for cation analysis.

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[3] *de maximis*, Geosyntec, 2011, Remedial Investigation Report (Appendix G: Dartmouth College Uranium Adsorption Study - Nielsen, L.C.., and Bostick, B.C., *Integrating Variable Aquifer Geochemistry and Sediment Properties into Models of Uranium Retention at the Nuclear Meals Incorporated Superfund Site.*

[4] *de maximis*, Geosyntec, 2011, Remedial Investigation Report (Appendix G: Dartmouth College Uranium Adsorption Study - Nielsen, L.C.., and Bostick, B.C., *Integrating Variable Aquifer Geochemistry and Sediment Properties into Models of Uranium Retention at the Nuclear Meals Incorporated Superfund Site.*

[p10 3.2.4 column test] Consider monitoring/adding a tracer. You will need it to determine porosity of the column (so results can be translated to pore volumes). Also needed for any geochemical modeling efforts.

RESPONSE: We have revised the text to include amendment of bromide (or a similar conservative tracer) to the column influent solution and measurement of bromide in the column effluent.

[p10 column test, weeks 2-3] Consider redox carefully. Glucose will drive fermenters. So, it will go anaerobic, but perhaps by a slightly different mechanism than intended (e.g., dissimilatory Fe reduction)? Also, it is hard to control/stop at Fe reduction and the system may go more reducing, especially with apatite II amendment. Vitamins are sometimes added in nutrient amendments, but it may or may not be necessary. It sounds like the groundwater will be sterilized in addition to filtration – if so, how will the GW be sterilized? 0.22um filtration usually does the trick. Note that sterilization can introduce O2 and degas CO2. That's expected and it's better to sterilize but knowing how the processing of the water affects the geochemistry is necessary. Consider measuring Fe(II), sulfide. May need closer monitoring and redox decision-making determination in this step (see redox comments above).

RESPONSE: We agree that these are important considerations during the anaerobic phase of the column test. Glucose will stimulate a range of microbial activity including iron reduction and we believe this is appropriate to simulate anaerobic conditions in the HB since we want to avoid promoting dissimilatory uranium reduction. As noted above, we have added measurement of redox indicators (nitrate, dissolved iron, sulfide) to select samples. Turbidity has been added to the field parameters measured during sample collection. The text has been revised to clarify that groundwater will be filter sterilized.

[week 4] This will depend greatly on how reducing the column went in the previous step. If a lot of reduced Fe, U, S, biomass is present, then there could be a large redox buffer in the column.

RESPONSE: We agree. As noted above, the column test will continue until oxidizing conditions are observed in the effluent.

[p11] Analyte list: Mn, alkalinity. Microbial activity will produce inorganic C, and P amendment can affect alkalinity. I would be good to have enough geochemistry to interpret changes between amended and control columns, especially changes in U concentrations. Another thought: consider raw/filtered analysis for Fe as well as U, as colloidal Fe is a possibility.

RESPONSE: We have added Mn to the analyte list and will be measuring inorganic carbon and phosphorus during the test to assess alkalinity. If effluent iron concentrations are elevated, we will consider analysis of filtered and unfiltered column effluent for iron to assess the possibility of colloidal iron in the column effluent.

[p13 4.2.1] sediment analyses: Mn, As – other elements? XRD? PSA?

RESPONSE: We have revised the text to include manganese and arsenic in the baseline soil characterization. We have historical XRD data on the soils;[5] particle size determination on the homogenized soils will not be critical data for the study.

[p14 4.2.2] ditto water analysis comments above.

RESPONSE: We added additional characterization of the groundwater at the time of sampling (unfiltered and 0.45 µm filtered) to identify potential changes in groundwater composition between sampling and initiation of the column and batch studies (baseline characterization). In addition, we added Mn, nitrate, and sulfide to the analyte list and turbidity to the field measurements.

[p14 4.2.3] Glass is not typically used for metal work as it may have some sorption capacity. Acid-washed plastic is standard, but given the size of the batch experiments, it is likely that a glass bottle effect is small.

RESPONSE: We will discuss with the laboratory the decision to switch to plastic bottles for this work.

[p15 4.2.3] These experiments could have wide divergence in redox conditions in the treatments. Is it valuable to control redox? Would that mimic the site conditions best? This comment relates to the general redox comment above. Fe(II), sulfide could be useful measurements to pinpoint process (not necessarily just relying on ORP) even if redox state is allowed to float depending on amendment. I assume the rubber stoppers are fixed to the bottles (e.g., serum bottles with sealed stoppers) - if you get any microbial activity, you may see flying rubber stoppers!

RESPONSE: The redox state of the batch and column experiments will depend on the treatment amendment. Since the redox conditions in the field will not be controlled, the redox state of the batch and column tests will also not be poised. We agree that analyzing nitrate, Fe(II) (directly or indirectly as dissolved Fe), and sulfide in the batch reactor and column effluent samples will provide valuable information regarding the geochemical processes controlling the redox conditions within the reactors/columns. We have added these analyses to the text and the sample matrix.

[p16 4.2.4] ditto tracer comment

RESPONSE: We have revised the text to state that bromide (or a similar conservative tracer) will be added to the column influent solution and measured in the column effluent.

[p16] Ditto comments about O2/CO2 exchange, alkalinity, U, calcite, etc.

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[5] *de maximis*, Geosyntec, 2011, Remedial Investigation Report (Appendix G: Dartmouth College Uranium Adsorption Study - Nielsen, L.C.., and Bostick, B.C., *Integrating Variable Aquifer Geochemistry and Sediment Properties into Models of Uranium Retention at the Nuclear Meals Incorporated Superfund Site.*

RESPONSE: As noted above, we have included additional baseline characterization of groundwater at the time of sampling to evaluate changes in composition (e.g., precipitation, degassing of CO2) during transport and storage.

[p17] Consider at least one filtered/unfiltered comparison, and adding Alkalinity, Mn

RESPONSE: We added manganese to the analyte list for the column effluent. As noted above, inorganic carbon and phosphorus are already being analyzed to monitoring changes in alkalinity. If effluent iron concentrations are elevated, we will consider measuring iron and filtered effluent samples to assess the possibility of colloidal iron in column effluent.

[p18] May be hard to measure to amount of uranium sequestered by measuring changes in solid phase U concentration. Consider calculating this value by difference if you know influent/effluent concentration and pore volumes put through the column during the 6 weeks.

RESPONSE: Thank you for this recommendation. The text has been revised to include this calculation.

[p18 Bicarb leach] How will this be done? My apologies if I'm not understanding this procedure, but if you add bicarb and pH increases, then you decrease pH with acid, you will just degas CO2. Consider sparging with CO2 to hit alkalinity and pH targets. Or, use a published carb/bicarb leach method (e.g., Kohler et al 2004), which is higher pH, but is a well characterized method for quantifying for labile U.

RESPONSE: A bicarbonate solution will be mixed with soil and the pH will be adjusted to 7.0. Small or no headspace in the container will minimize the amount of degassing from the bicarbonate solution following pH adjustment, allowing the bicarbonate concentration and pH to be relatively constant during the extraction. The objective of this leaching test is to mimic potential changes in groundwater composition in the overburden, therefore, we believe the proposed bicarbonate leach test is more relevant than the Kohler et al. extraction.

[p19] A Kohler bicarb leach (above) would complement this sequential extraction suite. Also, Step 3 is commonly done with Hydroxylamine + HCl to target Fe, Mn oxides.

RESPONSE: Thank you for this recommendation. We believe the proposed bicarbonate leach test is more suitable for replicating site conditions and will provide more relevant information on the potential for uranium remobilization than the Kohler et al. extraction.

Step 3 follows the standard Tessier extraction procedure for iron and manganese oxides,[6] which has a similar extraction efficiency as hydroxylamine in HCl.[7]

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[6] Tessier et al., 1979. Sequential extraction procedure for the speciation of particulate trace metals. Analytical Chemistry.

[7] La Force, M.J. and S. Fendorf, 2000. Solid-phase iron characterization during common selective extractions. Soil Science Society of America Journal.

[p20] As you are aware, U phase identification may hard by XRD, even at these concentrations. Also, be on the lookout for amorphous/poorly crystalline U-containing phases that can be challenging (but not impossible!) by XRD. SEM, although expensive, could help understand where U is found in solids.

RESPONSE: Thank you for these considerations – we agree that analytical techniques in addition to XRD will likely be necessary to identify the precipitated uranium phase. We have proposed QEMSCAN analysis, which is based on Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS), for samples that do not have a sufficient uranium concentration to resolve the identity of the solid phase by XRD.

[Section 5: Bedrock experiments] Many of the comments above about groundwater sampling, bedrock homogenized chip mineralogical analysis, batch reactors, extractions, tracers, etc., apply to this section as well.

RESPONSE: We have revised the text and sampling matrix to be consistent with changes made to the other treatability studies (e.g., additional groundwater characterization at time of sampling, analysis of manganese and redox indicators [nitrate, iron, sulfide] during baseline characterization and during the batch tests). Tracers will not be necessary for TS-3 since only batch tests will be performed.

[p22 5.2.1] To what size will the bedrock chips be crushed? Also, additional analytes may be needed here for consistency. As, Mn are missing in solids characterization, as is mineralogy (XRD). Alkalinity and possibly turbidity should be added during groundwater collection. Mn is missing from the batch analyte list.

RESPONSE: The crushed bedrock will be sieved in the laboratory to target the sand fraction. We have updated the baseline characterization to be consistent with the other treatability studies.

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September 4, 2020

Mr. Christopher Smith
Remedial Project Manager
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Mail Code OSRR 07-4
Boston, MA 02109-3912

Subject: **Nuclear Metals, Inc. Superfund Site, Concord, Massachusetts**
Remedial Design Work Plan
Responses to Comments and Revised Remedial Design Work Plan

Dear Mr. Smith:

Enclosed for your review and approval are Responses to Comments (RTC) received from EPA on the revised Remedial Design Work Plan (RDWP) dated August 31, 2020.

The final RDWP and accepted appendices have been uploaded to Project Portal. The remaining appendices will be finalized after approval of these RTC.

Final documents uploaded to Project Portal include:

RDWP

Appendices

C – PDI WP– Holding Basin Containment

F - Post Removal Site Control Plan (PRSCP)

G – Health and Safety Plan (HASP) (previously approved)

H – Emergency Response Plan

K – Site Wide Monitoring Plan (SWMP)

L - Community Relations Support Plan (CRSP) (previously approved)

Appendices to be finalized after approval of responses to comments:

A - PDI WP – Site-Wide Soils and Sediments

B –PDI WP – In-Situ Sequestration of Depleted Uranium and Uranium

D – PDI WP – 1,4-dioxane and VOCs in Bedrock Groundwater

E – TS WP – In-Situ Sequestration (accepted, waiting on further comments from USGS reviewer)

I - Sampling and Analysis Plan: Field Sampling Plan (FSP)

J - Sampling and Analysis Plan: Quality Assurance Project Plan (QAPP)

Please let me know if you have any questions.

Sincerely,

Bruce Thompson

Attachment – Responses to Comments

cc: Garry Waldeck, MassDEP
Settling Defendants
Mark Kelley, PE, Haley & Aldrich, Inc.
Carl Elder, PE, Geosyntec Consultants

Responses to Comments on Revised RDWP dated August 31, 2020

Remedial Design Work Plan (main text)

1. Section 2.7.5, last paragraph – Please update the dates for the Construction Completion Report and EPA's Approval and Notice of Completion of Work.

2. Section 5 – Please update the bullets concerning the Construction Completion Report and Notice of Completion of Work for the Groundwater NTCRA to show that both have been completed/issued.

Please address these comments and compile the revised RDWP for EPA approval.

Response: Comments addressed, document finalized, and uploaded to Project Portal.

Appendix A Sitewide Soil and Sediment

1. Attachment 1, Figure 1-2 – EPA notes there is minimal sampling proposed in the northeast area of AOI 4, between proposed sampling points 7 and 14. EPA recommends de maximis consider if additional points are needed in this area.

Response: This area was not proposed for remediation as the PCBs concentrations are less than clean up criteria and the uranium concentrations are consistent with surrounding data that do not pose unacceptable risk. Sampling is proposed north and south of this area, and if the sampling results to the north and south suggest that additional sampling step-outs and evaluation are necessary, then this area may be subject to additional sampling as described in Attachment 1.

2. Attachment 3, Section 4.2 – Revise the sampling depths listed here to match RTC #25, which stated samples would be collected in the missing depth intervals. The changes were made to the tables but not the text in this section.

Please address these comments and compile the revised Appendix A for EPA approval.

Response: The text will be updated accordingly.

Appendix B In-Situ Sequestration

1. For comments #8 & #10 (as well as comment #11 in Appendix D) regarding monitoring differences in concentration over time further clarification is required. The response indicates:

The samples collected after pumping will be used to evaluate whether the change in concentrations during pumping persist. Data will be plotted and a trendline will be fit to the data (e.g., in Microsoft Excel) to assess changes/trends in concentration over time between the baseline concentrations and a time when natural gradients have returned following the pump test.

Table 3-3 shows that analysis for contaminants will be performed on samples at baseline, 3.5 days, 7 days, prior to shutdown, and then in recovery on day 1, 2 and 21. The footnote to the table states that:

Groundwater samples collected during active pumping and the 21-day samples will be analyzed first and if they are different by at least 20% then other samples will be analyzed to evaluate concentration versus time.

The holding time for 1,4-dioxane is 7 days. Questions: By the time the sample from 21-days is analyzed, all the samples from the pumping period will be outside of holding time. How, then could analysis of additional samples be performed? How is "different by at least 20%" determined? Would that be percent difference in concentration between two consecutive samples? Which samples will be analyzed if the difference is greater than 20% - all samples in between?

Please respond to these concerns. After the questions are adequately addressed, please compile and submit the revised Appendix B for EPA approval.

Response: The sampling program during pump testing described in Appendix B has been modified to include collection of groundwater samples at the following times after the start of pumping: 0, ½, 1, 2, 3, 4, 5, 7, and every other day until pumping ceases. To accommodate the hold-time for 1,4-dioxane, all samples will be analyzed for the same parameters listed in Table 3-3 of Appendix B which includes 1,4-dioxane. This change is reflected in section 3.5.4 and Table 3-3 of the work plan.

With all samples collected during pumping being analyzed, EPA's additional questions about hold time and how the assessment of change in concentrations will be calculated are no longer applicable.

Appendix C Holding Basin Containment

All responses and revisions acceptable, no further comments. Please compile the revised Appendix C for EPA approval.

Response: Comments addressed, document finalized, and uploaded to Project Portal.

Appendix D 1,4-Dioxane and VOCs in Bedrock

1. See Appendix B comment above.

Please respond to these concerns. After the questions are adequately addressed, please compile and submit the revised Appendix D for EPA approval.

Response: Please see the response to comment #1 on Appendix B. Groundwater sampling and analysis during pump tests described in Appendix D have been adjusted to match the changes implemented for pump testing described in Appendix B. These changes are reflected in section 6.2.5 and Table 3 of Appendix D.

Appendix E Treatability Study

EPA/AECOM find that all responses and revisions are acceptable. However, EPA has engaged a USGS expert who is completing a review of this appendix. Additional comments will be provided imminently. Lagging approval of this Appendix should not impact the ability to begin RD field work.

Response: Appendix E will be finalized after receipt of USGS comments.

Appendix F Post Removal Site Control Plan

All responses and revisions acceptable, no further comments. Please compile the revised Appendix F for EPA approval.

Response: Comments addressed, document finalized, and uploaded to Project Portal.

Appendix H Emergency Response Plan

All responses and revisions acceptable, no further comments. Please compile the revised Appendix H for EPA approval.

Response: Comments addressed, document finalized, and uploaded to Project Portal.

Appendix I - FSP

1. For comment #4 (following validation guidelines for high moisture sediments) the response includes the following modification to the sampling SOP:

If solids content for a sediment sample is determined to be below 30%, the sample will be discarded, and a new sample will be collected.

It should be clarified how this will be tested in the field. Solids content cannot be visually assessed, so analysis involving drying the soil and weighing it would be required. Please clarify.

Please address this comment, then compile the revised Appendix I for EPA approval.

Response: The SOP will be updated to reflect that the Laboratory will determine the %moisture. If the laboratory reports moisture below 30% a new sample will be collected and resubmitted to the laboratory for analysis.

Appendix J QAPP

1. For comments #10, #11, #32, and #34 (regarding use of current validation guidelines including blank actions), the response indicates that updated validation blank actions will not be employed for consistency with historical data. However, the most obvious gap in the proposed validation actions noted is the application of blank action levels. The practice of negating results that are 5 or 10 times the concentration detected in a blank ended several years ago. Application of blank action levels in data validation levels can lead to an increase in false negative results and may mask useful information about the presence of site contaminants. The validation actions presented also retain the outdated practice of mathematically adjusting the blank result from an aqueous sample to generate a blank action level to a soil sample. Because contamination removed from equipment by water does not reflect contamination picked up by a solid, the blank results should be applied in only a qualitative sense, consistent with the latest guidance. Please address.

Response: The use of 5 and 10X multiplier for blank action levels had been carried through, consistent with the data validation approach at the site for the past eight years. However, we will move forward using the current National Functional Guidelines. Worksheets have been updated to reflect this.

In response to qualifying soil samples based on aqueous field / trip blanks, we agree this in an inappropriate practice. Worksheets 12 and 28 are incorrect and will be updated to reflect this. Please see attached updated sheets

2. For comment #12 (sensitivity requirements). The sensitivity requirements added state that the RL < PAL, however EPA recommends that the RL is less than 1/3 the RL or lower. Please address.

Response: Assuming this was meant to say that the RL is less than 1/3 the PAL. Worksheets were updated under this assumption. If this assumption is incorrect, please clarify. Please see attached updated worksheets.

3. For comment #15 (listing of analytical tasks). It is agreed that the RDWP appendices are detailed in the manner described in the response. However, the detail concerning extraction methods are not included in these appendices. Please include this information in the RDWP or other location where the link to sampling event and task can be readily made.

Response: Extraction methods and SOP references are on worksheets 12, 20 (SOP reference only), 19, 23 and 30.

4. For comment #36 (field data quality), the response does not address the comment. The response discusses how the field data will be used but does not

discuss how the quality of the field data will be assessed prior to use. Please address.

Response: All personnel that will managing field teams collecting data qualify as Environmental Professionals as defined in 40 CFR §312.10. Field data will be deemed usable (i.e., precise, accurate, and representative) when it is collected following the appropriate standard operating procedures (SOPs), using the proper equipment that has been correctly calibrated. The usability of field data, for example groundwater geochemical parameters such as dissolved oxygen concentration and pH, will be assessed through adherence to several protocols outlined in the RDWP. The Field Sampling Plan contains SOPs that will be followed by field staff during execution of the work. SOPs are included for calibration of field probes as well as collection of field data. In many cases, the SOPs include forms to be completed by field staff which support and document proper calibration of field instruments and data collection. These forms will be reviewed by field team leaders, who will then make the judgement regarding subsequent data usability. As an example, SOP NMI-003 describes the approach for calibrating a multiparameter meter for groundwater sampling and includes what calibration solutions/points to use for each probe, how often to calibrate, and has a calibration form attached. This SOP works in conjunction with SOP-GW-010 which specifies the procedure for collecting a representative groundwater sample and representative field groundwater geochemical data, per EPA guidance, using a calibrated probe. SOP-GW-010 also provides thresholds for acceptable data quality as well as a field form to assist staff in collecting and properly documenting data which meets minimum standards to be considered acceptable. In summary, field data will be deemed valid/usable provided they are collected using calibrated instruments per SOPs provided in the FSP.

5. For comment #38 (completeness), the response is not consistent with the introduction of the QAPP which states, "The purpose of the QAPP is to support the sampling and analytical methods and procedures that will be used during the RD/RA phases of the project, including pre-design investigations, SOW-specified groundwater monitoring events, and implementation of the remedial components." Please clarify.

Response: Noted, changes have been made to the text in the introduction. Please see attached updated QAPP text.

Please respond to these comments. After the questions are adequately addressed, please compile and submit the revised Appendix J for EPA approval.

Appendix K Sitewide Monitoring Plan

All responses and revisions acceptable, no further comments. Please compile the revised Appendix K for EPA approval.

Response: Comments addressed, document finalized, and uploaded to Project Portal.

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August 7, 2020

Mr. Christopher Smith
Remedial Project Manager
EPA Region 1
5 Post Office Square, Suite 100
Mail Code OSRR 07-4
Boston, MA 02109-3912

Subject: **Nuclear Metals, Inc. Superfund Site, Concord, Massachusetts**
Remedial Design Work Plan
Responses to Comments and Revised Remedial Design Work Plan

Dear Mr. Smith:

Enclosed for your review and approval are Responses to Comments (RTC) and the revised Remedial Design Work Plan (RDWP) and its' appendices, which consist of Pre-Design Investigation Work Plans (PDI WP), a Treatability Study Work Plan (TS WP), and Supporting Deliverables.

For reference, the RDWP appendices include:

A - PDI WP – Site-Wide Soils and Sediments

B –PDI WP – In-Situ Sequestration of Depleted Uranium and Uranium

C – PDI WP– Holding Basin Containment

D – PDI WP – 1,4-dioxane and VOCs in Bedrock Groundwater

E – TS WP – In-Situ Sequestration

F - Post Removal Site Control Plan (PRSCP)

G – Health and Safety Plan (HASP)

H – Emergency Response Plan

I - Sampling and Analysis Plan: Field Sampling Plan (FSP)

J - Sampling and Analysis Plan: Quality Assurance Project Plan (QAPP)

K – Site Wide Monitoring Plan (SWMP)

L - Community Relations Support Plan (CRSP)

Initial comments on RDWP Appendices A, B, C, D, E, and J were received on May 14, 2020. Initial comments on Appendices A and C were discussed with EPA, MassDEP, and AECOM representatives on June 1, 2020. Initial comments on Appendices B, D, and E were discussed with EPA, MassDEP, and AECOM representatives on July 5, 2020. Responses to these initial comments were provided on June 16, 2020, and an updated response was provided June 25, 2020.

Final comments were received on RDWP Appendices A, B, C, D, E, I and J on July 2, 2020. Comments on the RDWP and RDWP Appendices F, H and K were received on July 16, 2020. The RTC are attached to this letter, each comment received is followed by our response. The revised RDWP and appendices have been uploaded to Project Portal as MS Word documents in “track changes” with revisions shown in redline / strikeout for ease of review (some of the revised QAPP worksheets became too jumbled in RLSO, so all changes were accepted and a clean revision is instead provided). . Tables and figures that required revision are also provided. A complete revised RDWP will be prepared upon your approval of these responses.

In addition, as we discussed during review of the initial comments, “Implementation Plans” have been produced to detail our approach to certain PDI tasks. Draft Implementation Plans have also been uploaded to Project Portal, in sub-folders with each respective PDI or TS WP. Implementation Plans included with this response include:

SSS-1 and SSS-3 Soil and Sediment Sampling Implementation Plan

SSS-2 Depleted Uranium Penetrator Investigation Implementation Plan

SSS-4 Cooling Pond, Sphagnum bog, Septic field, and Landfill Implementation Plan

ISS TS HB Implementation Plan

HB-1, HB-2 and SSS-5 Drilling and Sampling Implementation Plan

1,4-Dioxane in Bedrock Groundwater Implementation Plan

Please let me know if you have any questions.

Sincerely,

Bruce Thompson

Attachment – Responses to Comments

cc: Garry Waldeck, MassDEP
Settling Defendants
Mark Kelley, PE, Haley & Aldrich, Inc.
Carl Elder, PE, Geosyntec Consultants

Responses to Comments dated July 16, 2020 on the Remedial Design Work Plan dated March 2020

1. Title Page. For correctness, delete "/Remedial Action" from the document title.

Response: Changed as requested.

2. Executive Summary, Page i, Paragraph 3 and Section 2. For clarity please indicate that the property also has soil and sediment contamination but off property contamination is limited to groundwater.

Response: Changed as requested.

3. Executive Summary, Page iv, 4th item. For clarity to reflect the Groundwater NTCRA is no longer applicable please insert "started" between "progress" and "under".

Response: Changed as requested.

4. Table of Contents, Tables. The table names and numbers are not consistent with the actual tables presented in the table section. Please make consistent.

Response: Corrected as requested.

5. Section 2.2.4 Cooling Water Recharge Pond (AOI-4), Page 4. The cited reference, currently shown as "Source", should be identified.

Response: Reference added.

6. Section 2.2.8 Pavement Drain Outfalls (AOI-9), Page 6, Paragraphs 1 and 2. The text references Figures 3.9.2 and 3.9.3 which are not provided in the figures section. Please correct the figure references, or if in another document provide the document name.

Response: References added.

7. Section 2.7 Basis For Remedial Action, Page 11. For clarity please revise the text to indicate that 1,4-dioxane currently does not have a MCL.

Response: Clarification added.

8. Section 2.7.1 Chemicals of Concern, PAHs, Page 11. For clarity please add "above ROD cleanup levels" after "found in the Site soils".

Response: Clarification added.

9. Section 2.7.3 Conceptual Site Model, AOI 4 and AOI 6, Page 13. For completeness, please clarify that surface water did not show unacceptable risk during the risk assessment process.

Response: Clarification added.

10. Section 2.7.3 Conceptual Site Model, AOI 16, Page 14. For completeness, please clarify that surface water did not show unacceptable risk during the risk assessment process.

Response: Clarification added.

11. Section 2.7.8 Performance Standards, Page 22. Sediment cleanup levels are also provided in Table L-4 of the ROD. Please add this reference.

Response: Reference added.

12. Section 2.7.10 Superfund Program Expectations, Page 20. Consistent with the ROD, please revise “expects to select a remedy” to “has selected a remedy”.

Response: Revision made.

13. Section 3.2 Contracting Approach, Page 26, Paragraph 2. For completeness, please add text that all disposal facilities must be approved by EPA.

Response: Text added.

14. Section 4.1 Anticipated Problems, Page 32, Paragraph 2. Because this section also describes anticipated remedial activities, please clarify that perimeter air monitoring is not anticipated to be necessary during the PDIs but may be necessary during the RA. Dust control (and limits) for site worker safety will likely not have the same limits as fence line criteria for protection of the public, so it is assumed that perimeter air monitoring may be necessary for some of the remedial activity components and will be included in the Remedial Design as appropriate.

Response: Text added.

15. Section 4.1.1.3 Site-wide Soil and Sediment Remedy Excavation Sequencing and Duration, Page 34, Paragraph 3. The first reference to an over the road limit for trucking of 20 tons seems to be applicable to any destination. If the 20-ton limit is for destinations outside Massachusetts, then the parenthetical descriptor for the 20-ton limit should be changed from “intra-state” to “interstate”.

Response: Correction made.

16. Section 4.1.1.7 Demonstration of Compliance Approach, Page 36, last paragraph. The text states that a field study will be necessary to evaluate gamma spectroscopy detection limits. However, no details on such a study appear to be presented in any of the supporting documents. Please address.

Response: Clarification provided that the study design will be submitted later in the RD process.

17. Section 4.1.1.11 Fill Between Gabion Walls, Page 37. Typo; assume “between” should be “behind”.

Response: Typo corrected.

18. Section 4.1.1.13 Tank House Foundation, Page 37. The text states “a portion of the basement of the building was reportedly filled with concrete”. Please clarify if this refers to a different historical activity than AECOM’s recollection of the tank house basement being backfilled with sand during the building NTCRA.

Response: The basement was filled with flowable fill during the Building NTCRA. This clarification was made to Section 4.1.1.13.

19. Section 4.2.1 Site-wide Soils and Sediments, Page 44, Paragraph 1. The text references Table 4 as a list of areas and PDIs. However, Table 4 is a list of ARARs. Please resolve.

Response: Text clarified.

20. Section 4.2.1 Site-wide Soils and Sediments, Page 44, Paragraph 1. The text references Figure 1 showing areas to be excavated. However, this information is presented in Figure 3. Please correct the reference.

Response: Reference corrected.

21. Attachment 1, Project Team Organization. Please correct formatting (spacing and capitalization) in the EPA block.

Response: Formatting corrected.

Responses to Comments dated July 2, 2020
on the Remedial Design Work Plan, Appendix A
Site-wide Soils and Sediment PDI WP dated March 2020

General Comments:

1. Following discussion with the project team, it was agreed that additional details and clarifications for procedures to be used to perform PDI SSS-2 (Depleted Uranium Penetrator Investigation) would be provided in an Implementation Plan to be submitted under separate cover for review and approval. Please include text in the revised SSS PDIWP which references this Implementation Plan.

> **Response: An Implementation Plan will be included in the revised SSS PDIWP.**

Specific Comments:

2. **Section 1.1, Page 1, Paragraph 2.** The paragraph lists the COCs, as summarized in the ROD as natural and depleted uranium (DU), PAHs, PCBs, VOCs, and SVOCs. However, the RAOs listed in Section 1.3, Page 2 include reference to copper, mercury, and lead in sediments, and soil cleanup levels in Table 1, Page 3 include arsenic and thorium, and sediment cleanup levels in Table 3, Page 3 include copper, mercury, and lead. For clarity, please also reference the other metals listed as COCs in the ROD.

> **Response: The COC list on Page 1 will be updated to include copper, mercury, lead, arsenic, and thorium.**

3. **Section 2, Page 4, Paragraph 1**. There is discussion about two different Exposure Areas A and B based on future development potential, but no indication of how that corresponds with any proposed activities. Line 7 ends with "and/or contaminant profiles are notably different than at other exposure areas." It's not clear what this means. Please clarify. Based on previous discussions, the difference is understood to be about potential future residential reuse. Please provide a figure showing the "A" and "B" areas and how they related to the AOIs.

> **Response: An additional figure showing Areas A and B and the AOIs will be added. Line 7 "and/or contaminant profiles are notably different than at other exposure areas" will be deleted**.

4. **Section 2, Page 4, PDI SSS-1 Paragraphs 1 through 4**. The paragraphs describe what portion, and why, the areas are included in the PDI. It would be helpful to identify where each of the Areas (and corresponding AOIs) are on Figure 1. Otherwise, the reader needs to open up the details of the Attachments. It would aid the reader to include an additional figure showing this with the areas described in the 4 paragraphs color coded to differentiate RAOs (Par 1 for residential exceedance of PCBs; Par 2 for residential exceedance of DU & PCBs; Par 3 for PCB >50 ppm; Par 4 Boundary of landfill/sphagnum bog). Please include a figure similar to the one described.

Response: An additional figure showing the alignment of the RAOs with areas of the Site will be added.

5. **Table 6, Page 7**. For PDI SSS-1, the table should include entries indicating: no samples required at A6, but samples will be collected between A2 and A6; supplemental sampling at AOI 4 and AOI 15; sampling at boundary of landfill/sphagnum bog (Areas B1/A2). For PDI SSS-3, the table should indicate that the proposed borings will evaluate utility impacts. For PDI SSS-4, for clarity please indicate where SSS-4 is tied into other PDI work (i.e. Appendix C).

Response: Text will be added to the table to state that no samples are required at A6 and that samples will be collected between A2/A4 and A6. Additional entries will be added to the table to include supplemental sampling at AOI 4, AOI 15, AOI 3 (Areas B1/A2), and AOI 7. Text will also be added to the table that the proposed borings for PDI SSS-3 will evaluate impacts from utilities. A clarification will be provided for where SSS-4 is tied into other PDI work, which will be contained in Appendix C.

6. **Section 3.1, Page 8**. Based on recent discussions with the project team and de maximis' June 16, 2020 *Response to Initial Comments,* for completeness add text that SSS-1 locations are intended as a first pass that may need additional step-out sampling and that confirmatory sampling will be required during actual excavation.

Response: Text will be added that the SSS-1 locations are intended as initial delineation and additional sampling may be necessary to refine the limits of excavation. Text will also be added that confirmatory sampling will be required during actual excavation.

7. **Section 3.1, Page 8, Paragraph 1**. The paragraph only references areas A4, A5, and B2 as mentioned in Section 2, PDI SSS-1, paragraph 1. If the section does not apply to the areas mentioned in Section 2, PDI SS-1, paragraphs 2 through 4 (Area A6, AOIs 4 and 15, and AOI 3) - what is the proposed methodology for those areas? Please clarify.

Response: Reference to the other AOIs will be included in Table 4 to this paragraph.

8. **Section 3.1, Page 8, Paragraph 2**. The report indicates that, even though PCBs and uranium are the primary COCs at these areas, all soil samples will be analyzed for the entire COC list. Include an explanation for why this decision was made.

Response: Explanation for why all site COCs are being analyzed at each location will be added to the text.

9. **Section 3.4.** Based on recent discussions with the project team and de maximis' June 16, 2020 *Response to Initial Comments,* for completeness please add text that removal or abandonment of the septic systems is part of the remedy.

Response: A clearer discussion of how the investigations conducted within the area of the septic system is to determine the limits of removal required for the full-removal of the septic system components.

10. **Figure 1, pdf Page 18.** The Area Names included in the Legend don't correspond with the text and it is difficult to discern the dashed boundaries. Please revise.

> **Response: Figure 1 will be revised to define the dashed boundaries and update the Legend.**

11. **Figure 2, pdf Page 19.** The coloring within the geophysical survey limit area is not needed and confusing with the underlying excavation depth colors. Please remove the color from the survey limit areas or use cross-hatching.

> **Response: The limits of the proposed geophysical survey will be shown with cross-hatching on the revised Figure**.

12. **Figure 3, pdf Page 20.** Legend indicates drive-point depths of 3-5 and 6-8 feet into sediment rather than 0-3 and 3-6 feet as indicated in the text in Attachment 4. Please clarify.

> **Response: The text and Figure legend will match. It is anticipated that the soft sediments are only 3 ft. thick within the cooling pond so the drive-points will be screened from 0 to 3 and from 3 to 6 ft. The deeper screened drive point is proposed to be in the natural underlying soil. If there is deeper soft sediment or sludge then the drive point within the natural soil could be deeper than 6 ft.**

13. **Attachment 1, Figures 1-8 and 1-9.** The areas depicted don't exactly match the areas shown in Figures 1-1 through 1-7, and some of the labels (AOI 7) are different between 1-8 and 1-9. The area boundaries should be shown consistently.

> **Response: The areas and labels will be corrected and updated.**

14. **PDI SSS-1, Table 1.** For sampling location SB-PD-02011 in AOI 2, suggest adding a sample for depth interval of 8-10 ft because supplemental Figure 11-1f shows elevated PCBs in that interval in that vicinity.

> **Response: One sample from 8-10 feet will be added at location SB-PD-02011.**

15. **PDI SSS-1, Figure 1-1.** No additional samples are proposed in the western portion of AOI 2, south of the Cooling Water Pond. Consider adding sample points in this area or explain why they are not needed.

> **Response: Two additional sampling locations with samples from 0-1 feet and 1-2 feet will be added along the western portion of AOI 2**.

16. **PDI SSS-1, Figure 1-2**. Minimal sampling is proposed in the northwestern area of AOI 4. Consider if additional samples would be appropriate in this area.

> **Response: Three additional sampling locations with samples from 0-1 feet and 1-2 feet will be added northwest of AOI 4**.

17. **PDI SSS-1, Table 2.** For sampling location #40 in AOI 4, suggest adding a sample at SB-PD-04040 for depth interval of 1-2 ft since supplemental Figure 10-2b shows elevated DU levels from that interval in SS-IR-04005.

Response: One sample will be added from 1-2 feet at SB-PD-04040.

18. **PDI SSS-1, Table 3.** Explain why there are so few samples proposed for the 1-2 foot interval in AOI 8.

Response: No samples were proposed for the 1-2 ft interval as existing data suggest there is contamination from 2 to 4 ft. The proposed delineation sampling is focused on lateral extent and to confirm vertical extent.

19. **PDI SSS-1, Table 4.** For AOI 9, Sample Location ID Numbers for SS-PD-09007 and SS- PD-09009 should be revised to be -000-date.

Response: Noted; these will be revised.

20. **PDI SSS-1, Table 5.** It is unclear why the delineation is limited to surficial soils (0-1 foot)? Elevated DU is detected at SS-RI-07008, 07016, and 07011 at the 1-2 foot interval so it would seem prudent to add that interval in borings 1,2,6, and 7. Please clarify.

Response: The RI data suggest contamination is confined to surficial soils; however, additional samples from 1-2 feet will be added at all seven locations.

21. **PDI SSS-1, Table 6.** For AOI 15, since supplemental Figure 10-6c shows elevated DU at SB-RI-11003 at the 2-4 foot interval, and to a lesser extent at the 4-6 and 6-8 foot intervals, consider adding samples at those depth intervals to one or more of sample locations SB-PD-15001 through SB-PD-15006.

Response: Additional sampling intervals will be added from 4-6 feet and 6-8 feet at SB-PD-15004. This area is planned to be excavated as part of the building demolition and utility removal. The goal of sampling in AOI 15 is to further delineate the extent of PCB>50 ppm impacted soil.

22. **PDI SSS-1, Table 7.** Please explain why three foot sample intervals specified for this area compared to two foot intervals in other areas. Also, since SB-RI-03011 in supplemental figure 10-7e shows elevated DU at 6-8 ft, suggest including a sample at location “SB-PD-03007” for depth interval of 6-8 ft.

Response: The sampling interval will be adjusted to be 0-2 feet, 2-4 feet, and 4-6 feet. Additional samples will be added from 6-8 feet and 8-10 feet at all locations. This investigation is the initial round of pre-design investigations of the old landfill. Due to the complexities of drilling through landfilled debris and difficulty in sampling soils below the debris, the plan is to conduct the future sampling after removal of the debris and landfilled material. The current PDI work is designed to collect enough information for determining debris volumes and types of material for a Contractor to determine the equipment and costs needed to excavate and transport the material off-site. The 30% Remedial Design will include a proposed layout of future borings or soil probes to provide the post-excavation compliance testing to evaluate current and future risk depending on the anticipated future use of the Old Landfill footprint.

23. **PDI SSS-3**. Based on recent discussions with the project team and de maximis' June 16, 2020 *Response to Initial Comments* add two additional boring locations under Building E considering historical pre-construction use of this area as a waste handling area.

Response: Two additional boring locations will be added at Building E.

24. **PDI SSS-3, Section 4.2.** Consider showing the sample locations on a figure that also shows the mapped utilities under the slab.

Response: The available utility information will be shown on the sample location figure for clarity.

25. **PDI SSS-3, Section 4.2, paragraph 1**. Explain why samples are not proposed to be collected in the 10-12, 14-18, and 20-24 foot intervals.

Response: Sampling intervals 10-12 feet, 14-18 feet, 20-22 feet, and 22-24 feet will be added at all locations.

26. **PDI SSS-4, Section 4.1 last sentence.** Suggest indicating that the surveys may be extended based on initial field results.

Response: The geophysical survey limits will be extended depending on the initial field results.

27. **PDI SSS-4, Section 4.3.** Suggest including analysis of VOCs, SVOCs and metals for septic field samples given that it was the common waste collection point.

Response: The analyte list will be expanded as recommended and the QAPP will be revised accordingly.

28. **PDI SSS-4, Section 4.6.** Consider collecting up to 4 rounds (rather than 2) of water level measurements to capture seasonal variability or add a brief explanation outline why no more than 2 rounds is needed.

Response: Quarterly water level measurements will be taken of each installed piezometer couplet to evaluate seasonal variability.

29. **PDI SSS-4, Section 4.7.** Clarify when the groundwater samples be collected. Assuming a complete round will be conducted during the initial event (to correlate with the sediment samples), consider collecting a subset of select samples during each seasonal event to determine if concentrations vary with water levels.

Response: The initial round of sampling will be conducted once all the piezometers are installed so the groundwater and sediment samples are collected within days of each other to correlate the groundwater and sediment concentrations. Quarterly sampling of each piezometer will be conducted to evaluate seasonal variation of the chemistry within the groundwater and surface water.

30. **PDI SSS-4, Section 4.7, Page 6:** The samples for groundwater and sediment will be analyzed for "chlorinated VOCs," but this list is not defined. Please indicate where the list of analytes is located or, if missing from the project plans, include this information. Note that this information is not provided in the QAPP (Appendix J).

Response: The list of chlorinated VOCs will be added to the text and included in the QAPP. The chlorinated VOCs include 1,1-Dichloroethane (DCA), trichloroethene (TCE), tetrachloroethene (PCE), and vinyl chloride. In addition, the groundwater COCs 1,4-Dioxane , bis(2-Ethylhexyl) phthalate, arsenic, barium, chromium, cobalt, copper, iron, manganese, molybdenum, uranium, and nitrate will be included in the groundwater and sediment testing. The analyte list is consistent with the Groundwater Cleanup Levels listed in Table L-1 of the ROD.

31. **PDI SSS-4, Section 4.8, Page 6:** The sediment sampling SOP in the FSP (Appendix I) includes several options for the equipment to be used but the option selected is not identified here. Some of the equipment is better suited to collecting a representative sample uniformly over depth and some are better suited for retaining fines. Please indicate the option that will be used. If the options are dependent on sediment conditions identified at the time of sampling, please provide the hierarchy of tool selection that will be applied.

Response: The Implementation Plan provides details of the sediment sampling and the proposed tool selection based on the sediment consistency and recovery. A summary will be provided in the text to clarify the sampling methods.

32. **PDI SSS-5, Section 1, Paragraph 2.** For clarification please add “for disposal” before “at an off-site …”

Response: Comment noted and edit will be completed.

33. **PDI SSS-5, Section 4.3:** Please clarify how the depths and locations for the 12 samples to be collected will be determined. It seems that the intention is to characterize each stratum encountered within the set of borings. Revise the FSP as necessary.

Response: The intention is to characterize the topsoil, B-horizon soil, and the natural parent geologic material, or C-horizon soil located above the groundwater table. The number of each soil strata tested will be identified in a table that will be added to the figure and referenced in the FSP.

34. **PDI SSS-5, Section 4.3:** Neither this document not the QAPP (Appendix J) present the Mass DEP criteria for background conditions nor demonstrate that the laboratory analyses selected are sufficiently sensitive to meet these requirements. Please provide this information here or in the QAPP.

Response: The laboratory detection limits for the site-specific and MassDEP background values for the compounds analyzed will be discussed in the QAPP.

Responses to EPA Comments dated July 2, 2020, and CREW Comments dated July 13, 2020 on the Remedial Design Work Plan, Appendix B

In-Situ Sequestration PDI WP dated March 2020

These responses also include responses to 13 July 2020 comments provided by Michael Webster and Kevin Trainer of GeoInsight, Inc. on behalf of the Citizens Research & Environmental Watch (CREW). In instances where the citizen groups' comments were not labeled as pertaining to a particular appendix of the RDWP, we used our judgement, given the nature of the comment, to incorporate the comment into responses for the appropriate RDWP appendix.

General Comments

1. As the two documents are closely related, ensure that revisions to both the ISS PDIWP and Appendix E, the Treatability Study Work Plan, are consistent.

> **Response: The project team has worked to ensure that changes to Appendix B and Appendix E are consistent.**

Specific Comments

2. Section 2.3.1, Page 7, Paragraph 3. The text describes the higher hydraulic gradient in the overburden to the west of the Holding Basin; however, examination of hydraulic head data from well clusters in that area indicate that the head in the shallow overburden is up to 18 feet higher than that in the shallow bedrock. Please identify the stratum that creates this unusually high vertical gradient.

> **Response:**
>
> **The following text was added to Section 2.3.1 to relate the high vertical gradient to the presence of a silt unit identified during the Remedial Investigation.**
>
> **" The high groundwater elevations in overburden and resulting steep hydraulic gradients in this area are attributed to a silt unit with hydraulic conductivities ranging from 0.4 ft/day at MW-S08 and MW-S23 and 1.5 ft/day at MW-S04 which are low relative to the rest of the overburden at the NMI property. This unit was identified and discussed in the Remedial Investigation report."**

3. Section 2.4.1.1, Paragraph 2. The text states that historical results are presented in the RI report, but that reference only includes data through 2011. Please provide a reference for the additional historic data presented on Figure 2-5.

> **Response: The additional historical results were collected during the Feasibility Study (FS) (de maximis, 2014) and several documents submitted to support the Non-Time Critical Removal Action (NTCRA) investigation. More precisely, analytical data from years 2012-2013 were collected during the FS and data collected during the 2015-2019 period were collected as part of the NTCRA. The following has been added to section 2.4.1.1 (as shown in the redline provided as Attachment B) to clarify this "…the**

Feasibility Study (de maximis, 2014), and several groundwater NTCRA reports (Geosyntec 2015; 2016; 2017a; 2017b)." New references were also added to the reference section..

Section 2.4.1.1, Paragraph 2. A discussion of why uranium concentrations appear to be attenuating (i.e., biological activity) would be helpful, and if it has any implications on the remedy selection. It is notable that 1,4-dioxane concentrations have not declined while uranium in bedrock has declined significantly. Please address.

Response: Section 2.4.1.1 is on uranium in overburden groundwater and does not indicate that concentrations are attenuating. We are assuming that this comment is with respect to Section 2.4.1.2 relative to bedrock groundwater.

The following text was added to Section 2.4.1.2 to describe the inferred reasons for uranium attenuation in bedrock groundwater.

"As documented in the RI Report, it was hypothesized that solubilization of uranium bearing minerals in bedrock occurred as a result of altered bedrock groundwater geochemistry caused by historic chemical releases into the Holding Basin. Recent decrease in U concentrations in bedrock may be due to removal of historical mechanisms that mobilized bedrock uranium (i.e. natural uranium in bedrock is no longer being released) coupled with dilution by non-impacted groundwater from upgradient areas."

Decreasing U concentrations and the lack of a continuing source has implications for the bedrock remedy which is why we have proposed testing short term pumping as a possible RA. More specifically, data show that U concentrations in bedrock are attenuating (e.g., wells MW-BM03 and MW-BS03 in the centerline of the plume have shown a >50% decrease in U concentrations since 2013). Considering the maximum U concentration in bedrock is currently only about 70 ppb, another 50% reduction in U concentrations would yield bedrock groundwater near or below the MCL. Given this, we feel that it is prudent to stay openminded to a pumping approach since it may enhance the effective attenuation which is ongoing. The pumping tests proposed as a PDI are being implemented as a potential means to accelerate natural attenuation by removing mass where uranium concentrations are higher.

4. Section 2.4.3.2, Page 12, First Bullet. Please state the MCL for vinyl chloride, because it is different from the MCLs for PCE and TCE.

Response: The text was revised to clearly specify the MCL for PCE and TCE is 5 µg/L and the MCL for vinyl chloride is 2 µg/L.

5. Section 2.5, Page 19. For completeness please add 1,4-dioxane to the list of contaminants that were detected above an MCL or ROD cleanup level, as it is a primary COC.

Response: The first paragraph of this section now has 1,4-dioxane included in the list of chemicals exceeding an MCL or ROD cleanup level.

6. Section 3.4.2.3, Page 27, Paragraph 2. It is recommended that the replacement well be installed downgradient of the BarCad well, in case the BarCad is a source of PFAS (as alluded to in the text).

Response: The replacement well will be installed approximately 15-20 feet downgradient from GZW-7-2 - which is the closest accessible downgradient location. The proposed well location has been adjusted on figures and the text has been revised to indicate that the replacement well will be installed downgradient of GZW-7-2. It is important to note, that while the PFAS detection may be attributable to the components used in the BarCad system (potentially Teflon tubing), well GZW-7-2 is not anticipated to be a significant source of PFAS in groundwater..

7. Section 3.4.3.1, Page 28. For completeness please add mineral identification (e.g., pyrite), to the extent possible, as an activity for the field geologist to perform during the logging of holes drilled into bedrock.

Response: The text was updated by adding "…as well as minerology, including pyrite to the extent possible, to assess the mineral composition and…" so that mineral identification will be recorded, to the extent possible based on visual observations of air rotary cuttings.

8. Section 3.5.4, Page 37, Paragraph 2: Please clarify how the 10% "difference" measured between the three sample results is determined. For example, relative percent difference between two consecutive results or relative standard deviation of 10% between all three results. Note that the analyses that will be conducted are not as precise as required for this exercise. According to Worksheet 12 of the QAPP (Appendix J), analyses for metals including uranium and 1,4-dioxane are only precise to within ± 20% as RPD (MS/MSD and LCS/LCSD). Therefore, the precision of the analytical method is not sufficient for the objectives for this task.

Response:

The work plan text was modified to no longer identify a calculated percentage threshold for change in concentration. Rather, a simple trend analysis will be used where results are plotted and a trend line is fit to the data to assess whether concentrations are increasing or decreasing over time. The revised Section 3.5.4 reads as follows:

"The samples collected after pumping will be used to evaluate whether the change in concentrations during pumping persist. Data will be plotted and a trendline will be fit to the data (e.g., in Microsoft Excel) to assess changes/trends in concentration over time between the baseline concentrations and a time when natural gradients have returned following the pump test. These data will help to understand how uranium mass in bedrock can be mobilized toward the pumping wells and removed. "

We have also revised Note 4 to Table 3-3 to state that at least20% difference will be used to determine which samples originally placed on hold will be analyzed. The revised Note 4 states: "Groundwater samples collected during active pumping and the 21-day samples will be analyzed first and if they are different by at least 20% then other samples will be analyzed to evaluate concentration versus time"

9. Section 3.5.7.2, Page 39. For clarity, please differentiate between the zone of influence, the area within which measurable drawdown occurs around a pumping well, and the capture zone, the area within which groundwater flow direction is to the pumping well.

Response: The zone of influence and the capture zone were clarified in the text of section 3.5.7.2 by defining zone of influence as "an area within which a measurable drawdown occurs at observation wells located around a pumping well" and capture zone as "the area within which groundwater flow direction is to the pumping well".

10. Section 3.5.8.2, Page 40: As noted in a previous comment, the precision for the uranium analysis is ≤ 20% as RPD. If rebound evaluation will be based on an observed change of ± 10%, how will this change be distinguished from analytical error? Also, as requested in the previous comment, please clarify how 10% change will be calculated.

Response: The work plan text was modified to no longer identify a percentage threshold for change in concentration. Rather, the results will be plotted, and a trend line fitted to the data to depict a trend. See response to comment #9. This paragraph now references use of a trendline.

11. Section 4.5.4, Page 51, Paragraph 2. The text states that the groundwater samples will be analyzed for fluorescent tracer dyes using the methods described in the QAPP (Appendix J), but the analysis of fluorescent tracer dyes is not mentioned in the QAPP. Please address by providing the missing information.

Response: Methods for analysis of fluorescent tracer dyes have been added to the QAPP.

12. Table 2-3. After an initial review of the metals results and subsequent discussions with the project team, de maximis clarified that only the total results were originally reported and provided an updated table on June 25, 2020 that lists both total and dissolved results. For the updated table, a row should be added that sums the U-235 and U-238 concentrations to calculate total uranium for comparison to the 30 ug/L total uranium clean-up standard.

Response: A row including the sum of U-235/U-238 concentrations has been added to Table 2.3.

13. Figure 2-6: This figure does not show the MW-01 cluster in this cross section although it is part of the A-A' cross section shown on Figure 2-5. Please add this location to the cross section because the uranium detected in MW-SD01, although below the MCL, has a DU signature as opposed to the lower uranium concentration (and natural uranium signature) at what is considered an up gradient cluster at MW-06.

This will aid the reader in understanding the shape of the DU plume and overburden groundwater flow.

> **Response: The cross section shown on Figure 2-6 has been expanded to the northwest to include MW-S01, MW-SD01, and MW-BS01.**

Response to Comments from CREW dated 13 July 2020

PFAS

Information included in Appendix B – In Situ Sequestration Predesign Investigation Work Plan indicated that groundwater sampled collected from a subset of 19 monitoring wells during the November 2019 comprehensive monitoring event were analyzed for per-and polyfluoroalkyl compounds (collectively known as PFAS). The subset of wells included upgradient, source area, and downgradient areas, and the Acton Water District Assabet Wellfield. The November 2019 sampling was the first time Site groundwater samples were analyzed for PFAS at the NMI Site.

PFAS was detected in groundwater samples from both overburden and shallow bedrock monitoring wells. The general distribution of PFAS was similar to the pattern of depleted uranium and VOCs/1,4-dioxane that have been detected in groundwater (i.e., the higher concentrations of PFAS are generally co-located in areas where higher concentrations of depleted uranium and VOCs/1,4-dioxane have been detected). We expect that PDI activities will include additional sampling to define the magnitude and extent of PFAS in both the overburden and shallow bedrock groundwater at the NMI Site. Once the magnitude and extent of PFAS are defined, the risk posed by these compounds in groundwater should be evaluated

> **Response: PFAS results from November 2019 are presented in Appendix B, ISS PDIWP. Except for one location (GZW-7-2) where the sample is believed to have been affected by well materials, PFAS concentrations are below the limits which would warrant further investigation or remediation. The concentration observed at GZW-7-2 is being addressed by installing a replacement well as described in Appendix B.**

Responses to Comments dated July 2, 2020 on the Remedial Design Work Plan, Appendix C Holding Basin Containment PDI WP dated March 2020

1. **PDI HB-1, Section 2.** Has consideration been given for soil and rock from the borings to be sampled to pre-characterize the containment wall spoils for disposal facility acceptance?

Response: The soils collected from the boring program will be collected and submitted for grain size distribution testing, and some soils will be retained for use in bench testing for the slurry and backfill testing. The rock core will be retained for abrasivity testing and compressive strength testing. The amount of recovery of the soil samples may not be adequate for the appropriate level of pre-characterization testing, and the spoils from the containment wall excavation will be a combination of soil, milled rock, bentonite, Portland cement, and the material being injected as part of the ISS program. The native soil may not be representative of the generated material from the construction of the containment wall. As a result, we expected the post excavation material generated to construct the wall would be tested either while generating or after the containment wall is constructed to adequately characterize the chemistry of this material.

2. **PDI HB-1, Section 4.1, Page 3.** For completeness please provide a reference for continuous Standard Penetration Tests (SPTs), which is assumed to be ASTM D1586.

Response: The SPT reference will be included with the other ASTM Standards attached to the RDWP. The ASTM D1586 standard is the appropriate reference for SPT.

3. **PDI HB-1, Section 4.1, Page 3.** For completeness please provide a reference to a common method for logging soils collected by SPT, such as ASTM D2488 (visual manual procedures or equivalent).

Response: The Unified Soil Classification (USCS) will be used to classify the soil. The method is equivalent to the visual manual procedures contained in ASTM D2488, which will be included in the RDWP with the other standards. Details of USCS are contained in the Field Sampling Plan (FSP), included as Appendix I.

4. **PDI HB-1, Section 4.1, Page 3.** For completeness please provide a reference for rock coring, which is assumed to be ASTM D2113.

Response: The ASTM D2113 standard for rock coring will be included with the other ASTM Standards.

5. **PDI HB-1, Section 4.1, Page 3.** For completeness please provide a reference for rock quality designation (RQD), which is assumed to be ASTM D6032.

Response: The ASTM D6032 for RQD will be included with the other ASTM Standards. Additional detail on the methods of describing rock core are also included in the FSP, included as Appendix I.

6. **PDI HB-1, Section 4.1, Page 3.** In the six initial borings (with 20 to 50 feet of bedrock coring each), please clarify if RQDs be collected at every five-foot interval.

Response: The RQDs will be collected every core-run which will vary from 5 to 10 ft depending on the driller and the tools the driller has available. At a minimum, each core run will be 5 ft. and the RQD will be determined for each 5 ft. interval. The driller may choose to drill two 5 ft. intervals at a time to keep the drilling moving.

7. **PDI HB-3, Section 4.3.** If swell index and fluid loss tests on the bentonite slurry are required based on the initial water chemistry testing, it is recommended the density of the slurry mixture should also be recorded. Please address.

Response: The density of the slurry will be added to the testing of each slurry evaluated.

8. **PDI HB-3, Section 4.4.** For completeness, the **c**oncrete mix design should consider the influence of aggregate size on hydraulic conductivity and strength. Please address.

Response: The aggregate size will be considered and will not exceed ¾-inches. The maximum particle size of each mix will be recorded for each mix.

9. **PDI HB-3, Section 4.4.** It is recommended that the **c**oncrete mix design evaluate the admixtures for anti-washout (Mastermix UW 450 or equivalent) and alternate admixtures to reduce hydraulic conductivity (MasterLife 300D). Please address.

Response: The Mastermix UW450 is for anti-washout and is more appropriate for backfill placed from the surface in a continuously excavated trench and not tremie-pumped backfill for a trench excavated in panels. Equivalent admixtures will be evaluated that will allow for the bentonite and Portland cement mixes to provide the appropriate strength and hydraulic conductivity parameters. The MasterLife 300D admixture will be evaluated for the mixes that are more like a concrete backfill with high compressive strengths. This admixture is much like Xypex, so one or the other will be evaluated for one of the concrete backfill mixes.

10. **PDI HB-3, Section 4.4.** Based on the previous comments more than five mixtures may warrant evaluation. Please address.

Response: The 30% Remedial Design will be prepared using the data collected during these Pre-Design Investigations. At a minimum, five mixes will be evaluated. Minimum requirements for wall permeability and compressive strength are not yet known in this early stage of the project and will be determined based on the outcome of hydrogeologic and

seismic evaluations included in our work scope. As a result, alternate mixes may be evaluated, including concrete containing more bentonite and less Portland cement or cement-bentonite backfill (i.e., not concrete backfill). Potential backfill mix designs could be adjusted several times based on the results of initial testing, resulting in greater than 5 mixes.

The bench scale testing program is intended to provide contractors with a mix design that satisfies the minimum strength and permeability requirements as a basis for their own independent containment wall backfill mix design. The containment wall specification will be performance-based, and the contractor will be required to develop and test mix designs based on their experience with using bentonite, Portland cement, aggregates, sand, and admixtures of their selection as needed to provide backfill that satisfies minimum permeability and strength requirements. Contractor testing will supplement the bench scale testing for more detailed evaluation of the actual mix design to be constructed.

Responses to EPA Comments dated July 2, 2020, CREW Comments dated July 13, 2020, and 2229 Main Street Committee Comments dated July 13, 2020 on the Remedial Design Work Plan, Appendix D 1,4-dioxane and VOCs in Bedrock Groundwater PDI WP dated March 2020

Additional changes in the document stemming from the initial work plan comments received on 14 May 2020, and logistical or implementation considerations are provided in redline strikethrough (tracked changes) and summarized below:

- Section 5.1.4 – Added analyses for total and dissolved uranium with speciation for U^{235} and U^{238} to be collected during the first sampling of monitoring wells MW-BS50 through MW-BS54 following their installation. Although the uranium concentrations at the wells are not anticipated to be elevated (e.g. higher than MCL = 30 µg/L), these concentrations will serve as a baseline and assist in selecting the analytes for future sampling events.
- Section 5.2.3 – Added discussion related to using rotosonic drilling methods to advance the overburden portion of the open bedrock extraction wells (BEWs) due to limited availability of dual-rotary equipment.

Specific Comments

1. **Section 3, Page 4.** Though there is reference to focusing on the downgradient edge of the plume, there is no mention that the pumping remedy is intended to be for containment rather than eventual compliance with cleanup criteria, as has been discussed during subsequent discussions with the project team. This is a critical point that should be made, or at least suggested. For example, this impacts the need to determine if there is a source or to define the impacts upgradient of MW-BS7-2 (the replacement for existing BarCad well GZW-7-2). This well shows a relatively high concentration and there are no nearby bedrock wells with lower concentrations. Figure 2-7 of Appendix B showing the 1,4-dioxane plume indicates the iso-concentration line for the cleanup criteria of 0.46 ug/L has not been defined north and east of this single well.

Response: Section 2 (Objective) and 3 (Purpose) of the Appendix D Work Plan were adjusted based on this comment and clearly state that the objective of the remedial action is to achieve the ROD cleanup levels for 1,4-dioxane and VOCs. Text added to these sections is below and link the RAO to the remedy selected in the ROD which, conceptually, includes overburden and bedrock extraction wells located off-property to capture deep overburden and bedrock groundwater containing 1,4-dioxane and VOCs before they discharge to the Assabet River or move under the River.

The following paragraph was added to Section 2:

> **"A Remedial Action Objective (RAOs) for 1,4-dioxane (and VOCs) stated in the Record of Decision (ROD) is the restoration of groundwater to meet project clean-up levels. The objective of this appendix is to describe pre-design work that will be performed to: (1)**

> **expand the delineation of 1,4-dioxane in bedrock at the Site, and; (2) collect data to assist in the design of the selected remedy for 1,4-dioxane and VOCs in bedrock as described the ROD in order to achieve this RAO.**
>
> **The recalcitrant 1,4-dioxane plume in bedrock covers a large footprint with concentrations several orders of magnitude above cleanup levels. Further, the crystalline bedrock is of low-permeability and relatively deep. As such, the selected remedy described in the ROD includes extraction and ex-situ treatment of VOCs and 1,4-dioxane.**
>
> **Based on the above, the objectives of the PDIs described below focus on design needs for a groundwater extraction remedy."**

The text in Section 3 was modified to the following, with red text used to show changes:

> **"The purpose of this work plan ~~was developed~~ is to detail ~~the~~ field activities to be conducted to further define the vertical and lateral distribution of 1,4-dioxane in bedrock groundwater, assess the hydraulic properties of the bedrock aquifer, and collect data required to evaluate the feasibility of a pumping remedy. As described above, a pumping remedy is proposed as the treatment approach for 1,4-dioxane and VOCs in bedrock. "**
>
> **With the exception of an additional delineation well along the western edge of the NMI Property line, this work plan focuses on the downgradient portion of the bedrock 1,4-dioxane plume (mainly areas near and to the north of Route 62) where 1,4-dioxane impacts in bedrock are not comingled with the uranium plume (Figure 2). ~~The~~ Pre-design activities, and specifically pumping tests like those described in this Appendix, planned ~~for~~ in the upgradient portion of the plume, where 1,4-dioxane detections coincide with elevated uranium concentrations, are described in PDI-ISS-2 – Appendix B."**

1,4-dioxane impacts upgradient of MW-BS7-2 will be evaluated via bedrock observation wells (OWs) and wells instrumented with continuous multi-level tubes (CMTs) installed along the alignment of the vertical barrier wall as proposed in RDWP Appendix C - Holding Basin Containment Pre-Design Investigation Work Plan. These wells will be sampled for several analytes, including U-235/U-238, and 1,4-dioxane as described in RDWP Appendix C, Section 4.7. These data will be used to inform the distribution of 1,4-dioxane and uranium in the vicinity of the Holding Basin.

2. **Section 3, Page 4, Paragraph 1 and 1st bullet.** The opening sentence indicates the intent is to define lateral distribution, but the first bullet item talks about vertical distribution. It seems the first sentence should reference both vertical and lateral distribution. Please address.

Response: This sentence has been revised to read "...the vertical and lateral distribution."

3. **Section 4.3, Page 5, last paragraph.** For clarity please review the second occurrence of "vertical gradients" in the last sentence.

Response: This sentence has been revised for clarity by removing "the vertical gradient" when necessary.

4. **Section 5.2.1, Page 9, Paragraph 3, 3rd Bullet.** Words seem to be missing at the end of this bullet. Please revise the bullet by adding the missing words.

Response: This third bullet has been revised to include a missing reference to MW-BS15 (i.e., "…of MW-BS15" was added to the end of the sentence).

5. **Section 5.2.5.1, Page 11.** Please add mineral identification (e.g., pyrite), to the extent possible, as an activity for the field geologist to perform during the logging of holes drilled into bedrock.

Response: The text was updated by adding "…as well as minerology including pyrite to the extent possible to assess the mineral composition and…" so that mineral identification will be recorded, to the extent possible, based on visual observations of air rotary cuttings.

6. **Sections 5.2.5.2 and 5.2.5.3, Pages 11-12.** Formatting. These sections have two numbers each. Please delete the incorrect numbers.

Response: The section header formatting was corrected.

7. **Section 5.3.2, Page 14, 2nd bullet.** BEW-5 is listed twice. Please correct.

Response: The typo was corrected to BEW-6.

8. **Section 6.2.5, Page 19, Last Paragraph.** The text states that the recovery samples will be collected 1, 2, and 21 days after pumping from the extraction well(s) is terminated. Please include an option for collecting additional samples at later times, if the data from the pumping and post-pumping samples suggest that longer-term monitoring would be beneficial to the rebound evaluation.

Response: A sentence in this section was added to include an option of collecting additional samples beyond 21 days post pumping. The added text states:

> **"Additional recovery samples may be collected beyond 21 days if the pumping and post-pumping data suggest that longer-term monitoring would be beneficial to the rebound evaluation."**

9. **Section 6.2.6, Page 20, Paragraph 1.** The text states that water may be pretreated for uranium using resins as described in Section 5.4; however, Section 5.4 has no such description. Please correct the inconsistency.

Response: This section was modified to reference an SOP for management of Investigative Derived Waste (IDW) instead of Section 5.4. This SOP, included in the Field Sampling Plan, describes pre-treatment (and other

handling) of pumped water using resin (where needed) prior to off-site disposal.

10. **Section 6.2.8.2, Page 21.** Please differentiate between the zone of influence, the area within which measurable drawdown occurs around a pumping well, and the capture zone, the area within which groundwater flow direction is to the pumping well.

Response: The text in this section was revised to clarify the distinction between the zone of influence and capture zone. The second sentence in section 6.2.8.2 was revised to define the zone of influence as "an area within which a measurable drawdown occurs around a well" and capture zone as "the area within which groundwater flow direction is towards the pumping well".

11. **Section 6.2.9.2, Page 22.** Please clarify how the 10% change in 1,4-dioxane will be calculated. Note that the analyses that will be conducted are not as precise as required for this exercise. According to Worksheet 12 of the QAPP, analysis for 1,4-dioxane is only precise to within ± 20% as RPD (MS/MSD and LCS/LCSD). Therefore, the precision of the analytical method is not sufficient for the objectives for this task.

Response: The work plan text was modified to no longer identify a calculated percentage threshold for change in concentration. Rather, a simple trend analysis will be used where results are plotted and a trend line will be fit to the data to assess whether concentrations of 1,4-dioxane and VOCs are increasing or decreasing over time. The revised Section 6.2.9.2 reads as follows:

> **"The samples collected after pumping will be used to evaluate whether the change in concentrations during pumping persist. Data will be plotted and a trendline will be fit to the data (e.g., in Microsoft Excel) to assess changes/trends in concentration over time for 1,4-dioxane between the baseline concentrations and a time when natural gradients have returned following the pumping interval. These data will help to understand how 1,4-dioxane mass in bedrock can be mobilized toward the pumping wells and removed."**

We have also revised Note 4 to Table 3 to state that at least 20% difference will be used to determine which samples originally placed on hold will be analyzed. The revised Note 4 states:

> **"Groundwater samples collected during active pumping and the 21-day samples will be analyzed first and if they are different by at least 20% then the rest of samples will be analyzed to evaluate concentration versus time."**

12. **Figure 1.** Typo. The title block lists as Figure 2-1. Please correct.

Response: This figure number was revised to Figure 1.

13. **Figure 9.** The legend is missing descriptions for some of the symbols. Please revise the legend as appropriate.

Response: The figure legend was revised to include missing symbol descriptions. The missing symbols were an artifact of exporting the figure from ArcMap into pdf.

Response to Comments from CREW dated 13 July 2020

1. As described in Section 4.1.6 of the RD/RA Work Plan, work performed pursuant to the RI/FS and Groundwater Non Time-Critical Removal Action (NTCRA) Administrative Orders of Consent (AOCs) delineated the downgradient, off-NMI property extent of 1,4-dioxane and VOCs in groundwater. Installation and operation of the NTCRA extraction well, with treatment in the temporary and final systems, appears to have limited the further migration of 1,4-dioxane and VOCs to the Acton Water District Assabet 1A production well. However, there remains 1,4- dioxane and VOCs up gradient of the extraction well in both overburden and bedrock.

Response: We agree with the above CREW statement. Work described in Appendix D of the RDWP includes installation (and sampling) of additional monitoring wells and pump testing to further investigate and assess remedial options for 1,4-dioxane and VOCs upgradient of the operating extraction well.

2. It is CREW's understanding that the NTCRA activities were focused on addressing conditions near the leading portion of the 1,4-dioxane plume, and specifically, cutting off the continued migration of 1,4-dioxane in overburden soils to the supply well. However, it appears that the center of mass associated with the 1,4-dioxane plume in overburden groundwater is located several hundred feet upgradient of the extraction well, on the east side of the Assabet River. The RD/RA Work Plan is silent with regard to evaluating whether the NTCRA successfully meets all of the remedial action objectives associated with VOCs and 1,4-dioxane in overburden groundwater, and more specifically, whether the NTCRA system will be effective at treating the full 1,4-dioxane plume, and can accommodate and/or be expanded efficiently to address possibly more concentrated and larger plume impacts over time (as the plume continues to migrate toward the municipal supply well).

Response: Sections 2 and 3 of Appendix D have been revised to clarify that a goal of the remedial action is to achieve RAOs in the ROD including achieving cleanup levels for 1,4-dioxane and VOCs in groundwater. These sections also better clarify that a purpose of testing described in Appendix D is to gather information needed to design the selected remedy from the ROD. Please also see response to EPA comment #1.

The operating treatment plant constructed under the NTCRA has additional capacity, but the ability to treat this additional groundwater using the existing system, an expansion of the existing system or some other option will be assessed as part of remedial design. The first step of such an analysis is the current scope which is to assess whether groundwater extraction is implementable and potentially effective as well as what might need to be treated (e.g., flow rates, concentrations, chemicals).

3. It is CREW's expectation that the RD process will include evaluation of:

- the efficacy of installing additional extraction well(s) on the east side of the river;

  Response: Appendix D of the RDWP includes installation of bedrock wells and extraction testing to the east of the Assabet River for this purpose.

- analyses of estimated time to achieve groundwater cleanup levels relying solely on the NTCRA extraction well;

  Response: The objective of the NTCRA was to prevent further migration of contaminated groundwater to the Acton municipal wells. Further investigations are targeted at identifying feasible remedial methods and identifying which ones will be most effective at achieving site cleanup levels. An evaluation of the timeframes to reach cleanup levels may be considered for various pumping arrangements as part of the design.

- modeling of expected plume migration and behavior in the absence of addition actions/extraction wells; and

  Response: The trajectory of the 1,4-dioxane and VOCs plumes in the absence of pumping is known from the lengthy historical record collected prior to the NTCRA. The trajectory of 1,4-dioxane and VOC plume when pumping at the existing extraction well (EW-1 only) is understood from recent and ongoing sampling (e.g., the November 2019 event). We recommend relying on site data when they are available in favor of modeling predictions. With that said, the existing groundwater model has been calibrated to the current pumping situation (EW-1 only) and can be further refined to match current water level and Assabet well pumping conditions to evaluate (using particle tracing) the expected migration of the 1,4-dioxane plume.

- modeling of expected plume migration and behavior with installation of additional extraction well(s) on the east side of the river?

  Response: The NTCRA design included modeling to evaluate hydraulic conditions and plume behavior for various wells and locations including a well east of the river. Similarly, modeling may be performed as part of the remedial design; however, an assessment of the ability to extract groundwater from the impacted bedrock zone must be determined first. We expect to evaluate and implement optimization of the NTCRA pumping system, which may include installation of additional overburden and/or bedrock wells east of the river.

Response to Comments from Len Rappoli on behalf of the 2229 Main Street Oversight Committee dated 13 July 2020

1. I thought that a delineation of the bedrock fracture zones was performed as part of an earlier investigation. To what extent is any previous information, if available, on

locations of bedrock fractures taken into account in planning the depth of the new bedrock extraction wells

> **Response: Only limited delineation of fracture zones at specific wells as opposed to fracture hydraulic connectivity evaluations were performed during the RI. The delineation of bedrock fracture zones was performed at open bedrock extraction well SW-2A in August 2007 and summarized in the Remedial Investigation (RI) report (de maximis, 2014). The fracture delineation entailed borehole geophysics, heat-pulse flow meter measurements, and extraction packer testing of five discrete intervals in bedrock well SW-2A formerly used as a source of cooling water for the NMI facility. The testing indicated the presence of significant water-bearing fractures at 155-169 and 249-262 feet below the ground surface, and that the majority of groundwater flow in this well came from a deep fracture zone located approximately 490-510 feet below ground surface (ft bgs). Uranium impacts were limited to the shallower fracture zones, generally less than 50 ft below the top of the weathered bedrock.**
>
> **The acoustic televiewer data at SW-2A informed the azimuth and dip magnitude of the water bearing fractures at specific depths and when coupled with uranium concentrations from discrete packer testing were used to extrapolate the likely depth of uranium impacted water bearing fractures at downgradient locations to inform monitoring well depths. In addition, transducers were used in monitoring wells during extraction packer testing of SW-2A, however, no significant responses were observed. There are coring data from numerous other wells on-site and as expected, generally indicate less fracturing with depth. Borehole geophysical logging was completed at only one other well (MW-BM03) at the Site. Thus, there is not significant data relative to hydraulic connectivity in bedrock across the site, which will be a focus of the PDI.**
>
> **As indicated by the November 2019 sampling results, the uranium concentrations in bedrock across the site have attenuated considerably relative to those observed during the RI; these results, along with existing rock core data were considered in selecting the location and proposed depth (173 feet below ground surface, 73 feet below the top of bedrock) of the open borehole extraction well BEW-1. The work plans describing new extraction wells in bedrock outline the borehole geophysical and packer testing that will be performed in the new wells to identify and assess bedrock fractures.**

2. Due to 1,4-Dioxane and VOC plumes being comingled it is my understanding that VOCs in downgradient groundwater are being mitigated along with1,4-Dioxane by the current groundwater extraction system. The focus is on 1,4-Dioxane. Not much is said about VOCs. Is there a figure that displays isocontours of concentrations of the various chlorinated VOCs still present in overburden groundwater based on the November sampling round?

Response: VOC exceedances are not as widely distributed and generally contained within the footprint of the 1,4-dioxane plume. The distribution of VOCs in groundwater during the November 2019 can be seen in the exceedance maps which were provided as Attachment A of Appendix B in the RDWP. Because VOCs do not significantly extend beyond the 1,4-dioxane plume and have lower exceedance ratios, and because it is anticipated that pumping and remediation of 1,4-dioxane would result in VOC concentrations decreasing below their respective remediation goals, 1,4-dioxane is the focus of remedial efforts and received more discussion in the RDWP. In terms of treatment, 1,4-dioxane is notoriously difficult to treat in groundwater as compared to VOCs and the advanced oxidation process used by the NTCRA system destroys both VOCs and 1,4-dioxane.

3. The purpose of the PDI for bedrock VOCs and 1,4-Dioxane is to evaluate a bedrock pumping scenario for removal of these contaminants as an alternative to in situ treatment. If sufficient fracturing is present in bedrock to create an adequate radius of influence, extraction may be the best option for contaminant removal from bedrock groundwater given the problematic nature of adding amendments. Is there a chance that prolonged pumping from bedrock wells may reduce the potentiometric head in bedrock to cause seepage of DU from overburden into bedrock?

Response: A layer of glacial till described as a dense and heterogeneous mixture of clays, silts, sands and gravels, which mantles the bedrock has been observed at the site ranging from 5 to approximately 35 feet in thickness. The till thickness in the area beneath the Holding Basin, where DU is present in the deep overburden, was observed to range between approximately 5 and 15 feet. This layer is expected to limit the downward migration of groundwater and contaminants from overburden to bedrock. Also, the selected remedy includes ISS for uranium in overburden. ISS will be designed to stabilize uranium and prevent migration (including vertical).

As a precaution, Appendix B and D PDI work plans include water level monitoring in overburden wells during the installation and pump testing of bedrock extraction wells. The overburden wells selected for water level monitoring are presented in Appendix B Table 3-2 and shown on a plan in Figure 3-4, and Appendix D Table 3 and Figure 9. The water level data collected in these wells will be used in conjunction with the water levels measured in bedrock during pumping to evaluate the head differentials and assess the potential for vertical groundwater migration from overburden to bedrock.

Finally, the mobilization of DU into bedrock is unlikely based on historical data. Specifically, there was limited DU flux into the bedrock during pumping of bedrock supply wells SW-2 and replacement well SW-2A located just to the south of the Holding Basin. Based on historical records, these wells pumped approximately 49 gpm in the period from 1982 to 1993, with even higher rates reported in the early 1980s (de maximis, 2014). Although, the isotopic signature at shallow bedrock well GZW-7-2 had historically fluctuated below 0.5 percent U-235, this trend reversed in 2009,

indicating that the magnitude of mixing between overburden DU plume and bedrock is likely limited (de maximis, 2014). In summary, if more than a decade of bedrock pumping at nearly 50 gpm adjacent to the holding basin did not cause DU flux from overburden to bedrock, then it is unlikely pumping at much lower rates will induce DU flux into bedrock.

4. The Appendix D PDI plans for five new shallow bedrock monitoring wells to further delineate the bedrock 1,4-Dioxane plume. The figures show some uncertainty in the 0.46ug/l contour at the northwestern extent of the plume near the Assabet River. Will the new monitoring wells address this uncertainty?

Response: The proposed monitoring well locations are designed to better identify and assess the extent of the plume. The additional bedrock monitoring wells are intended to provide delineation to the northeast (MW-BS50 and MW-BS51) and southwest of the plume (MW-BS53 and MW-BS54) as well as the core of the plume (MW-B52). The specific area of the plume referenced by the reviewer as the northwestern portion located near the Assabet River is not accessible to drilling due to the Assabet River and Muskrat Pond, resulting in only a narrow causeway between them where Knox Trail is located. A well cluster was proposed a few feet off Knox Trail, adjacent to Muskrat Pond, as part of the NTCRA Work Plan (Geosyntec, 2015). However, after evaluating the underground utilities, access challenges and the need to block or partially restrict Knox Trail traffic, a decision was made, in coordination with the EPA, MassDEP and the oversight consultants, that it was not possible to install a well in this location. Instead, MW-BS34 and MW-BS32 are in this vicinity and bound the 1,4-dioxane plume; data from November 2019 for these wells are on Appendix D, Figure 7.

5. The new monitoring wells are proposed to extend 25 feet into bedrock. If information about hydraulic connection is needed, is 25 feet adequate or should the borings be extended beyond 25 feet to better the chance of intercepting a fracture.

Response: The majority of bedrock wells installed at the Site have been completed as shallow bedrock wells screened in the top 20-25 feet of the bedrock. This zone is where the 1,4-dioxane plume was identified and where additional delineation efforts are being undertaken. The presence of 1,4-dioxane in deeper bedrock will be evaluated at open bedrock wells BEW-4, BEW-5, and BEW-6, where samples for 1,4-dioxane will be collected from discrete water bearing fractures/fracture zones during packer testing. It is possible that no water-bearing fractures are found in the top 25 feet of bedrock, and drilling needs to continue until a fracture(s) is intercepted. This decision will be made by the project team based on field observations at a specific well. However, given the previous experience at this Site, it is anticipated that drilling deeper than 20-25 feet below the top of bedrock will not be necessary.

6. Appendix D also plans the drilling of several new bedrock extraction wells. Which will be installed first, the monitoring wells or the extraction wells? If the extraction wells

are installed first, would that give a better inkling of how deep to extend the monitoring well borings and at what depth to place the screens.

Response: The bedrock monitoring wells will be installed first and instrumented with pressure transducers to monitor the hydraulic response in bedrock during installation of the bedrock extraction wells and inform the team on the fracture connectivity in the vicinity of the bedrock extraction well (see section 5.2.5.2 of Appendix D of the RDWP). Though additional information gathered during bedrock extraction well installation could assist in monitoring well installation, it is understood that the majority of 1,4-dioxane impacts are present in shallow bedrock as evidenced by results from the MW-BS15/BM-15 well cluster, where the most recent 1,4-dioxane detection at shallow bedrock well MW-BS15 installed 3-13 feet into bedrock was 73.4 µg/L compared to 0.806 µg/L at MW-BM15 installed approximately 35-45 feet into bedrock.

7. On the figures It would help if Route 62 was clearly shown.

Response: Noted, figures that need revisions will include a more evident labeling/marking for Rt 62. These markings will be present in figures moving forward. Historical figures and figures not needing additional revisions will not be revised at this time.

Responses to EPA Comments dated July 2, 2020 and CREW Comments dated July 13, 2020 on the Remedial Design Work Plan, Appendix E Treatability Study Work Plan dated March 2020

General Comments

1. EPA has engaged an expert from the United States Geological Survey (USGS) to assist with the review of this document. EPA will coordinate with de maximis to provide additional comments from the USGS expert upon completion of their review.

Response: Noted.

Specific Comments

2. **Section 2, Page 2, Paragraph 2.** As discussed with de maximis, after an initial review of the proposed treatability amendments, an additional option warrants consideration or further discussion within the treatability study work plan.

EPA's contractor AECOM has experience with another phosphate amendment that was developed by Sandia National Laboratory to sequester uranium and has been applied at several DOE sites (Szecsody et al 2016; Rigali et al., 2018; DOE 2019). AECOM suggests that de maximis consider this amendment as part of their in situ sequestration treatability study.

The suggested amendment is a mixture of calcium chloride, trisodium citrate, and several phosphate reagents, of which dibasic sodium phosphate (Na2HPO4) predominates (DOE 2019), that are dissolved in water and injected into the subsurface to precipitate an in situ permeable apatite barrier. The primary advantage of a precipitated apatite barrier over competing trench and injection technologies is that the injected solution flows into areas with the highest soil porosity prior to precipitating apatite, so more apatite forms in areas where larger volumes of impacted groundwater flow.

The apatite barrier can be formed in a few ways, depending on the soil characteristics and the type of contaminant needing treatment. Typically, an aqueous solution containing a compound of calcium or sodium citrate and sodium phosphate is dissolved in water and pumped into the subsurface. The indigenous soil bacteria biodegrade the citrate (an organic compound) leaving calcium available to precipitate with phosphate as poorly crystalline apatite, an insoluble and stable mineral that immobilizes contaminants. As groundwater flows through the permeable apatite barrier, the contaminants sorb to the precipitated apatite and are subsequently sequestered. The precipitated apatite also serves to treat the uranium source by coating the soil with an insoluble precipitate that reduces uranium leaching from urainiferous minerals in the aquifer sediments.

Please either consider adding this amendment as part of the TSWP or provide an explanation for why the proposed amendment is not worth investigating further for the Site.

References

Szecsody, J.E., R.C. Moore, M.J. Rigali, V.R. Vermeul, and J. Luellen, 2016. Use of a Ca-Citrate-Phosphate Solution to Form Hydroxyapatite for Uranium for Uranium Stabilization of Old Rifle Sediments: Laboratory Proof of Principle Studies, Pacific Northwest National Laboratory. March. PNNL-25303. 26 pp and appendices.

Rigali, M.J., and others. 2018. In Situ Hydroxyapatite Permeable Reactive Barrier Performance at the Old Rifle, CO Uranium Processing Mill Site. American Geophysical Union, Fall Meeting, Abstract H21D-01.

U.S. Department of Energy Legacy Management (DOE). 2019. Results of the Laboratory Batch Test of Phosphate Amendment Added to Shiprock Sediment and Groundwater. May. LMS/SHP/S24333. 14 pp.

Response: Thank you for pointing out this alternative amendment. Please consider the background relative to possible amendments as described herein. As part of the RI, we had discussions with scientists from the Pacific Northwest National Laboratory (PNNL), located at the Hanford Site. PNNL used a soluble phosphate and calcium amendment to form apatite in-situ. We sent them our data and after reviewing our hydrogeologic regime and groundwater geochemistry, their recommendation was to use solid apatite if it could be injected directly and not rely on a liquid amendment that needs to have an in-situ reaction occur as a precursor to the sequestration reaction. In fact, it was the recommendation of Dr. Dawn Wellman, Division Director at PNNL, that led us to investigate the use of Apatite II from PIMS. Based on conversation with PNNL, we did not consider trying to form apatite in-situ and did not evaluate the chemistry of the reaction with conditions at NMI. While the Sandia approach could be feasible at NMI, it requires biological and chemical reactions to occur in-situ to form apatite as a precursor to the sequestration of aqueous uranium. A simpler and more reliable approach is to inject apatite directly as suggested by scientists at PNNL.

We have reviewed two of the three references provided in the comment (we could not locate the USDOE 2019 report about the Shiprock lab work). The work by Szecsody et al. 2016 describes lab column tests on Rifle, CO sediments; these contain sediments with up to 1.4 ppm extractable uranium and groundwater at ~32 ppb (amended to achieve 170 ppb). Columns were amended with calcium at 0.4 ppm, phosphate at 4 ppm, and citrate at 2.6 ppm. In November 2019, uranium concentrations at the NMI site in the overburden groundwater were as high as 2,600 ppb, and calcium concentrations were as high as 165 ppm. We expect there to be adequate calcium in the groundwater and soil to facilitate precipitation of calcium phosphate in our tests of sodium monophosphate, and we do not believe the use of citrate is needed to successfully deploy an apatite-based uranium sequestration strategy. Of concern is the uranium present in the soil at NMI, up to approximately 500+ mg/kg in the overburden. Citrate is a strong chelator of uranium and the addition of citrate may mobilize uranium from the overburden soil, contributing to higher concentrations in groundwater after injection of calcium citrate (uranium forms a stronger

complex with citrate than does calcium (i.e., uranium-citrate logK is 8.7 and calcium-citrate is ~3). In addition, there is the potential to form a ternary uranium-iron-citrate complex that is also very stable and soluble (logK 17 – 20; Kantar et al., 2005). The application of citrate to soil has been evaluated as a means of mobilizing uranium and metals (Francis and Dodge, 1998). Uranium citrate is resistant to microbial degradation and may persist in groundwater (Francis et al., 1992), and may be resistant to precipitation with phosphate. Chelation and stabilization of uranium and iron in the aqueous phase is therefore not favorable for immobilization of uranium, and we are concerned about the risks of using citrate at the NMI site.

<u>References</u>

Francis, A.J., and Dodge. C.J. 1998. Remediation of soils and wastes contaminated with uranium and toxic metals. Environmental Science and Technology 32: 3993-3998.

Francis, A.J., Dodge, C.J., Gillow, J.B., and Cline, J.E. 1991. Microbial transformation of uranium in wastes. Radiochimica Acta 52-53: 311-316.

Kantar, C., Gillow, J.B., Harper-Arabie, R.H., Honeyman, B.D., and Francis, A.J. 2005. Determination of stability constants for ternary Fe-U-citrate complexes. Environmental Science and Technology 39: 2161-2168.

3. **Section 2, Page 3, Paragraph 1.** For completeness and to aid the reader, specify the chemical formula for chernikovite ((H3O)2(UO2)2(PO4)2 •6H2O), a member of the meta- autunite mineral group.

Response: The chemical formula for chernikovite has been added to the text.

4. **Section 3.2.1, Page 6, Step 5.** The text discusses establishing a calibration curve from a handheld radiation survey instrument to a mass-based uranium concentration of mg/kg using the on-site laboratory. However, in discussions with the project team after the initial evaluation of the Site-wide Soils and Sediment Pre-Design Investigation Work Plan (provided in Appendix A), de maximis indicated no on-site instrumentation (such as XRF) that was capable of mass based measurement was planned to be deployed during the PDIs. Furthermore, the text estimates a detection limit of 10 mg/kg using the survey instrument, but no information on using the radiation survey instrumentation for conversion to mass based results is provided in either the Field Sampling Plan (Appendix or the Quality Assurance Project Plan (Appendix J). Please address.

Response: Matt Norton of DDES has indicated that they will be using gamma spectroscopy (Falcon 5000 HPGe Spectrometer) to identify and quantify in mg/kg the isotopes of uranium in soils. Guidance on using the Falcon 5000 HPGe Spectrometer is included in the FSP as Standard Operating Procedure HP-NMI-024 (Operation of the Falcon 5000 HPGe Spectrometer)

5. **Section 3.2.1, Page 7, Step 7.** The soil samples' geochemistry might be better preserved and unnecessary exposure to the atmosphere reduced by vacuum sealing

the samples in plastic bags once they have been radiologically screened. At minimum, refrigeration should be considered. Please address.

Response: The referenced text states that samples will be sealed in zip top plastic bags to limit unnecessary exposure to the atmosphere and preserve sample geochemistry. Later, in Step 9 the work plan indicates that samples will be placed in coolers with ice for shipment to the laboratory. A note has been added to the text stating "Samples to be stored on-site shall be placed in a refrigerator until packing for shipping is complete". Text has been added to Step 7 to indicate that as much as possible the air should be pushed out of the bag prior to sealing with the zip top.

6. **Section 3.2.1, Page 7, Step 10, 2nd bullet.** Please clarify why iron, aluminum, and calcium were selected for analysis. Arsenic is included in later sections, and should it be included here. It is recommended manganese also be included as hydrous manganese oxides are common in soils. If there are other leachable metals that might compete for uranium sorption sites they should also be analyzed. Please address.

Response: In addition to evaluating the concentration of uranium in the HB soil, the analytes selected to be included in the baseline characterization of the HB soil are based upon the following:

Iron: an important sorbing phase for uranium and is also redox-active – since zero-valent iron is one of the amendments proposed for study as a stabilizing agent for uranium. The aqueous iron concentration is an important indicator of soil redox environment, which can influence uranium speciation.

Aluminum: another sorbing phase for uranium, knowing its concentration will allow us to assess how much of a role this element may play in this regard, and it is also an indicator of the clay (aluminosilicate) content of the HB soils.

Calcium: Given that calcium carbonate is likely a significant component of the HB soil mineralogy, the concentration of calcium in combination with inorganic carbon content of the soil will provide information on aqueous uranium speciation and lability in the HB soil.

We agree that manganese is also a sorbing phase for uranium, and some manganese may be introduced into the soil through the addition of ZVI (manganese is typically a trace constituent in the iron). Manganese oxides are also redox active and may dissolve in response to the addition of amendment that alter the redox status of the soil.

Manganese and arsenic have been added to the baseline analysis. The baseline concentration of these elements is relevant to the overburden soil as the addition of amendments may result in their mobilization. Constituents that may be mobilized in the HB soil will be contained by the barrier; however, identifying which constituents may be mobilized in response to the HB soil amendments will be important to select the best

amendment that balances robust uranium immobilization with minimal mobilization of other soil constituents.

7. **Section 3.2.1, Page 7, Step 10, last bullet.** Please define what would be considered “sufficient” baseline uranium soil content.

Response: Our reporting limit (RL) target for uranium in aqueous samples will typically be low enough to evaluate treatment of uranium to below the EPA maximum contaminant level (MCL). The MCL for uranium is 0.030 mg/L, therefore we will target an RL of 0.01 mg/L. The SPLP procedures uses 2-liters of water and 100 grams of soil (20:1 solution:solid ratio). To detect 0.01 mg/L, the soil will need to have 2 mg/kg uranium (assuming 10% of this uranium is leachable, this gives 0.01 mg/L leachable uranium). Since soil uranium concentrations that are above the RL by 10x or 100x are preferable for reliability of the results, sufficient baseline uranium soil content is 20 to 200 mg/kg, with higher concentrations preferable to testing in-situ stabilizing amendments. “Sufficient” baseline uranium soil content has been defined in the text.

8. **Section 3.2.2, Page 8, Paragraph 1.** As discussed with the project team after an initial review of the proposed investigation, the well proposed for low uranium concentration appears to have much lower native metals concentrations than typically seen in other wells and may not be considered representative of groundwater in contaminated areas. It is understood that alternative wells are being evaluated that consider the groundwater geochemistry. Please address.

Response: MW-S21 has always been considered a background well for the DU plume, which is why we chose this location. However, it is correct that other wells have elevated metals concentrations more similar to that observed within the DU plume. Thus, we evaluated the geochemistry and metals content relevant for uranium mobility (Ca, Fe, Mg, K, Na, DO, ORP and pH) of numerous wells near the plume without detectable levels of DU and have determined that MW-S30 is a good choice. The text has been revised to reflect the change in background well from MW-S21 to MW-S30.

9. **Section 3.2.3, Page 8, Paragraph 2, bullet list.** For completeness, please discuss the basis for the selected amendment weight percentages in the soil column.

Response: The mass loading of Apatite II and ZVI amendments in the column tests for Holding Basin soils was selected to be representative of a typical bulk mass loading achieved in the field using direct-push technology (DPT) jet injection. The bulk mass loading of injected amendments is a function of the mass of amendment per fracture, the fracture ROI, the vertical spacing between individual fractures at each injection location, and the overlap of ROIs between adjacent injection locations. As described in Appendix B, injection design parameters will be evaluated based on the results of the treatability studies as well as ISS pilot testing in overburden. Assuming typical values for these parameters based on previous experience implementing DPT direct-push jet injection,

a mass loading of 1% to 1.5% was selected for the column tests. A discussion of the basis for the mass loading has been added to the text.

10. **Section 3.2.4, Page 9, Paragraph 2.** Nitrate is not specified for baseline analysis in Section 3.2.2 (Groundwater Collection) but is included here. Also, on page 10, please clarify why arsenic is included for analysis here (and in the subsequent section) as it also was not included in the baseline analyses. Please resolve.

Response: Arsenic is included as part of the baseline groundwater characterization (Section 3.2.2) and we will add this to the baseline HB soil characterization (see response to comment 6 above). Nitrate is proposed to be analyzed in the influent groundwater to the HB soil column before the initiation of reducing conditions (weeks 2-3 of the column test) to determine the necessary glucose amendment to the column influent to achieve iron-reducing conditions. We propose measuring nitrate in the column influent during the column test rather than during baseline groundwater characterization to ensure that the glucose dosing is accurate.

11. **Section 3.2.4, Page 10, Paragraph 3.** The procedure states dissolved iron will be monitored as a redox indicator (based on higher dissolved iron concentrations reflecting more reducing conditions). Has there been any consideration given to directly measuring ferrous iron to evaluate reducing conditions? Please address.

Response: We will consider the use ferrous iron analysis in the lab if this is convenient and available at the laboratory (e.g., if they are able to use a spectrophotometer to measure the o-phenathroline-Fe(II) complex that forms in a colorometric analysis (i.e., Hach kit for ferrous iron)). In the absence of this being available, samples that are taken, filtered, and immediately preserved with nitric acid will provide a reliable indicator of the presence of dissolved iron (ferrous iron).

12. **Section 3.2.4, Page 10, last paragraph.** For completeness, please define what the criteria are for total results that would trigger analysis of dissolved constituents.

Response: If total uranium results fall above the target for uranium stabilization (total uranium concentrations $\geq$0.030 mg/L) in two consecutive sampling events, these samples will be filtered and analyzed for dissolved constituents in order to understand whether colloidal (micro- or nano-particulate) uranium is present in the samples analyzed for total (unfiltered) uranium. This has been clarified in the text.

13. **Section 3.4, Paragraph 2.** Based on text in other associated documents and additional discussions from the initial review of the work plans, the means for how a drill rig will access the holding basin will be provided in an implementation plan to be provided under separate cover. Please revise the text to reflect this detail.

Response: Text has been added to the work plan to indicate that drill rig access information will be provided in the implementation plan.

14. **Section 4.2.1, Page 12, Paragraph 3.** For clarity please explain if "Total (acid digestible)" refers to standard EPA metals soil preparation methods (to reflect environmental availability) or a complete mineral breakdown via hydrofluoric acid to measure all of the analyte present in a sample.

> **Response: Total refers to acid-soluble elements based upon digestion by EPA Method 3050B, "environmentally-accessible" elements determined by leaching in nitric acid and hydrogen peroxide. The digestion with hydrofluoric acid will result in the dissolution of strongly bound elements in soil (e.g., those associated with silicate minerals that are not likely to dissolve from soil under the geochemical conditions presented by the overburden groundwater system). The text has been revised to clarify that EPA Method 3050B will be used to measure environmentally accessible elements in soil samples.**

15. **Section 4.2.1, Page 12, last paragraph.** For completeness, please define "enough" in terms of concentration. Also please correct the typo "in" to "is".

> **Response: Similar to the response to comment 7 (above) we require enough uranium to be present in the soil to achieve the RLs for the individual selective extraction steps. In the sequential extraction procedure, typically 20 – 100 mL of extraction fluid is employed with 1 – 5 g of soil. Assuming 5 g of soil extracted by 100 mL of fluid, with 10% extracted and at 10x - 100x the RL, enough uranium is defined as 20 - 200 mg/kg (in this case, this gives us 0.1 – 1 mg/L leachable uranium in the extraction step). This has been clarified in the text.**

16. **Section 4.2.2, Page 12, Paragraph 1.** This is the first mention of a "sorption capacity test". For completeness, please describe this test.

> **Response: The sorption capacity test is described in Section 4.2.3. The text has been revised to refer the reader to Section 4.2.3 for additional details.**

17. **Section 4.2.4, Page 17, 3rd bullet.** Typo. Footnote reference number should be superscript to distinguish from preceding publication year.

> **Response: The footnote reference number has been changed to superscript.**

18. **Section 4.2.4, Page 19, Paragraph 3.** Please clarify how the solubility of Apatite II (27 mg/L) was determined. How does this value relate to the solubility of hydroxyapatite? Also, clarify why it is important to keep the phosphorus solution concentration at approximately 5 mg/L.

> **Response: The provided value is determined based on the observed concentration of phosphorus for groundwater (wells MW-8A and MW-S24) equilibrated with Apatite II, which is approximately 5 mg/L (Lammers et al., 2017). This measured P concentration agrees with the value calculated in PHREEQc using an experimentally determined value for Apatite II solubility (Oliva et al., 2012) in equilibrium with Site groundwater at the measured pH. This reference has been added to the text.**

Based on the phosphorus content of Apatite II (18.5 wt % phosphorus), 27 mg/L Apatite II is equivalent to 5 mg/L phosphorus assuming stoichiometric dissolution. This value, we stress, is approximate and may be slightly different for groundwater equilibrated with Apatite II in batch mode. A constant phosphorus concentration in the column influent is ideal for data analysis and determination of the phosphorus distribution coefficient.

The solubility of Apatite II (Ksp = -50.8 = $a_{Ca2+}^{5}\, a_{PO4\text{-}3}^{3}\, a_{OH-}$, Oliva et al., 2012) is greater than the solubility of hydroxyapatite (Ksp = -59.4 = $a_{Ca2+}^{5}\, a_{PO4\text{-}3}^{3}\, a_{OH-}$, USGS PHREEQC database).

19. **Section 5.2.2, Page 22, Paragraph 1, 3rd sentence.** For clarity, please revise “expected” to “initially assumed”.

Response: The word “expected” has been changed to “initially assumed”.

Response to 13 July 2020 CREW Comments

Appendix E - Treatability Study Work Plan

The proposed set of studies are well described and appear complete and well thought out. Bigger picture questions based upon an initial review include.

1. One key question is associated with how long the sequestered material will remain insoluble. How will the results of these relatively short-term tests be used to predict long-term behavior, and possible changes in ambient geochemical conditions?

Response: Sequential extractions and solid phase analyses of the final solids in the column and batch tests will be used to evaluate the stability of the sequestered uranium under each amendment. Uranium that is only extractable in the later steps of the sequential extractions for this study is in the mineralized or highly sorbed phases. These forms are highly stable over the long term.

Although the treatability studies are relatively short in duration, the column and batch studies will be used to identify the best performing amendment under the geochemical conditions of the site in terms of removing uranium from groundwater. These results will be evaluated in consideration of other published studies in which the long-term stability of different forms of sequestered uranium were evaluated. By way of example, there are “natural analog” studies where natural systems that contain uranium phosphate minerals have been studied and have shown little solubility of uranium in groundwater. The Coles Hill uranium deposit in Virginia is a good example of this – autunite is a component of the uranium ore in this deposit, and in the saturated zone, uranium is present in groundwater at very low concentrations.

2. On page 10, #7, the Work Plan indicates that soil samples collected from the saturated and unsaturated zones will be homogenized before undergoing baseline characterization. Homogenization was chosen in part based upon the assumption that

"alteration of the redox state of the column influent will overpower any differences in geochemical conditions between the saturated and unsaturated zones." We ask that USEPA evaluate the validity of this assumption, and the homogenization approach. It seems that the focus of the treatability studies should include evaluating likely "in-situ" conditions as much as is possible/feasible, considering a likely in-situ injection and treatment approach.

Response: For the Holding Basin, it is important to note that the in-situ conditions post-installation of the vertical barrier wall and cap will very likely be different than the current in-situ conditions. Thus, simulating the current conditions is not germane to the TS-1 Holding Basin Treatability Study, as it is in the TS-2 Treatability Study for the overburden downgradient of the Holding Basin where the saturated zone will remain an unconfined aerobic aquifer.

3. Descriptions of the number and types of amendments/reagents varies between Appendix B and Appendix E, and is somewhat confusing (2 reagents, 3 reagents, 4 reagents?). Inclusion of a flow chart might make the proposed tests and sequence of amendments/reagents more clear.

Response: There are flow charts for each treatability study in Appendix E as Figures 1A, 1B, and 1C that illustrate the number and types of amendments proposed. What is presented in Appendix E are amendments to be tested in the laboratory during treatability studies. From these laboratory studies, a subset of amendments which show the most favorable results, will be field (pilot) tested as described in Appendix B. Given this, a different suite of amendments is identified in Appendix E than in Appendix B, and the exact amendments identified for pilot testing (in Appendix B) will be determined depending on results of the treatability testing.

Holding Basin – AOI 1 – Paragraph 3

Currently, there are no groundwater data for conditions directly beneath the Holding Basin. De maximis cites safety concerns to justify the not installing a monitoring well or conducting groundwater sampling within the Holding Basin during PDI activities. While CREW does not dismiss the cited health and safety considerations, we do ask de maximis and the agencies to consider the possible implications of not having "baseline" groundwater quality information for the area directly beneath the holding basin (i.e., the concentrated source area). In particular, we note the following two considerations:

- baseline groundwater quality information would be very useful for evaluating and designing a uranium stabilization approach for the dissolved and adsorbed uranium that will remain in the soils within the containment wall/area; and

Response: We appreciate this comment and agree that the mobilization of equipment into the Holding Basin for the collection of treatability study samples presents a unique opportunity to collect a groundwater sample beneath the Holding Basin. We propose to collect a groundwater sample from the shallow saturated zone (within 10 feet of the water table) when collecting

saturated soil samples. The groundwater sample will be collected using a temporary well or the Push-Ahead sampler developed by Cascade Drilling (this was created for use with sonic drilling equipment and was the device used in the downgradient plume area during the NTCRA investigation several years ago). We have added the Section 3.2.2.1 – Groundwater Sample Collection Beneath the Holding Basin to the Appendix E Work Plan. This new section describes the collection of the groundwater sample as follows:

"As discussed in the sections above, drilling equipment will be mobilized into the Holding Basin to collect soil samples for treatability studies, including from the saturated zone beneath the Holding Basin. A groundwater sample will be collected from the shallow saturated zone (approximately the upper 10-feet) using a temporary well or a Push-Ahead sampler developed by Cascade Drilling. If the Push-Ahead sampler is used, the sampler will be driven at least 5 feet ahead of the override casing and into the native formation without the use of drilling water that could alter the geochemistry. Prior to the sample collection, the temporary well screen or the Push-Ahead sampler will be purged until field parameters (temperature, dissolved oxygen, oxidation-reduction potential, pH, specific conductance and turbidity) stabilize consistent with low-flow groundwater sampling procedures."

- an understanding of "baseline" groundwater conditions within the Holding Basin will be useful for evaluating the success of remedial approach and integrity of the containment wall, once constructed, and interpreting groundwater quality monitoring results for areas near and in the vicinity of the containment wall.

Response: We agree that having a current understanding of the geochemistry in the saturated zone beneath the Holding Basin may be useful if conditions are significantly different than observed in wells immediately downgradient of the Holding Basin (HBPZ-2R and MW-S24). As indicated in the response above, we have added Section 3.2.2.1 – Groundwater Sample Collection Beneath the Holding Basin to the Appendix E Work Plan. This section will state that:

"The groundwater sample will be analyzed for the following suite of parameters:

- **VOCs via Method 8260**
- **1,4-dioxane via Method 8270SIM**
- **SVOCs via Method 8270**
- **Total and dissolved uranium with U^{235}/U^{238} speciation via Method 6020A ICP-MS**
- **Total and Dissolved Metals via Method 6020A ICP-MS (Al, Sb, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Tl, Th, V, Zn)**
- **Nitrate/Nitrite via Method 353.2**
- **Total Phosphorous via Method 365.1**

- **Orthophosphate via Method SMP4500P-E**
- **Dissolved Organic Carbon via Method 9060**
- **Total and Dissolved Cations (As, Fe, Mn, Ca, Mg, Na, K) via Method 6020A ICP-MS**
- **Anion (Sulfate, Fluoride, and Chloride) via Method 300**
- **Carbonate and Bicarbonate Alkalinity via Method 310.1**

This suite of analytes is consistent with the November 2019 parameters sampled in monitoring wells MW-S24 and HBPZ-2R to allow for a direct comparison of groundwater beneath the Holding Basin and immediately downgradient."

- Baseline information from the middle of the Holding Basin could potentially be obtained during the PDI using one-time, discrete sampling methods that would not require the installation of permanent well(s).

Response: As noted in the responses to comments above, we have added collection of a groundwater sample from beneath the Holding Basin to Appendix E of the RDWP.

Responses to EPA Comments dated July 16, 2020 on the Remedial Design Work Plan, Appendix F Post Removal Site Control Plan dated March 2020

General Comments

1. **Holding Basin and Landfill Covers**. To prevent further potential spread of contamination, the routine inspections should also include an overall evaluation of the integrity of the temporary covers installed by EPA during the 2002 Time Critical Removal Action (TCRA). If not appropriate to include with this document which focuses on the Building NTCRA, please include in the appropriate RDWP appendix.

   Response: The text has been modified to include inspections of "temporary cover over the holding basin" and "temporary cover over the landfill" in Section 3.1. References to the "temporary cover" has been modified to "temporary covers" throughout the document. Additionally, Attachment A, of the text, has been modified to include sections for inspections of the holding basin and landfill covers.

2. **Figure 2**. The dashed magenta lines are not included in the legend. Please add.

   Response: The figure has been updated to include the dashed magenta lines on the legend and labels them as "overhead electric line".

Responses to EPA Comments dated July 16, 2020 on the Remedial Design Work Plan, Appendix H Emergency Response Plan dated March 2020

General Review Comments

1. The document covers both the NMI property (located in Concord) and the groundwater treatment plant (GWTP) located in Acton, with references to each specific town's appropriate public safety organizations and utility providers in most but not all instances. For example, Section 3.4 (Electrical /Power) appears to cite only utilities for the NMI Property but not the GWTP. Please review the document to ensure applicable organizations are referenced to cover both the NMI property and the GWTP.

> **Response: The text has been revised to provide missing information for the GWTP where necessary. The missing utility information addressed in the comment has been updated in Section 3.4. Additional revisions referencing Acton-specific contact information and reporting authorities have been made where applicable throughout the text.**

Specific Review Comments

1. Section 2.3, Page 6, Paragraph 2. The text states "The SPM reports to the SPM." Please clarify.

> **Response: This sentence has been deleted from the text. Paragraph 1 of Section 2.3 explains that the Site Project Manager (SPM) is to report to the Project Coordinator (PC). The contradictory sentence identified in the comment has been removed.**

2. Section 2.4, page 8, first sentence. There is a period typo at the end of this sentence, please correct.

> **Response: This sentence was reviewed and the punctuation error identified in the comment was not apparent. Upon review of Section 2.4, a period typo in the fifth paragraph of Section 2.4 was identified and resolved. It is assumed that this comment was applicable to the observed punctuation error and has thus been addressed.**

Responses to EPA Comments dated July 16, 2020 on the Remedial Design Work Plan, Appendix K Site Wide Monitoring Plan dated March 2020

General Review Comments

1. For ease of reference, please include page numbers on the text.

   Response: The text has been updated with page numbers.

2. Attachment – Monitoring Well Evaluation. The Attachment is called "Monitoring Well Assessment" in the Table of Contents and Well Evaluation and Maintenance Summary in Section 2.2. Please correct the inconsistencies in the naming of the attachment.

   Response: The title of the "Monitoring Well Integrity Assessment" has been corrected throughout the document. Revisions were made to the table of contents, Section 2.2, and the attachments section of the text for consistency.

Specific Review Comments

3. Section 2 Background, 3rd to last paragraph. For the 2016 monitoring well installation event the text references the proposed plan from 2014. As the Record of Decision was issued in September 2015, prior to the well installation, please reference the ROD as the controlling document.

   Response: The reference in the text has been updated to cite the ROD as the controlling document. Section 5 has been updated to add the citation of the ROD the list of references.

4. Section 3.1 Sampling Design and Rationale, First Paragraph in Section 3.1. The second sentence states that a second comprehensive round will be performed once all wells proposed under the PDI WPs are installed (targeted for Fall 2020). The first sentence in Section 3.1.4 states that a second comprehensive round is anticipated to be performed one year after installation of the final PDI well. Please revise these sentences to eliminate any inconsistency.

   Response: The text has been modified to remove the inconsistency identified in the comment. The phrase, "(targeted for Fall 2020)" has been removed from Section 3.1 as a targeted date is not relevant until completion of PDI monitoring wells. Additionally, Section 3.1.4. has been updated to state "A second comprehensive sampling event will be completed upon installation of all monitoring wells associated with the Pre-Design Investigations."

5. Section 3.1.1 Monthly Sampling, Second Bullet. Clarify Assabet 2A will also be evaluated for 1,4-dioxane.

   Response: The text has been updated to include 1,4-dioxane analysis at both Assabet 1A and 2A production wells.

6. Section 3.1.4 Comprehensive Sampling, First Bullet. The statement in the first paragraph that the wells to be sampled in the second comprehensive round include all wells in which a cleanup level was exceeded in the first round, seems somewhat inconsistent with the first bullet, which states that one objective of the second comprehensive round is to confirm that the various contaminant plumes are still contained (or not expanding). Please explain how plume expansion will be detected or confirmed if wells outside the plumes are not sampled to clarify this apparent, or actual, inconsistency.

Response: Agreed. The second comprehensive event will be a duplicate effort of the November 2019 sampling scope with the addition of the new monitoring wells installed during the pre-design investigations.

Table 2.4.1 has been updated to mirror the 2019 comprehensive sampling scope. Additionally, Figure 4 (Comprehensive Monitoring Well Network) has been removed, as Figure 1, monitoring well network presents the wells to be included in the comprehensive sampling. Figure 1 will be modified upon final installation of all PDI wells.

7. Section 4.1 Reporting. The annual reports should also include plume maps for primary COCs, to illustrate extent in comparison to previous data and to demonstrate plume stability or containment. Please revise the text to include this element of reporting.

Response: The following has been added to the text, "figures depicting concentration contours for primary contaminants of concern will be incorporated to assist in monitoring the conditions of the various plumes."

8. Section 4.2, Schedule. States "In summary, select wells are scheduled to be sampled monthly, a larger set will be sampled semi-annually, and an even larger sampling program is scheduled to occur annually." This sentence is confusing given that the semi-annual sampling is for groundwater levels only, while the monthly sampling includes 1,4-dioxane analysis. Please clarify.

Response: We agree this sentence is confusing and has been removed. A table has been included in Section 4 to summarize the sampling schedule and provide the total number of wells to be sampled and monitored during each event.

9. Table 1, First Page. The heading for the far-right column is "Misc (see Footnote 5)", but the table has no such footnote. Please correct the inconsistency.

Response: The format of this table has been corrected and the footnote now states, "5. Geochemistry Parameters include: Total Phosphorous (Method 365.1), Orthophosphate (SMP4500-E), Dissolved Organic Carbon (Method 9060), Anions (Method 300) and Alkalinity (Method 310.1)"

10. Table 2.2. Because the semi-annual monitoring rounds are for water-level measurement only, please delete "and Quality" from the table title.

Response: "and Quality" has been removed from the title of the table.

11. Table 2.2, Last Page. The footnote appears to be cut off. Please show the complete footnote.

Response: The format has been adjusted to display the entire footnote.

Responses to EPA Comments dated July 2, 2020 on the Remedial Design Work Plan, Appendix I Field Sampling Plan dated March 2020

General Comments:

1. EPA finds that the Standard Operating Procedures (SOPs) are comprehensive, clear, and well-written.

Response: Noted.

2. EPA's comments on other RDWP appendices may necessitate revisions to the FSP. Please make any additional revisions as required.

Response: SOP NMI-005 – Investigation Derived Waste Handling and Storage and NMI-GW-020 – Field Analysis of Fluorescent Tracer Dye in Groundwater have been updated to reflect changes based on EPA's comments on other RDWP appendices.

3. The QAPP (Appendix J, Worksheet #14) states that field sample identification is provided in the FSP, but the nomenclature for single-blind field duplicates, trip blanks, equipment blanks, and other field QC samples is not described. Please indicate where this information is located or include it if it is missing.

Response: QAPP Worksheet #14 has been updated to include field sample identification.

Specific Comments

1. **SOP NMI-S-001, Section 1.2, Page 1:** Although the documents (e.g., Appendix A, SSS-1) mention use of aluminum pans for homogenization instead of stainless-steel bowls, it is not clear whether the pans are disposable and they are not an option presented in this SOP. Please revise either the PDI documents or the SOP and please clarify whether these are single-use pans. If including an option for aluminum pans, please include cautions in SOP describing when use is not appropriate (e.g., sampling for aluminum).

Response: An option for disposable aluminum pans has been included throughout the SOP and a note has been added that disposable aluminum pans shall not be used if analysis of aluminum is required.

2. **SOP NMI-S-001, VOC Sampling Text, multiple locations:** The method used to collect soil samples with stainless steel spoon or tongue depressor is not consistent with current best practices of using either an encapsulated collection device or a coring device which is then used to transfer a preset mass of soil into pre-weighed vials pre-preserved with water or methanol such as that described in NMI-S-007. For clarity and consistency, please revise the VOC sampling text to reference the VOC sampling SOP.

Response: The VOC sampling text has been updated to reference the sample methods described in NMI S-007 – Extraction/Preservation of Soil/Sediment for VOCs.

3. **SOP NMI-S-002, Sediment Sampling, Section 2.4, Page 14:** The SOP states that samples may be frozen to suspend holding time. Sample preservation and holding time are not presented in the QAPP for sediment samples. Please indicate whether the intention is to freeze sediment samples to suspend holding time and whether that is suitable for VOC analyses.

> **Response: As there is no intent to freeze sediment samples to suspend hold times, all references have been removed.**

4. **SOP NMI-S-002, Sediment Sampling, General:** The EPA Region 1 data validation guidelines indicate that analytical data must be rejected if solids content falls below 30% unless, in the judgement of the validator, “sampling and/or analytical preparation steps were employed to address high moisture soil/sediment/solid samples, such as removing the aqueous portion or increasing the sample size.” Either in the SOP, WP or QAPP, please present the approach that will be used in order to avoid losing data because of elevated moisture content.

> **Response: The following text has been updated to indicate the approach that will be used in order to avoid losing data due to elevated moisture content.**
>
> > **“Per EPA Region 1 data validation guidelines, analytical data must be rejected if solids content for a sample falls below 30% unless, in the judgement of the validator, sampling and/or analytical preparation steps were employed to address high moisture soil/sediment/solid samples. If solids content for a sediment sample is determined to be below 30%, the sample will be discarded, and a new sample will be collected.”**

5. **SOP NMI-001, General:** The SOP is for CoC, handling, packaging and shipping of non-radioactive samples. Soil samples collected as part of PDI SSS-2 will include soil from locations with elevated gamma emissions based on the gamma walkover survey. Please provide a reference.

> **Response: A reference to SOP HP-NMI-12 – Radioactive Materials Receipt and Shipment has been included in SOP NMI-001.**

Responses to EPA Comments dated July 2, 2020 on the Remedial Design Work Plan, Appendix J Quality Assurance Project Plan dated March 2020

General Comments

1. EPA's comments on other RDWP appendices may necessitate revisions to the QAPP. Please make any additional revisions as required.

Response: Noted.

2. Format, Typos, Production Errors. There are several typos and production errors. For clarity, please correct the following:

a. Several of the bookmark links are not working or there are multiple links for parts of the same page. For clarity, please review and fix the bookmarks. Please add the missing bookmark definition to the table of contents.

Response: Noted, bookmarks will be updated.

b. Section 1.0, second to last paragraph, last sentence: There are words missing. For clarity, please include the missing text.

Response: Noted, text has been added.

c. Section 3, references: Delete the duplicate reference to “USEPA, 2005a” listed within “USEPA, 2004.”

Response: Noted, text has been deleted.

d. Worksheet #6: Correct typo “Manaager” in third row.

Response: Noted, text has been corrected.

e. Worksheet #12 and #28: The worksheets are numbered, but the numbers are not sequential, and several tables have the same number. For clarity, please correct the numbering of the worksheets.

Response: All worksheets have been corrected.

f. Worksheet #12: For clarity, please add the footnote references to the worksheet where missing (e.g., Worksheet 12-5, perchlorate, page 1, notes 4 and 5).

Response: Worksheet has been corrected.

g. For completeness and clarity, please include document control headers and page numbers on the Worksheets #15.

Response: Worksheet has been corrected.

h. Please correct the entry in the table of contents for Worksheet #15. It says the limits are for groundwater but there are other matrices included.

Response: Worksheet has been corrected.

i. On Worksheet #15, ALPHA Wet Chemistry, “Nitrogen, Nitrite” is listed twice with the same laboratory limits and units.

Response: Worksheet has been corrected.

j. For Worksheet #15, GEL Soil, the table title says soil but the units shown for metals and isotopes are for aqueous analyses.

Response: Worksheet has been corrected.

k. For Worksheet #15, GEL Soil Wet Chemistry, the table title says soil but many of the analyses are for aqueous analyses.

Response: Worksheet has been corrected.

l. On Worksheet #15, GEL Soil Wet Chemistry, dissolved inorganic carbon is listed twice with the sample limits and units.

Response: Worksheet has been corrected.

m. On Worksheet #20, Dissolved Organic Carbon is listed twice with the same SOP and Polonium-210 is listed three times with the same SOP. Please correct for clarity.

Response: Worksheet has been corrected.

n. On Worksheet #20, please correct the frequency typos in the laboratory duplicate column starting with Soil/sediment Uranium-235 and continuing in all rows below.

Response: Worksheet has been corrected.

o. On Worksheet #20, it appears the SOP numbers in the soil/sediment starting with Uranium-235 and through zinc are incorrect (sequential numbering was applied).

Response: Worksheet has been corrected.

p. On Worksheet #25, for the GEL SOPs, replace “ME” with “MA” or include these SOPs in Worksheet #23.

Response: Worksheet has been corrected.

q. Worksheet #27, third bullet in section on sample handling should indicate the tape is to prevent the cap from coming loose, not the label.

Response: Worksheet has been corrected.

r. Worksheet #37: For clarity or completeness, please remove or explain the highlighting.

Response: Worksheet has been corrected, highlighting has been removed.

3. UFP-QAPP Worksheets: The document uses a combination of two versions of the UFP- QAPP worksheets, the original and the streamlined versions. For clarity, please indicate which version is being used and use only those worksheets throughout the document.

Response: Noted, worksheet has been corrected, separate WS 19 and 30 have been created.

4. Inconsistencies and Errors in Analyses Presented: Several errors, inconsistencies and omissions in the information provided for the sample analyses were noted. As a result, most of the information required for the intended sample analyses is

unclear. Analyses appear on one worksheet, but not on others. There are incorrect or inconsistent SOP references associated with an analysis and matrix. SOPs are cited but are not included on Worksheet #23. For correctness and clarity, please conduct a thorough and detailed review of all worksheets in the QAPP against the intended analytical program and the laboratory SOPs that will be used. Correct the errors and inconsistencies that are identified. The following are examples, not a complete list:

Response: Noted, inconsistences have been corrected.

a. Laboratory limits for Bismuth-210 and Actinium-227 are included in Worksheet #15 under soil analyses, but the units are aqueous. The preservation and containers are included under groundwater in Worksheet #19&30.

The SOP is listed in Worksheet #23 and QC samples are presented for water in The SOP is listed in Worksheet #23 and QC samples are presented for water in Worksheet #28, but there is no information for the analytical technique (gamma spec) in either Worksheet #24 or #25.

Response: Bismuth-210 and Actinium-227 These would only be analyzed as part of the natural uranium decay series if gamma-spec was to be used. The PDI does not call for any gamma spec analyses. However, it is possible that gamma spec would be used at some point in the future as a component of confirmatory sampling. Therefore, Bismuth-210 and Actinium-227 analyses were added for soils only (and removed all aqueous references) to appropriate worksheets. Worksheet 24 and 25 has been updated to include gamma spec information.

b. In general, the wet chemistry and IDW analyses are presented in some worksheets and not others. For clarity, please take a consistent approach in presenting the information for these groups of analyses, please include text clarifying what is not included, and please provide justification for the omissions.

Response: Noted, worksheets have been corrected.

c. It is not clear when analysis will be performed for lead versus lead-210. Lead-210 is listed for soil analysis on Worksheet #15, however the units are aqueous. There is no Worksheet #12 that lists lead-210 (no table lists the SOP associated with it, GL-RAD- A-018). Worksheet #20 indicates groundwater and soil/sediment samples will be analyzed for lead, but both cite the lead-210 SOP.

Response: Aqueous samples for Lead-210 will not be collected, but soil samples will be collected for Lead-210 analysis. All appropriate worksheets have been updated to reflect this.

d. The metals analyses are unclear, possibly owing to omissions in the SOP Worksheet (#23) and/or errors in the methods cited. Method 6010 is cited for aqueous and soil in Worksheet #12, but Worksheet #15 contains only the limits for soil and TCLP analysis for leachate (no groundwater). Worksheet #19&30 show preservation/ containers for 6010 for groundwater, but not soils. Worksheet #20 lists metals analyses using SOP GL-MA-E-014 but that is the ICP-MS SOP (according to Worksheet #23). There is no SOP in Worksheet #23 for ICP-AES (SOP listed in Worksheet #12 is GL-

MA-E-013). Also, different method versions (6010B and 6010D) are listed in different worksheets. Because individual isotopes for uranium (U-235 and U-238) are to be reported which can only be accomplished via method 6020 (ICP-MS), please clarify when method 6010 (ICP-AES) will be used for analysis of Site samples.

Response: All metals analyses (with the exception of radiochemistry parameters) will be analyzed using Method 6020A. The 6020A analysis will include Uranium-235, Uranium-238 and / or Total Uranium. All appropriate worksheets have been updated to reflect this. NOTE: TCLP Metals will be analyzed by Alpha using Method 6010.

e. Analysis of mercury is also unclear. Mercury analyses in aqueous and soil are listed in Worksheet #12, #15, 19&30 and are also listed in Worksheet #20, but with different SOPs: For water, the ICP-MS SOP is listed (GL-MA-E-014). For soil, an SOP is listed that is not named anywhere else in the document (GL-MA-E-018). Worksheet #28 lists mercury analysis by SOP GL-MA-E-010, but there is no such SOP on Worksheet #23. It seems likely that SOP GL-MA-E-010 is the correct SOP and is missing from Worksheet #23. However, since Worksheet #20 should list the analyses to be performed, it cannot be determined whether the error is in listing the SOPs or including mercury as an analyte when analysis will not be performed.

Response: The correct SOP reference is GL-MA-E-010. All affected worksheets have been corrected.

5. Inconsistencies in Analyses between the Work Plans and QAPP: The terms used to describe the analyses to be conducted are not consistent between the work plans and QAPP, therefore the required details of the analytical program cannot be discerned. Please use consistent terms for analyses between the PDI work plans and QAPP. Some examples follow:

Response: Noted, inconsistences have been corrected.

a. PDI SSS-1 indicates PAH analysis is required. There is no analysis specifically for PAHs identified in any of the QAPP worksheets. Worksheet #20, for example, lists the number and type of samples to be submitted, but only SVOCs is listed for soils. To complicate matters further, SSS-1 lists PAHs but other PDI documents specify only the four PAHs with cleanup levels.

Response: Noted, this has been corrected.

b. PDI SSS-1 indicates that soil will be analyzed for uranium using Method 6020. There is no mention of analysis of soil for uranium in the QAPP except one entry on Worksheet #15 but that is for uranium by Method 6010. Some of the other worksheets list analysis of soil for Uranium-235 and 238 by Method 6020.

Response: Noted, this has been corrected.

c. PDI SSS-4 indicates that groundwater and sediment will be analyzed for chlorinated VOCs. There is no mention of chlorinated VOCs in the QAPP therefore the intended analyte list is not clear.

Response: Noted, this has been corrected and will be clarified in the revised SSS-4.

Specific Review Comments

6. Worksheet 1, Page 1. The preparer's contact information and the preparation date are missing. For completeness, please include this information.

Response: Noted, this has been corrected.

7. Worksheet 3, 4, 6 and 7. The titles applied to certain individuals are not consistent from one worksheet to another. Some of these are not correct (e.g., the EPA RPM on Worksheet #6 is listed as the "Project Coordinator"). On Worksheet 7, there are roles and responsibilities for titles that do not exist in the table above (e.g., "QA Manager" for non-laboratory organizations, "Field Program Coordinator," "Field Project Manager"), and there are titles for which the roles and responsibilities are not presented (e.g., "Field Team Manager"). For clarity and completeness, please use a consistent set of titles to describe the roles of staff involved in the project and please present the roles and responsibilities for each of those project staff.

Response: Noted, this has been corrected.

8. Worksheet 4-1, Page 1. The QA Manager should be independent of the Project Manager to avoid conflicts of interest while addressing quality issues on a project. "QA Coordinator" is the title provided that comes closest to "QA Manager" for de maximis. The QA Coordinator is the same as the Alternate Project Coordinator and the Project Manager for two of the PDIs. Please identify the QA Manager or explain how quality assessment and corrective actions will be conducted in a manner independent of the pressures of project management.

Response: Noted, this has been corrected, the QA Coordinator has been changed.

9. Worksheet 8, Page 1. PDI SSS-2 describes gamma walkover surveys using an NaI detector. If special training is required for the use of this instrument, please include that information.

Response: Noted, an Implementation Plan (Site-wide Soils and Sediments Depleted Uranium Penetrator Investigation Implementation Plan (PDI SSS-2)) has been added as Attachment 6 to the revised RDWP-Appendix A Site-wide Soils and Sediments with additional details.

10. Worksheet 12: Some of the data validation criteria are inconsistent with the most recent validation guidelines. For example, application of a blank action limit to qualify results as non-detected is not consistent with EPA National Functional Guidelines. Please review the data validation criteria and revise those that are not consistent with the current validation guidelines. Please populate the reference number in the sampling procedure column.

Response: Sampling SOP references have been added to all Worksheet 12s. The data validation criteria presented is consistent with how the NMI project has been validated in the past. ddms acknowledges that validation criteria have changed slightly, but feels it is important to keep validation criteria as is for project consistency.

11. Worksheet 12: The data validation criteria column presented on the worksheet suggests that outdated validation guidelines are being cited. For example, on Worksheet 12-5 page 1 (Ammonia Nitrogen), the validation action for blank contamination indicates results up to 5 times the blank concentration will be qualified as non-detected (U). Per current EPA guidance this is no longer considered appropriate. See later comments on the validation guidelines required. If this column is retained in Worksheet 12 (see previous comment), please correct the validation requirements for consistency with the latest National and Regional data validation guidelines.

Response: Same as response to comment 10.

12. Worksheet 12: The worksheet must document the MPCs in terms of precision, bias, sensitivity and completeness. Only the requirements for precision and bias are presented. For completeness, please include the information for sensitivity and completeness for each worksheet.

Response: Noted, Sensitivity requirement added to WS-12 only where there was a project required RL. Completeness is discussed on WS-37.

13. Worksheet 12-5, Metals ICP: There are two worksheets titled Metals ICP for aqueous samples. Both list SW-846 6010B and SOP GL-MA-E-013 but one lists GL-MA-E-006 and the other lists GL-MA-E-009. Of these three SOPs, only one is listed in Worksheet 23 (GL- MA-E-009L hot block digestion). Please indicate the difference between these two worksheets and indicate where in the UFP-QAPP it is made clear which worksheet applies to which samples.

Response: Noted, All Metals worksheets have been revised/corrected and updated.

14. Worksheet 12-5, Metals ICP, Metals including Uranium and Thorium: The method listed is 6020A. This is an ICP-MS method. “ICP” as used in the title refers to ICP-AES (not MS). Please correct the table title.

Response: Noted, All Metals worksheets have been revised/corrected and updated.

15. Worksheet 14: The listing of analysis tasks on this worksheet does not include a level of detail consistent with the example in the 2005 UFP-QAPP Manual where all the methods of extraction and analysis are presented for each analysis task. For completeness, please add information on the analyses that will be conducted for each FSP, PDI and TSWP.

Response: The RDWP appendices are very detailed in listing where to sample, when, how and why. Repeating this in the QAPP would be unnecessary and duplicative. We suggest leaving those details in the PDI and TS WPs, so that future changes to PDIs or TW WPs do not then mandate revisions to the QAPP.

16. Worksheet 14, page 4. There are three levels of data reporting presented. Please indicate where the data reporting level that will be used is presented for each analysis, matrix, sampling event and investigation.

Response: Noted, worksheet 14 has been updated Level 2-Modified Reporting: Modified reporting is used for analyses that are performed following standard USEPA-approved methods and QA/QC protocols. Based on the intended data use, modified reporting may require some supporting documentation, but not full CLP or CLP-type reporting will be performed on all data.

17. Worksheet 15: The worksheets are not complete, and the information missing is critical to determining whether the analyses proposed are adequate to meet project objectives. Please revise the worksheets to include the following:

a. the project action limits (PALs) for each matrix, method, analyte and project objective;

Response: Noted, PALs have been added to all worksheet 15s.

b. the reference limits on which the action limits are based; the project quantitation limit goal (PQLG);

Response: Noted, PQLGs have also been added to all worksheet 15s.

c. the laboratory-specific quantitation limits and laboratory-specific detection limits;

Response: These were already present on worksheet 15.

d. definition of and basis for determining the laboratory-specific quantitation limit and the laboratory-specific detection limit (note that the laboratory-specific quantitation limit cannot be lower than the lowest calibration standard for any given method and analyte);

Response: Footnote was added to Worksheet 15.

e. highlighting to indicate all laboratory-specific quantitation limits and laboratory-specific detection limits that are at or above the PQLG;

Response: Noted, completed

f. an indication (i.e., highlighting, footnote) of which analytes are critical to project-specific decision making;

Response: Noted, completed

g. on worksheet 15 or other suitable worksheet, the basis for arriving at each set of PALs; and

Response: Noted, completed

h. on worksheet 15 or other suitable worksheet, discussion of how limitations in the data resulting for PQLs above the PQLG will be addressed while still achieving project objectives.

Response: Noted, see below.

PALs and DQOs for the same matrix and analysis may vary between the various RD/RA activities and even within the activity depending on the specific objectives for each sampling and analysis task. Versions of Worksheet 15 for all anticipated aspects of the RD/RA program should be provided in the QAPP. For example, PALs may differ for aqueous samples depending on if the data will be used for comparing groundwater concentrations to cleanup criteria, comparison to surface water discharge criteria, or comparison to risk criteria. Optionally, it may be clearer if completed versions of the Worksheets 15 that pertain to a specific RD/RA activity are presented in the detailed WP for that activity if they differ from those presented in this QAPP. Please address.

> **Response: It is not practical or workable (for field staff) for execution of the PDIs to have separate work sheets for each sampling and analysis task. The work plans are detailed on work to perform and sampling. Further, and perhaps more importantly, the RDWP uses similar analyses by compound and media across the site. For example, groundwater will be analyzed for 1,4-dioxane to <MDL in sheet 15 whether it is a sample from a MW for delineation and comparison with the standard or a sample collected during a pump test for trend analysis. Because our MDLs in sheet 15 are below cleanup standards, then they will achieve all DQOs for any task objective. Stated differently, the approach is to use a MDL that will meet all DQOs, and not to adjust MDLs to meet a DQO. PALs have been added to worksheet 15.**

18. Worksheet 15: Although several of the tables list soil in the title, the units in the tables are aqueous. Unless the units are wrong, most of the analyses required for soil and sediment (other than those required for waste characterization) are missing. Please correct the units or provide the missing information.

> **Response: Noted, corrected.**

19. Worksheet 15: PALs and the requirements for each analysis will vary by matrix and objective but only general media (e.g. aqueous) are listed. For clarity, please indicate the applicable matrix on each worksheet.

> **Response: Noted, corrected.**

20. Worksheet 15, Wet Chemistry: The UFP-QAPP manual indicates that the analytical methods should be presented in this worksheet, but that information is missing from this worksheet. For completeness, please add the analytical methods in an additional column represented by the information provided.

> **Response: Noted, Methods and SOP references have been added to worksheet 15.**

21. Worksheet 19&30: The UFP-QAPP manual specifies that the laboratory name and data package turn-around time be included on this worksheet. For completeness, please include this information.

> **Response: Noted, this information has been added to worksheet 30.**

Worksheet 19&30: Please correct the jars for soil/waste classification to indicate where amber glass is required and correct the type for “ounce”.

> **Response: Noted, corrected.**

22. Worksheet 19&30: The worksheet should include the required information for soil and sediment samples and analyses, in addition to the waste characterization analyses. For completeness, please include the missing information.

Response: Noted, corrected.

23. Worksheet 19&30: Although listed under groundwater, the container, preservation, and holding time for metals including uranium and thorium by Method 6010 is for soils. Please correct.

Response: Noted, corrected.

24. Worksheet 20: For clarity, please clarify that submittal of samples for field duplicates, MS/MSD and laboratory duplicates will be 1/20 per investigation per sampling event (as opposed to 1/20 samples submitted for groundwater over the life of the program combined).

Response: Noted, a footnote has been added for clarification.

25. Worksheet 20: The logic behind which analyses and matrices have rinsate blanks is not clear. For example, one might assume only analytes considered contaminants (as opposed to supporting data for groundwater chemistry) would merit a rinsate blank. If that were the case, it is not clear why there is no rinsate blank for perchlorate or metals, but there is a rinsate blank for alkalinity. For clarity, please indicate the logic behind the rinsate blanks or correct the table.

Response: Noted, information has been added to Worksheet 20.

26. Worksheet 20: The worksheet presents QC samples that are not consistent with typical performance of the analysis or other information in the QAPP. Analysis of MS/MSD for TO- 15 air samples is listed, however MS/MSD is not typically performed and the QC sample is not identified on the corresponding Worksheet 28. Trip blanks are listed for each cooler for air samples, but Worksheet #19/30 indicates the air samples will be collected in 6L canisters, cooling is not required, and trip blanks are not listed on the corresponding Worksheet #28. MS/MSD is listed for TSS, reactive cyanide and reactive sulfide, but these are not typically performed and MS/MSD is not listed on the corresponding Worksheet 28. Please review the field QC samples required for each analysis and matrix and correct Worksheet 20.

Response: Noted, worksheet 20 and 28 have been corrected.

27. Worksheet #23: There are laboratory SOPs missing from this table. Please include the missing SOPs. Examples: GL-MA-E-009, GL-MA-E-013.

Response: Noted, worksheet 23 has been updated

28. Worksheet 27: According to the sample handling procedures, the sample container cap will be wrapped with clear packing tape. Because samples will be submitted for PFAS analysis, additional precautions may be required to avoid contamination. Please confirm that this procedure is acceptable for PFAS samples or clarify.

Response: Noted, additional details have been added to individual RDWP PDI and their accompanying Implementation Plans.

29. Worksheet 27: The sample handling section indicates samples are placed in bubble wrap, but no mention of placing the samples in zip-seal bags is made. It is recommended to avoid cross-contamination in the event of breakage or sample leaks that the containers are individually bagged.

Response: Noted, additional details have been added to individual RDWP PDI and their accompanying Implementation Plans.

30. Worksheet 28: For these worksheets, the sampling SOP listed is “TBD” and the number of sample locations is listed as “numerous.” For completeness, please include this information or identify the specific places where the details are presented.

Response: Noted, sampling SOP references have been added to all WS-28.

31. Worksheet 28: For these worksheets, the frequency of the field duplicates and field equipment blanks are listed as “TBD.” For completeness, please include this information or identify the specific places where the details are presented.

Response: Noted, this information has been added to all WS-28.

32. Worksheet 28: As indicated in an earlier comment on Worksheet 12, some of the validation actions shown are outdated and require correction. Please revise for consistency with the most recent validation guidelines.

Response: As previously stated, for project consistency, the validation criteria presented in the QAPP are the criteria historically used for this site.

33. Worksheet 36: The validation requirements are presented for “water.” Please confirm that this applies to all aqueous samples associated with the RDWP, excluding those for waste characterization as noted, regardless of the task or data quality objectives. Please provide the validation requirements for the other sample matrices that will be collected and analyzed.

Response: Noted, corrected.

34. Worksheet 36: For analytical methods with a basis that is the same or similar to the methods included in the EPA Region 1 and national validation guidelines, validation actions should be based on EPA guidelines. Measurement performance criteria (e.g., surrogate recovery criteria) may default to the requirements presented in the QAPP. If a similar analytical method is not addressed by the EPA Guidelines, alternative guidelines may be proposed.

Response: As previously stated, for project consistency, the validation criteria presented in the QAPP are the criteria historically used for this site.

35. Worksheet 36: Please include in the QAPP copies of the ddms validation SOPs that are referenced in this worksheet.

Response: SOPs have been included.

36. Worksheet 37: The worksheet addresses how the usability of laboratory data will be assessed, but much of the data supporting the objectives for the RDRA will be generated in the field. Please discuss how the usability of these data will be assessed.

Response: The work plans provided as Appendices A-E of the RDWP describe the field testing (included collection of field data) and the decisions which will be made using these data on a task-by-task basis. There is also discussion on the use of field data in some SOPs - specifically, how field parameters will inform when a groundwater well has been sufficiently purged.

37. Worksheet 37, page 1: The introduction for the data usability assessment indicates it will be performed for data associated with delineation, risk assessment or confirmation of remedial achievement. Please clarify what data will be generated to support the RDRA that is not intended to be included in this assessment.

Response: The RDWP includes data which will not be used for these purposes. Some examples include, data collected during pump testing to assess changes in concentration, data collected as part of IDW management, parameters which does not have a clean-up criteria, etc.

38. Worksheet 37, page 3. According to this worksheet, completeness for the project is calculated using the total number of valid results generated to the total number of results generated. Assuming that the term project in this case applies to all the sampling and analysis associated with the RA program, calculating completeness in this manner will not provide information useful in determining whether there are sufficient data to meet project objectives for each of the investigations or studies to be conducted. For example, the goal of 90% completeness could likely be met even if all results for 1,4-dioxane in groundwater for the program were rejected. Please provide a more meaningful means for assessing whether sufficient data were gathered to meet each of the project objectives associated with each project within the RA program. Planned samples that were not collected should also be accounted for in the total sets of results considered.

Response: This QAPP is not intended for a RA but rather to collect pre-design data necessary for the RD. An updated/revised QAPP will be generated for the RA.

39. Worksheet 37, page 4. The text concerning sensitivity indicates that the laboratory MDLs must satisfy the project requirements as they relate to the project action limits. Although the laboratory MDLs must certainly be below the project action limits, it is more critical that the laboratory-specific quantitation limits are at or below the project action limits. For completeness, please revise the text accordingly.

Response: Noted, WS-37 has been revised.

40. Worksheet 37, Page 4. The National Functional Guidelines proposed for guiding the validation are out of date (2014). Please cite the most recent National Functional Guidelines. Currently these are from 2017. Please update the references in Section 3 accordingly. Note that the validation guidelines must be adapted to the non-CLP methods and differences between the older SW-846 methods that will be used and the current CLP methods (e.g., for both 8260C and 8270D, the lack of closing calibration standards, surrogates instead of deuterated monitoring compounds).

Response: Noted, WS-37 has been revised.

41. Worksheet 37, Page 4. Please include the full reference for the EPA New England Environmental Data Review Program Guidance and correct the title. Data validation should also be conducted in accordance with the EPA New England Environmental Data Review Supplement for Region 1: Data Review Elements and Superfund Specific Guidance/Procedures (Final #1, June 2018).

Response: Noted, WS-37 has been revised.

42. Worksheet 37, Page 4: It is not clear from the text what is MassDEP protocol and how it will be used in combination with the EPA national and EPA regional validation guidelines without resulting in conflicting validation guidance. Please clarify what is meant by MassDEP protocol and how it will be used in combination with EPA guidance.

Response: Noted, WS-37 has been revised.

43. Worksheet 37, Page 4: It is not clear why the CT RCPs (Connecticut Reasonable Confidence Protocols) should apply to the reporting limits, hold times, preservatives and QA/QC for this project, which is in Massachusetts. Please correct or explain.

Response: Noted, WS-37 has been revised.

44. Worksheet 37, Page 6: The qualifiers listed for validation do not include J+ and J- which are included in the updated National Functional Guidelines. Please update the list of qualifiers presented.

Response: Noted, WS-37 has been revised.

45. Appendix J-1: According to the text in Section 2, page 5, the laboratory QA Plans, SOPs and certifications should be included in Appendix J-1. The appendix does not include QA plans or laboratory certifications. Please provide the missing information.

Response: QA Manuals and certifications included. (GEL certifications are included in the laboratory QA Manual).

46. Appendix J-1: Although the SOPs listed on WS #23 are included in the Appendix, additional SOPs not listed on WS #23 are also included. It cannot be confirmed that all the SOPs required are included because it is not clear that WS #23 presents a complete list of the SOPs applicable to the project. Please clarify.

Response: Worksheet 23 has been updated as needed.

47. Appendix J-1, SOP GL-RAD-D-003: Pages 19 through 37 of the SOP are missing. Please include the missing information.

Response: Noted, these have been added.

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June 25, 2020

Mr. Christopher Smith
Remedial Project Manager
EPA Region 1
5 Post Office Square, Suite 100
Mail Code OSRR 07-4
Boston, MA 02109-3912

Subject: Nuclear Metals, Inc. Superfund Site, Concord, Massachusetts
Remedial Design / Remedial Action
Remedial Design Workplan - Response to Initial Comments

The purpose of this letter is to provide a response to comments to support further discussion. It is our understanding that the comments received from EPA and AECOM are the initial comments on the Remedial Design Work Plan, and more detailed comments will be forthcoming.

For easier reference, each comment received is followed by our response.

We look forward to discussing these responses with you.

Sincerely,

Bruce Thompson

Attachment – Responses to Comments

cc: Garry Waldeck, MassDEP
Settling Defendants
Mark Kelley, PE, Haley & Aldrich, Inc.
Carl Elder, PE, Geosyntec Consultants

Appendix A – Sitewide Soils and Sediments

PDI SSS-1 Soil Characterization

- Appendix should ultimately incorporate the additional figures that were provided to EPA/AECOM showing the prior sampling locations that helped to determine where additional samples are needed.
- With the newly proposed soil/sediment sampling locations, is the thought that what is proposed in this PDI will be the majority of the data that needs to be collected prior to developing excavation plans using some sort of spatial averaging technique such as thiessen polygons? Or are the points proposed viewed more as a first pass with significantly more sampling to be done prior to developing excavation boundaries.
- A general comment is that ultimately whatever is proposed for confirmatory sampling will need to consider how the data will feed into a residual risk assessment.

Response: Additional SSS PDI Figures 1-8 and 1-9 illustrate the proposed initial delineation locations superimposed, respectively, on the RI depleted uranium and PCB data. The proposed sample locations are intended to be the first pass with step-out sampling to be conducted as needed to adequately develop the lateral and vertical limits to the excavation boundaries. The data outside the established excavation limits will then be used with confirmatory sampling data to determine an exposure point concentration (EPC) for use in evaluating residual risks. Details concerning the methods for establishing EPCs and conducting the residual risk assessment will be provided in the Construction Quality Assurance/Quality Control Plan (CQA/QCP).

PDI SSS-2 DU Penetrator Investigation

- Details on how the top 6-inches of soil will be removed and handled need to be provided, whether added to Report or kept separately as an implementation plan.
- There are references to the gamma detector not being able to detect deeper than a few inches – if so, is it still appropriate to remove soil in 6” increments? Or would the ~3-6” interval not be adequately characterized. The plans also state the detector would be held no more than 4” above ground – if removing up to 6” at time, the bottom of that removed “sheet” of soil would have been up to 10” from the detector. Assume implementation plan would address this sort of question.
- Is there a maximum depth for 6-inch lifts proposed or the plan is to continue until no gamma impacts are noted?
- Has use of a portable XRF been considered for use during the PDI investigations? A review of on-line info indicates detection limits similar to that of the NAI detector (30 mg/kg) but with more specificity.

Response: Details of the DU Survey and soil handling will be prepared in an Implementation Plan. The depth of soil to be removed between scans will be refined based on instrument sensitivity; RSCS will provide details on their instrumentation operation and limitations. Soil screening will continue until no gamma impacts are noted. The use of a portable XRF was considered but that instrument could only be used to quantify uranium in soil samples (i.e., it cannot be used as ground scanning tool like a NAI detector), and since there is not a real time excavation and backfill requirement, there is time to allow for the analytical lab to turn around data for our decisions to backfill or contain the soils.

PDI SSS-3 DU Sub-Slab Investigation

- What is the rationale for the proposed depth (up to ~26 feet) of drilling in these areas, vs. other areas of soil removal where removal below 10 feet bgs is not contemplated. And will there be step out sampling on high hits in these areas extending to these greater depths?
- The concept of the investigations is to look for possible releases from former utilities and cracks in the slab within the building. However, based on construction on top of the former waste handling area, the potential also exists for subsurface contamination present that was left in place or manipulated prior to construction (up to 20 ft below current grade per RI report). Although the response to comments indicated that all borings in building E would be advanced to 20 feet, this did not occur, so there is limited information about contamination levels under the building E slab. Should this be addressed during the sub-slab investigation?
- Is there a concern that once the slab is removed and restored, the former impervious surface could now be subject to precipitation and groundwater infiltration? Should this be evaluated (i.e., consider performing SPLP analyses on high concentration sub-slab samples) or will slab removal be immediately followed by removal of contaminated soil below the slab?

Response: The initial borings proposed through the slab are intended to correspond to locations where utility penetrations and or cracks in the slab were identified during the Building NTCRA. It is unknown if there was significant vertical migration of material or if impacts are confined to the shallow soils. The deeper analysis will allow for us to determine potential migration of compounds of concern (e.g., potential source to groundwater) and to eliminate the need to chase vertical migration throughout the area beneath the slabs or only within limits of utilities and/or cracks in the slab. Up to two additional borings will be conducted within Building E footprint to supplement the one currently shown on the Figures. Updated Figures will be prepared for the revised RDWP.

The concept we expect to explore for slab and soil removal is to conduct slab removal and impacted soil remediation progressively, to avoid exposure of large areas of impacted soil to precipitation. This process would start with removal of a section of the slab cover, then removal of the corresponding slab section, then remediation of that section of soil (to the extent soil remediation is needed). The work would then move to the next section of slab and continue until the entire slab and soil remediation is completed. There may or may not be any backfill needed to achieve reasonable finished grades other than loam and seeding to mitigate for future erosion. Regardless, we will coordinate finish grading and surface treatments with the Reuse Committee. The recharge areas that the buildings cover is significant, and it may be beneficial to allow for natural recharge to occur within the Building footprints following slab and soil removal. This will be part of the groundwater plume evaluations by Geosyntec.

PDI ISS-4 Cooling Pond, Bog, and Landfill Excavation Evaluations

- What is the purpose of the geophysical/test pit excavation of the septic system? Is the removal of the septic system appurtenances required/anticipated? If the septic system and its components were not to be removed, is there another area of the property where a new system could feasibly be installed for re-use? If not, there would be concerns about asking whoever redevelops the property to deal with potentially contaminated septic system material removal.
- If sheeting is anticipated to be required for the sediment removal in the bog, characterization (soil type and thickness) of the materials underlying the peat will be required to design the sheeting requirements. How deep are the hand probes anticipated to be? Characterization of the underlying materials is also likely to be required in the slope stability modeling. Can any of the transects proposed in the Proposed Slope Stability Investigation Plan shown in Appendix C, Figure 4 be extended to collect deeper data in and beneath the bog?
- It was previously believed that the Cooling Water Pond and sediments are ‘perched’ above the groundwater table, so it’s not clear why potential recontamination of sediment is now a concern. Is the purpose of the evaluation to confirm this is the case under all hydrologic conditions? IF so, multiple rounds of measurements should be considered, because the differences in head are potentially seasonal. It should also be noted that existing sediment COCs targeted for removal (PCBs, copper) are not groundwater contaminants.
- There seems to be a limited amount of historic and proposed sampling for sediment in the cooling water pond, outside of the piezometer points proposed to be added. Should sediment samples be collected at these points to further refine the amount of removal required, or is it viewed as unnecessary because of the nature of the material in the pond (i.e., layer of “pond muck” just needs to be removed across the whole thing).

Response: We expect to remove or abandon the existing septic systems as part of the remedy. The Ground Penetrating Radar (GPR) is intended to confirm the locations of the septic system components, with some limited test pits to field truth the GPR and to collect some samples for chemical characterization of the soils underlying the leach field. In addition, the GPR and test pits will identify if drums or other debris is buried between the gabion walls north of the Cooling Water Recharge Pond (pond).

Sheeting or other temporary excavation support may be needed on the outboard side of excavations for sediment removal in the sphagnum bog to protect adjacent areas of the bog. Extensive measures would be required to provide drill rig access and protect the bog to obtain deep subsurface information during the PDI. Sediment samples from the bog will be collected during the PDI to depths possible without a rig. The Implementation Plan will provide a series of alternate methods of sediment collection.

Although strength data may not be collected, grain size distribution and correlations with other borings nearby will be made to establish appropriate data if sheeting is needed to temporarily support the sediment excavation. Additional information determined to be necessary for design of temporary excavation support would be obtained during construction when heavy equipment access is established, and protective measures are in place.

The purpose of the piezometers is to evaluate the vertical gradients from the underlying sand to the soft accumulated sediment within the cooling pond. The perched condition may not be the case as there is limited addition of water into the pond under current hydrologic conditions. The seasonal low water condition of the pond will tie into the limits of “Land Under Water” as defined in the Wetlands Protection Act, so seasonal data of groundwater measured in the piezometers and the surface water elevations will be collected and used to develop the footprint of the future pond. It is understood that PCBs and copper are not necessarily compounds associated with groundwater, but they are the drivers for the sediment removal. We expect there is an upward gradient from the underlying sand into the softer sediment within the pond. The chemistry of this underlying sand layer needs to be better understood to make sure there are not compounds of concern in groundwater that could preferentially sorb onto newly placed organic soil that may become the new sediment benthic layer of the pond.

The sampling of the existing sediment will be expanded if the depth of the soft sediment is far greater than the amount necessary to be removed based on the chemical testing data. From a constructability perspective, it is anticipated that all the soft sediment will be removed across the entire footprint and not surgically remove only a portion of the soft sediment.

PDI SSS-5 Barrow Source Eval

- No initial comments

Response: There are some existing monitoring wells that are critical to the long-term monitoring and future monitoring of the ISS by Geosyntec so the limits of potential borrow material excavation will need to be updated to reflect these well locations. The general intent of the borrow source investigations will not be changed, but actual locations of borings may be adjusted if excavation of soils is not feasible if the network of wells is needed according to Geosyntec.

Appendix B – ISS PDI

PDI ISS-1 Sitewide Groundwater Monitoring

- Are results for metals total or dissolved? Concern about increasing concentration of natural U at shallow bedrock well ML-3-3 (barcad) at a concentration of 28 ug/L, higher than historically seen and approaching clean-up criteria. Presence of 1,4-dioxane indicates site related.

Response:

Total concentrations for metals are discussed in text and presented on tables and figures. For clarity, Table 2-3 has been revised to present results for metals (total and dissolved).

Although, the November 2019 detection at ML-3-3 is the highest reported for this well and the concentration is near the MCL, concentrations have been highly variable at this well and the 2019 detection is just slightly above the historical maxima for this well (26 µg/L) reported for the sample collected on 1 September 1999.

- Plume outline and iso-concentration lines under building for DU in overburden are heavily inferred and doesn't explain the DU at MW-SD01. How will RA injection locations be determined (i.e., more accurate 30 ug/L iso-concentration outline)?

Response:

The inferred DU isoconcentration contours are based on the most recent available groundwater data from November 2019. The DU concentration at MW-SD01 has fluctuated since the RI and may represent a stringer of elevated DU that has migrated south of MW-S06. However, the U concentration at MW-SD01 has not exceeded the MCL of 30 ug/L during 15 years of monitoring; therefore, this well is outside the area where ISS injections are likely to be considered for the RA. The concentrations detected at MW-S06 and MW-SD06 further bound the U plume downgradient of the former building.

Collection of groundwater data from beneath the former building is suggested in several EPA comments, so a well couplet will be installed through the former building slap west of MW-8A. This couplet would better define the DU plume beneath the former building and determine if the DU plume may be migrating south of MW-S02 and MW-SD02 toward MW-SD01. The proposed wells are shown on attached revised Figures 2-5 and 2-6, which show, respectively, plan view and cross-section location details.

This couplet will be constructed like MW-S02 and MW-SD02 with a well screened in deep overburden and a well screened across the water table. These wells they may be helpful for the ISS pilot test in overburden as an additional monitoring couplet. However, these wells are likely to be destroyed when slabs are removed so they are unlikely to serve as long-terms wells at the site. As mentioned in the RDWP, continuing monitoring is planned at MW-S/SD02 and MW-S/SD06.

- The results of MW-SO2 are discussed, citing historical results and claiming there is a significant decline in concentrations. But a review of the historical data shows results have fluctuated widely, without a clear trend. So it appears more data will need to be collected before definitively stating concentrations have declined. Is there a conceptual reason for why the results of this well have fluctuated so widely?

Response:

Concentrations have indeed been variable over time and MW-S02/SD02 will continue to be sampled. We are unsure as to the reason for this variability except to say that there is some variability at MW-8A where, there was a significant drop in DU concentration from 2013 to 2017, which was also observed at MW-S02. As noted above, an additional well couplet beneath the building is also proposed.

- Figure 2-5 is useful for looking at historical DU concentrations in overburden wells and comparing them to current ones. Please provide a similar figure for uranium in bedrock.

Response:

In the past, a figure has been presented with the historical U concentrations in bedrock wells. Figure 2-7.1 has been updated with historical and recent bedrock data and is attached. During preparation of this figure, the November 2019 data were revisited, and we felt that it would be appropriate to expand the 70 µg/L U contour eastward in the area near GZW-10-2, MW-BS-13, and MW-BS03. Revised RDWP Figure 6b, Appendix B Figures 2-7, 3-3, and 3-4; RDWP Appendix D Figures 6, 7, and 9 incorporate this change, and are attached.

- A discussion of why uranium concentrations appear to be attenuating (i.e., biological activity) would be helpful, and if it has any implications on the remedy selection. It is notable that 1,4-D concentrations have not declined while uranium in bedrock has declined significantly.

Response:

As documented in Section 5.2.2.1 of the RI Report, it was hypothesized that solubilization of uranium bearing minerals in bedrock occurred as a result of altered bedrock groundwater geochemistry due to impacts from the Holding Basin. It may be that the decrease in U concentrations in bedrock is due to 1) removal of historical mechanisms that mobilized bedrock uranium (i.e. natural uranium in bedrock is no longer being released) and 2) dilution by non-impacted groundwater from upgradient areas.

Decreasing U concentrations and the lack of a continuing source has implications for the bedrock remedy which is why we have proposed testing short term pumping as a possible remedy. More specifically, data show that U concentrations in bedrock are attenuating (e.g., wells MW-BM03 and MW-BS03 in the centerline of the plume have shown a >50% decrease in U concentrations since 2013). Also, the maximum U concentration in bedrock is currently only about 70 ppb so another 50% reduction in U concentrations would yield bedrock groundwater near or below the MCL. Given this, we feel that it is prudent to stay openminded to a pumping approach since it may enhance effective attenuation which is ongoing and the pumping tests proposed as a PDI are needed to provide design information for ISS in bedrock.

- What is the geochemistry of overburden under slab (i.e., more anerobic than groundwater on both sides of slab)? Are there potential issues or conditions being altered once the slab is removed?

Response:

Table 2-2B provides geochemistry of MW-8A and MW-S02 which are water table wells located immediately upgradient and downgradient from the slab, respectively. These wells both have aerobic and oxidizing groundwater with DO in the 8-9 mg/L range, ORP between 100 and 200 mV. pH of water at these wells is 5.95 to 6.25. These data would indicate that groundwater beneath the slab is aerobic and oxidizing with a pH near 6. Of these wells, MW-S02 is a reflection of groundwater migrating from beneath the slab - groundwater at this well is not, geochemically, very different from water at MW-8A on the upgradient side of the slab so groundwater geochemistry does not change underneath the slab. This is not surprising given the 50-60 feet of the unsaturated zone at the site. As mentioned above, a well couplet beneath the former Building D slab is being proposed.

- Have there been shifts in groundwater flows due to differences in recharge from precipitation since the building was removed and roof drains are no longer directed to the cooling water pond?

Response:

Although the buildings have been removed, the foundation slabs remain in place and an impermeable rubber membrane was installed on top of the slabs. The roof drains, which formerly discharged to the Cooling Pond, have been sealed and the precipitation runs off the slab as sheet flow and infiltrates into the surrounding ground surface, with no preferential direction to the flow. Although, the water levels in the Cooling Pond have been lower (de maximis, personal communication and 19 May 2020 Site visit), the groundwater flow direction and gradients in overburden inferred from the November 2019 data are generally similar to those reported in the RI report.

- Section 2.4.3 references VOCs detected above the cleanup level. What is the plan to meet cleanup levels for these VOCs – continue with 1,4-d extraction approach and hope for attenuation?

Response:

VOCs above clean-up levels exist but are smaller in their distribution and exceedance level compared to 1,4-dioxane. So, like the approach used for the NTCRA, treatment for VOCs is combined with treatment for more widely-distributed 1,4-dioxane with an understanding that capturing 1,4-dioxane will also capture VOCs (and knowing that the advanced oxidation treatment approach used for 1,4-dioxane destruction will also treat VOCs).

The highest VOCs are detected in three wells located upgradient of the Holding Basin HB-10, HB-10S, and HB-11 where PCE ranged from 7.7 to 42 µg/L. In the same three wells TCE ranged from 1.7 to 10 µg/L. TCE was also detected at 7.8 µg/L in a sample collected from MW-T10. Historically, the PCE concentration at HB-10 ranged from 25.5 to 73.1 µg/L with the maximum detected in 2011. At HB-10S, the November 2019 detection of 42 µg/L is the second highest detected compared to 60 µg/L 2005, and at HB-11 the November 2019 detection (7.7 µg/L) is the lowest detection compared to historical results of 8.1 and 22 µg/L detected in 2005. At MW-T10, the November 2019 TCE detection falls within the historical range of between 0.82 µg/L 2005 to 10.1 µg/L in 2013. TCE detections at wells HB-10, HB-10S and HB-11 have historically been below 3 µg/L. In general, VOC concentrations are within 10-fold of the MCL; in comparison, 1,4-dioxane concentrations are several orders of magnitude above the MCL.

Although, PCE and TCE concentrations in some wells exceed the Vapor intrusion Screening Levels (VISL), the depth to water in the wells near the Holding Basin exceeds 30 feet, and at wells MW-T10 and MW-S17 the depth to impacted groundwater is deeper than approximately 55 feet, therefore vapor intrusion does not appear to be a concern. Further, groundwater in the vicinity of higher PCE/TCE concentrations (i.e., near wells HB-10/10S/11) will be encapsulated by the vertical wall and cap as proposed in RDWP - Appendix C Holding Basin Containment.

- Section 2.4.5.1 references other metals detected above the cleanup level. What is the plan to meet cleanup levels for these metals?

Response:

In bedrock, these metals will be removed with uranium as a result of pumping at the proposed bedrock extraction wells. In overburden, treatability studies include analysis for metals to evaluate whether these are sequestered by Apatite II.

PDI ISS-2 Pumping and Rebound for Uranium

- Has the timeframe for evaluating potential rebound been considered? Concerns that what may be a reasonable rebound monitoring period may be too long in terms of coordinating future injections with any other ongoing site work?

Response:

Uranium in bedrock has attenuated since the RI/FS as noted above. Also, the amount of mass representing the U plume in bedrock is very small. The concept of pumping as a pre-design test is to explore if we can pump groundwater (and U from bedrock) – this will also provide an indication about whether it is feasible to pump ISS amendments into bedrock. Thus, pumping from bedrock is an analog to testing the implementability of ISS in bedrock and may have the added benefit of removing enough mass to show that U concentrations can decrease to MCLs reasonably quickly via attenuation. Therefore, there is ISS information to be gained from pumping plus a potential to see if pumping bedrock can be a more straightforward means for achieving project goals.

The timeframe for evaluating potential rebound has been considered, however, we have concluded that we cannot fully evaluate this until we have pumping data. When we have results for bedrock yields and contaminant concentrations over the time of pumping, we will communicate with the project team to discuss the viability of a pumping alternative, and if needed, a schedule and methods for injection testing will be proposed.

- A general note is that reaching the threshold to determine “yes pumping was effective we don’t need in-situ treatment” may be difficult to define. For example, would need to agree on rebound monitoring period. Also, if an area of bedrock shows a concentration of uranium in the high 20 mg/l range, at what point do we say it is sufficient even though the ROD called for in-situ treatment which would theoretically provide more long term certainty about the effectiveness of the remediation. Thinking about this in the context of forgoing the in-situ bedrock treatment requiring an ESD or ROD amendment—may be a difficult bar to get over.

Response:

As described in comments above, U in bedrock is attenuating and this is expected to continue. Pumping is proposed as a means to test a key component the implementability of an ISS remedy for BR (i.e., the ability to deliver amendments into bedrock) while also removing mass and potentially identifying an alternative approach which achieves project goals more straightforwardly (i.e., pumping or pumping with natural attenuation).

However, we agree that the threshold at which it could be determined whether pumping is effective or not would be difficult to define. As stated above, when we have results for bedrock yields and contaminant concentrations over the time of pumping and after pumping, we will communicate with the project team to discuss the viability of a pumping alternative, and if needed, a schedule and methods for injection testing will be proposed.

- Is there concern about the potential for open boreholes to spread contamination in bedrock?

Response:

Although there is a potential for open borehole flow to spread contamination in bedrock, the vertical hydraulic gradients within bedrock inferred from November 2019 data for well pairs MW-BS03/BM03 and MW-BS15/BM15 indicate upward gradients at these locations located along the centerline of the uranium and 1,4-dioxane plumes. This indicates that there is a low risk of spreading contamination to deeper bedrock.

Open boreholes are recommended to have wells which produce enough yield. The investigation program also includes testing to determine where water bearing fractures are along the borehole. If strong downward gradient are observed in BR wells, then we may propose individual sealed well screens within the borehole or even a solid FLUTe™liner.

PDI ISS-3 Pilot Test in Overburden

- Should injections into till be considered as it is possible source of back diffusion?

Response:

ISS injections are not planned for till because the till is not believed to be a significant source zone or migration pathway for DU. Concentrations of DU in monitoring wells screened in till in the pilot test area are significantly lower than in sand (e.g., 59.8 ug/L in MW-T24 versus 2,675 ug/L in MW-S24). Given the relatively low hydraulic conductivity of the till and how thin till is, ISS treatment is targeted toward the stratified drift units where the majority of DU mass is located and U mass flux is occurring; overburden ISS includes injections into the deep overburden which will sequester U potentially migrating up from till.

- Ultimately, is the vision that the ROI for all injection points would overlap in the area of the overburden where the MCL is exceeded? Or is the idea that some of the overburden with levels exceeding the DU MCL would be left to “flow through” reactive zones and ultimately be treated. Given how long it took DU in overburden to spread across the property, what sort of timeframe would this look like?

Response:

It is likely that treatment of groundwater flowing through the reactive zones will result in decreased DU concentrations downgradient of the reactive zones, and the timeframe for treatment downgradient of the reactive zones will be assessed as part of the pilot test. In each of the two pilot test areas, the performance monitoring well network includes monitoring wells within the injection ROIs and downgradient from the injection ROIs. Spacing of injection points, the degree of ROI overlap and the expected timeframe to achieve the MCL will part of full-scale design and based on DU concentration trends in pilot test monitoring wells along with estimated seepage velocities from hydraulic conductivity and recently hydraulic gradient data (as well as results from tracers injected during the ISS pilot test).

- What about testing injection into the holding basin? Does not appear to be proposed under this PDI or as part of the holding basin PDI. Sufficiently different material it may require its own testing, have significantly different ROI, etc? What about sequencing injections in the HB vs. constructing the containment wall?

Response:

There is significant risk to the liner as well as human health when working in/through the holding basin. Soils from beneath the holding basin will be collected and tested in the laboratory as described in Appendix E of the RDWP, but field pilot testing is not planned for the holding basin. Results of the ISS pilot testing performed immediately outside of the holding basin will be used to design ISS for saturated soils beneath the holding basin. Since the formation is the same beneath and immediately outside the holding basin, and all the sludge emplaced in the Holding Basin has been removed, we do not recommend incurring the risks and logistical challenges associated with working inside the holding basin when the injectability of ISS amendments into the aquifer can be equivalently tested using pilot-scale injection outside of the holding basin.

ISS Injections will likely be performed before constructing the containment wall to avoid having ISS injections potential damage the wall.

- Pilot test 1 assumes a ‘granular’ reagent and pilot test 2 assumes a ‘soluble’ reagent. Shouldn’t the reagent type for each area be determined by the results of the treatability studies?

Response:

As described in Section 4.3.1 of Appendix B, the reagent(s) for the ISS pilot tests will be selected based on the results of the treatability study (Appendix E). The ISS injection approach presented in the RDWP was developed to provide EPA with a pilot test design for each type of potential reagent (solid versus liquid). If reagents identified by treatability studies warrant a change in the injection approach, then these testing programs will be updated/modified prior to implementation.

PDI ISS-3 Pilot Test in Overburden

- No initial comments/questions

Appendix C – HB PDI

PDI-HB-1 Bedrock and Soil Characterization For Containment Wall Design

- Is there a concern of spreading contamination with the bedrock borings?
- The plan acknowledges portions of the pumphouse infrastructure may need to be removed, but what is the ultimate plan for the pumphouse foundation itself?
- The PDI appears to assume a Hydromill will be used to install the containment wall. Are any other technologies under consideration, and if so, will the boring program provide the necessary data?
- Is the bedrock data proposed to be collected also sufficient for any possible bedrock grouting that would be required to encapsulate the HB material?

Response: The borings proposed are all intended to be advanced with casing and using a drive and wash drilling method above the bedrock. This method will limit the potential to dragging contaminants downward during the drilling process. The rock core will be conducted through the cased hole, and the observation wells or CMTs will be grouted or installed with bentonite to isolate zones and to minimize the migration of contaminants from one lithology to another.

Based on our review of existing foundation details of the pump house and the alignment of the proposed containment wall, it is expected that much of the existing pump house foundation can remain as the wall will contain the majority of the pump house. A shallow portion of the pump house building slab will be removed for the construction of the containment wall. Test pits are proposed on the north and south sides of the pump house to confirm the design drawings are accurate and that our proposed limited foundation removal is feasible and appropriate.

The PDI assumes that a hydromill will be used to construct the portion of the wall below bedrock as necessary. It is likely that a clam shell bucket will be used under slurry to excavate the portion of the containment wall above bedrock. It may be more efficient to switch over the tooling from clam shell to hydromill at the top of glacial till, as the till is expected to be very dense with cobbles and boulders that are difficult to excavate with a clam shell. The proposed borings and soil samples being collected are suitable for other construction methods including secant piles or even grouting of discontinuities encountered in the bedrock.

PDI-HB-2 Seismic Evaluation

- No initial comments, might benefit from some sort of presentation on this given the uniqueness.

PDI-HB-3 Bench Scale Testing of Wall Mix Designs

- This section would benefit from additional discussion of why these specific mixes were selected. Are alternative pozzolanic materials and mixtures being considered?

Response: The mix designs will be developed as part of the PDI. A total of five will be developed that meet the strength and hydraulic conductivity parameters to be determined during this data collection phase. It is anticipated that one alternative admixture to the mix design is Xypex that would reduce the hydraulic conductivity of the concrete significantly.

PDI-HB-4 Characterization of Soils for Cover Design and Slope Stability

- *No initial comments/questions*

PDI-HB-5 Seepage Analysis for Containment Wall Design

- General question – how much effort is it worth spending to determine if containment wall can be advanced only to till vs. bedrock, considering how much of a problem it would be if evaluation determined only till was necessary but it did turn out to be a pathway. Could the design recover from that?

Response: The level of effort to evaluate the containment wall embedment into glacial till is minor once the model is set up. The design is to be a robust design that looks at the containment wall as an effective cutoff to existing and future groundwater flow pathways. The glacial till may be too thin to provide an effective cutoff so depending on the subsurface conditions the evaluation of the wall embedded into the till may be eliminated from the analysis. In the event till is at least 10 ft. think across the entire wall footprint then the seepage will be evaluated with the toe embedment of the wall within the till strata.

Appendix D – 1,4-D and VOCs in GW

- Two of the proposed open bedrock wells for uranium (BEW-1, BEW2) are not proposed for 1,4-dioxane rebound testing. What is the rationale, given that the 1,4-dioxane exceeds the MCL at both locations? Data viewed as unnecessary? To avoid managing uranium contaminated GW?

Response:

Wells proposed for both 1,4-dioxane and uranium rebound testing are focused on determining whether pumping can effectively reduce contaminant mass in the bedrock formation. Samples collected during pumping of BEW-1 and BEW-2 will also be analyzed for 1,4-dioxane."

- Is there a need to determine if there is a source or to define the impacts upgradient of MW-BS7-2? This well shows a relatively high concentration and there are no nearby bedrock wells with lower concentrations. Figure 2-7 of appendix B showing the 1,4-dioxane plume indicates the iso-concentration line for the cleanup criteria of 0.46 ug/L has not been defined north and east of this single well.

Response:

MW-BS7-2 is located immediately downgradient of the holding basin which is a source of contamination at the site, so while an upgradient well would be prudent at most site, such a well is not necessary for NMI since the holding basin can be presumed as the source. Also, a well upgradient of MW-BS7-2 would need to be installed through the HB which poses high risk.

Given that the 1,4-dioxane remedy is being design for physical containment within the holding basin and hydraulic containment downgradient, knowing 1,4-dioxane concentrations upgradient of MW-BS7-2 would not change the remedy. Therefore, we do not recommend installing a well which would be a high-risk event when the resulting information would not change the conceptual remedy. If H&A wells around the HB can provide groundwater samples, then these may be analyzed for 1,4-dioxane, but again, the data would not change the pumping design for 1,4-dioxane.

Appendix E – Treatability Study

- General: Has Sandia National Laboratory's hydroxyapatite barrier approach been considered for pilot study testing? An apatite barrier is formed in situ in soil by injection of chelated calcium and phosphate solutions which combine following microbial degradation of the calcium citrate to precipitate hydroxyapatite. It has been demonstrated to be particularly successful in sequestering uranium. IT is a patented technology but may be worth considering.

Response:

This is a good question that deserves a little background. As part of the RI, we had discussions with scientists from the Pacific Northwest National Laboratory – PNNL, located at the Hanford Site. PNNL used a soluble phosphate and calcium amendment to form apatite in-situ. We sent them our data and after reviewing our hydrogeologic regime and groundwater geochemistry, their recommendation was to use solid apatite if it could be injected directly and not rely on a liquid amendment that needs to have an in-situ reaction occur as a precursor to the sequestration reaction. In fact, it was the recommendation of Dr. Dawn Wellman, Division Director at PNNL, that led us to investigate the use of Apatite II from PIMS. Based on conversation with PNNL, we did not consider trying to form apatite in-situ and did not evaluate the chemistry of the reaction with conditions at NMI. So, while the Sandia approach could be feasible at NMI it requires biological and chemical reactions to occur in-situ to form apatite as a precursor to the sequestration reaction of U to apatite. A simpler and more reliable approach is to inject apatite directly as suggested by scientists at PNNL.

We are happy to discuss alternatives after results of the treatability testing are known.

- Why is STPP proposed for bedrock only, why is SMP propose for overburden only?

Response:

The use of STPP for BR and SMP for overburden is based on solubility and reaction timing and hence the ability to distribute the amendments into BR versus overburden. The table on page 2 of Appendix E describes these properties and why each chemical was selected, but in summary STPP is selected for BR because it is more soluble and slower to react so it may better distribute in BR where permeability is lower. In overburden, permeability is higher so distribution should be less challenging and therefore SMP is preferred.

TS-ISS-1 Holding Basin Soils

- The well proposed for low uranium concentration appears to have much lower native metals concentration than typically seen in other wells. Is this considered representative of groundwater in contaminated areas? Another well to consider would be MW-SD01, which appears more similar in composition and has DU of 8 ug/L.

Response:

We understand your concern and are consider alternative wells for low concentration groundwater. We are looking at groundwater geochemistry at several wells to pick this source.

- Does it make sense to evenly mix the amendments in the column? When in reality injections would not result in even mixture across the HB area?

Response:

We are not trying to model an individual fracture in the columns. Rather, we are modeling groundwater flowing through the bulk aquifer with apatite emplaced. As such, the columns will model the average apatite mix as a percent of aquifer materials.

If the goal of the treatability testing was to model a fracture, we cannot do it in a 3-inch column because lenses are horizontal and discontinuous, and lenses will work within the aquifer as a system. If we wanted to attempt to model this, we'd have to create a large "sand box" model to represent the discontinuous lenses within an aquifer. Creating this type of a physical model is infeasible due to cost and challenges related to accurately representing the aquifer (e.g., depositional layering). Instead, column tests are designed to look at bulk treatment for a percent apatite in soil, and then pilot tests are performed to assess in-situ performance.

- When running the column test in the different influent redox scenarios across the 4 weeks, how do you account for uranium not just having been flushed out during the earlier parts of the column test? Can you accurately compare effluent concentrations in week one to week four, or is it more just to see if there is remobilization, and the exact concentrations aren't important because it is relative?

Response:

The changing redox is to look at remobilization (e.g., will there be an increase in U concentration in effluent after changing redox of influent).

- Is there a threshold for results which would indicate that neither the apatite or ZVI appear to have worked adequately?

Response:

Ideally, we will achieve U under 30 ppb, but this is not necessarily needed in the treatability study. The treatability study looks at percent U reduction for what we feel is an achievable amount of apatite that can be emplaced. This percent reduction for a treatment zone determined in treatability testing will be extrapolated to site needs as part of design to determine extent/amount of treatment zones.

TS-ISS-2 Overburden Groundwater

- Again, does it make sense to evenly mix the amendments in the column tests, or can a ISRZ from an injection be more closely simulated.

Response:

A 3-inch column is too small to model physical characteristics of amendment distribution and the aquifer. Columns are intended to represent the treatment area as a whole and not an individual lens.

- Why are the amendments proposed to be tested only with the most highly contaminated groundwater? Would it not make sense to also test groundwater contaminated at levels closer to the MCL to see if adequate treatment is still achieved?

Response:

ISS is not like a biological reaction where certain mass is needed to support a reaction. As a chemical reaction, ISS is more akin to a GAC system where if treatment achieves goals at higher concentrations it is very likely to work at lower concentration. Nevertheless, field pilot testing is designed to be implemented in higher and lower concentration areas of the overburden U plume to confirm the effectiveness of the technology throughout the overburden plume.

TS-ISS-3 Bedrock Groundwater

- Any ability / opportunity to test bedrock that is collected for potential back diffusion of uranium prior to going through rest of the batch/column protocol?

Response:

The site was impacted decades ago and there is clear evidence of decreasing U concentrations in BR (see also response to prior comment about the mechanisms causing attenuation of U in bedrock). We don't feel that a laboratory back diffusion experiment, which artificially extracts U, would be more insightful regarding attenuation of U at the site than the ongoing record of GW data. Based on groundwater data from the bedrock U plume, we also don't think a release of U from back diffusion is likely.

- Again, is there value in testing less highly contaminated bedrock groundwater closer to the MCL?

Response:

Highly contaminated is a relative term. The highest contaminated BR groundwater is 70 ppb (~2x the MCL). Given the nature of sequestration (i.e., similar to sorption with GAC), if it is effective for groundwater with U closer to 70 ppb then it is very likely to be effective for groundwater >30 ppb.

<u>Appendix J – QAPP</u>

- Worksheets 35 and 36 are listed in the table of contents but not provided in the QAPP, please forward.
- The text states Appendix J-1 is available on the portal, but it does not appear to be.

*no comments/questions on other appendices for the time being.

Response:

The requested worksheets and appendix were provided through Project Portal.

Figure 1-8

Pre-Remedial
Design Investigation

Sitewide
Total Uranium
Maximum Concentration

Nuclear Metals, Inc.
Concord, Massachusetts

URANIUM DATA POINTS RELATIVE TO ROD CLEAN-UP CRITERIA REPRESENT MAXIMUM RESULT AT THAT LOCATION

Map Legend:

- ▢ Areas of Investigation (AOI)
- ⊠ ROD Excavation Boundary
- ▢ Site Boundary

Soil ROD Cleanup Criteria (2.7 mg/kg)

- ■ > 10x
- ■ > 5x
- ■ > 2x
- ■ > 1x
- ■ < Cleanup Level
- ■ ND

Sediment Cleanup Level (2.7 mg/kg)

- ▲ > 10x
- ▲ > 5x
- ▲ > 2x
- ▲ > 1x
- ▲ < Cleanup Level
- ▲ ND
- ◆ PCB Sampling Location
- ◆ U Sampling Location

Spatial Projection:

N

Coordinate System:
MA State Plane Mainland
FIPS Zone: 2001
Units: US Survey Feet
Datum: NAD83

Plot Info:

Project No.: 3243
Plot Date: 6/12/2020
Arc Operator: LDS
Reviewed by: KS/EC

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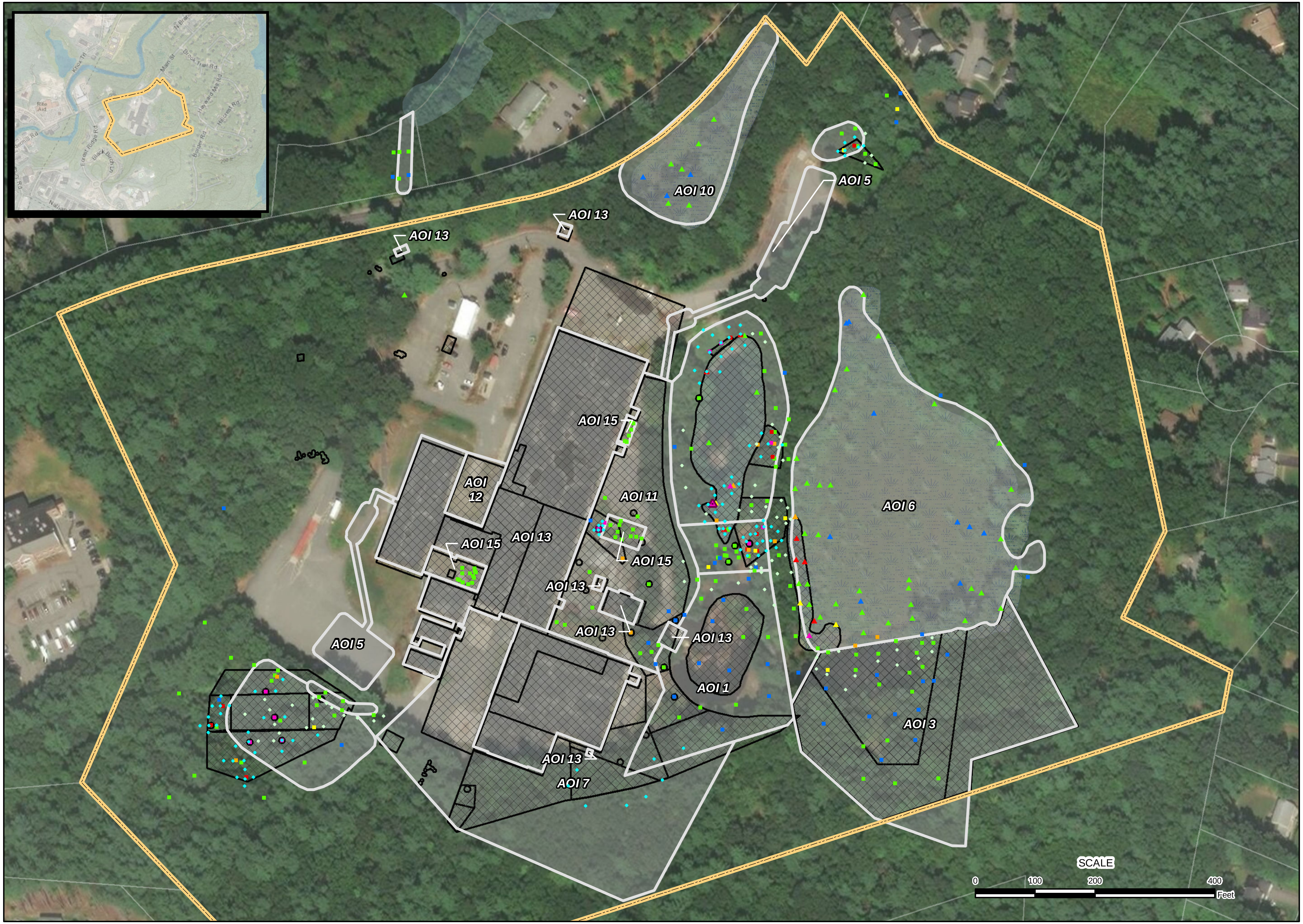

Figure 1-9

Pre-Remedial Design Investigation

Sitewide
Total PCBs
Maximum Concentration

Nuclear Metals, Inc.
Concord, Massachusetts

PCBs DATA POINTS RELATIVE TO ROD CLEAN-UP CRITERIA REPRESENT MAXIMUM RESULT AT THAT LOCATION

Map Legend:

- ▢ Areas of Investigation (AOI)
- ⊠ ROD Excavation Boundary
- ▢ Site Boundary

Soil ROD Clean Up Criteria (1.0 mg/kg)

- ■ > 50x (TCSA Cleanup Criteria)
- ■ > 10x
- ■ > 5x
- ■ > 2x
- ■ > 1x
- ■ < Cleanup Level
- ■ ND

Sediment ROD Clean Up Criteria (1.0 mg/kg)

- ▲ > 50x (TCSA Cleanup Criteria)
- ▲ > 10x
- ▲ > 5x
- ▲ > 2x
- ▲ > 1x
- ▲ < Cleanup Level
- ▲ ND
- ◆ PCB Sampling Location
- ◆ U Sampling Location

Spatial Projection:

N

Coordinate System:
MA State Plane Mainland
FIPS Zone: 2001
Units: US Survey Feet
Datum: NAD83

Plot Info:

Project No.: 3243
Plot Date: 6/12/2020
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Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	ASSABET-1A		ASSABET-1A (dup)		ASSABET-1A		ASSABET-1A (dup)		ASSABET-2A		ASSABET-2A		GZW-10-2		GZW-10-2	
			Sample Date	11/18/2019		11/18/2019		11/18/2019		11/18/2019		11/18/2019		11/18/2019		11/15/2019		11/15/2019	
			Fraction	D		D		T		T		D		T		D		T	
			Formation													Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	**26.9**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	**2.49**	J	**3.01**	
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**2.53**	J	**2.91**	J
Barium	7440-39-3	2000	ug/l	**59.2**		**57.3**		**59.4**		**58.1**		**44.2**		**43.2**		**11.1**		**15.6**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**36800**		**35900**		**37300**		**36100**		**29000**		**27800**		**102000**		**106000**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	**3.34**	J	**6.85**	J
Cobalt	7440-48-4	6.0	ug/l	**2.08**		**2.01**		**2.03**		**1.97**		**3.94**		**3.79**		**0.526**	J	**2.28**	
Copper	7440-50-8	1300	ug/l	**19.1**		**18.6**		**19**		**19.4**		**1320**	J	**660**	J	**0.684**	J	**1.07**	J
Iron	7439-89-6	14000	ug/l	**325**		**304**		**372**		**328**		**249**		**434**		< 33.0	U	**61**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**3.66**		**7.46**		< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**8660**		**8340**		**8680**		**8450**		**7690**		**7330**		**36300**		**37100**	
Manganese	7439-96-5	300	ug/l	**689**		**655**		**686**		**670**		**101**		**98.5**		**282**		**643**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	**6.71**		**7**	
Nickel	7440-02-0		ug/l	**11.4**		**11.2**		**11.6**		**11.2**		**3.59**		**3.35**		**3.27**		**5.53**	
Potassium	7440-09-7		ug/l	**5120**		**4910**		**5120**		**5030**		**5190**		**5070**		**6110**		**6200**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**83200**		**80400**		**83400**		**82100**		**68100**		**64600**		**36200**	J	**36800**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	**0.492**		**0.511**	
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	**67.7**		**70.6**	
Calc U-235/U-238			ug/l													**0.0072674**		**0.0072380**	
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	**13.5**	J	**12.7**	J	**14.6**	J	**14.8**	J	**42**	J	**20.5**	J	**37.2**		**62.2**	

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	GZW-11-2		GZW-11-2		GZW-7-2		GZW-7-2		GZW-8-2		GZW-8-2		ML-1-3		ML-1-3	
			Sample Date	11/14/2019		11/14/2019		11/18/2019		11/18/2019		11/19/2019		11/19/2019		11/15/2019		11/15/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	30	J	275		1160		2070		1910		2520		3110	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	7.12		7.55		4.02	J	5.84		4.33	J	4.47	J	6.27		6.37	
Barium	7440-39-3	2000	ug/l	11.5		12.6		58.2		77.2		50.9		49.2		16.2		19.5	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	0.287	J	0.229	J	0.246	J	0.335	J
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	23500		23300		92700		92400		25900		24700		37000		36900	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	4.63	J	< 3.00	U	3.33	J	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	0.728	J	2.27		3.06		3.07		0.37	J	0.516	J
Copper	7440-50-8	1300	ug/l	2.78	NJ	< 0.300	UJ	3.89		15.4		10.1		10.5		3.13		7.5	
Iron	7439-89-6	14000	ug/l	38.7	J	120		682		3430		3650		4440		1600		2330	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	1.45	J	7.74		4.01		3.58		4.94		6.56	
Magnesium	7439-95-4		ug/l	9990		10100		22200		23600		10800		10700		7520		7680	
Manganese	7439-96-5	300	ug/l	57.6		81.4		402		552		686		922		108		125	
Molybdenum	7439-98-7	100	ug/l	10		10		44.1	J	34.2	J	< 1.12	U	< 1.34	U	4.22		4.32	
Nickel	7440-02-0		ug/l	< 0.600	U	< 0.600	U	1.83	J	4.96		5.36		3.87		2.16		2.95	
Potassium	7440-09-7		ug/l	3330		3350		6530		7030		6700	J	5990	J	4900		4870	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	13200		13100		105000		106000		44600	J	39900	J	8130	J	8060	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	0.831	J	< 2.00	U	< 2.00	U	4.15		5.3	
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	0.314		0.334		0.0171	J	< 0.010	U	0.0747		0.0766	
Uranium-238	7440-61-2	30	ug/l	0.71		0.759		44.2		46.9		2.03		0.704		10.3		9.59	
Calc U-235/U-238			ug/l					0.0071041		0.0071215		0.0084236				0.0072524		0.0079875	
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	9.03	J	5.96	J	6.24	J	5.09	J	6.02	J
Zinc	7440-66-6		ug/l	3.41	J	3.85	J	4.97	J	23		85.4		127		< 20.0	U	< 20.0	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	ML-3-3		ML-3-3		MW-BM03		MW-BM03		MW-BM15		MW-BM15		MW-BS01		MW-BS01	
			Sample Date	11/19/2019		11/19/2019		11/15/2019		11/15/2019		11/19/2019		11/19/2019		11/12/2019		11/12/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**2790**	J	**758**	J	< 19.3	U	**71.4**		< 19.3	U	**34**	J	**218**	J	**144**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**6.13**		**6.28**		< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**13**		**21.2**		**583**		**608**		**3.44**	J	**3.5**	J	< 9.59	U	**9.39**	
Barium	7440-39-3	2000	ug/l	**27.6**	J	**22.9**	J	**112**		**118**		**73.4**		**75.1**		**22.8**		**21.4**	
Beryllium	7440-41-7		ug/l	**0.286**	J	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**12400**		**14800**		**77000**		**84300**		**42900**		**42900**		**33300**	J	**29900**	J
Chromium	7440-47-3	100	ug/l	**5.56**	J	< 3.00	U	< 3.00	U	**11.4**		< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	**2.75**		**2.86**		**3.26**		**4.03**		< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**1.2**	J	**4.02**		**0.616**	J	**4.92**		< 0.300	U	**0.313**	J	**0.362**	J	< 0.300	U
Iron	7439-89-6	14000	ug/l	**1750**	J	**659**	J	**1130**		**1280**		**2010**		**2120**		< 33.0	UJ	< 33.0	UJ
Lead	7439-92-1		ug/l	**4.65**		**1.59**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**3470**		**3710**		**25200**		**26200**		**17600**		**17600**		**10200**		**9340**	
Manganese	7439-96-5	300	ug/l	**97.9**		**140**		**290**		**298**		**170**		**170**		**42.2**	J	**37.2**	J
Molybdenum	7439-98-7	100	ug/l	**14.9**		**69.9**		**14.1**		**14.3**		< 2.96	U	< 2.93	U	**8.09**		**7.35**	
Nickel	7440-02-0		ug/l	**3.27**		**2.25**		**4.9**		**5.85**		**0.991**	J	**1.26**	J	< 0.600	U	< 0.600	U
Potassium	7440-09-7		ug/l	**4950**	J	**3560**	J	**8520**		**8570**		**5150**		**5170**		**6490**		**6220**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**68100**		**150000**		**47600**		**49600**		**26600**		**26600**		**24600**		**24500**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	**5.38**	NJ	< 0.700	UJ	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.0555**	J	**0.207**		**0.315**		**0.33**		< 0.010	U	< 0.010	U	**0.0419**	J	**0.0396**	J
Uranium-238	7440-61-2	30	ug/l	**7.69**		**28.1**		**43.2**		**45**		< 0.067	U	< 0.067	U	**5.68**		**5.45**	
Calc U-235/U-238			ug/l	**0.0072172**		**0.0073665**		**0.0072917**		**0.0073333**						**0.0073768**		**0.0072661**	
Vanadium	7440-62-2		ug/l	**7.38**	J	**3.48**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 20.0	U	< 3.30	U
Zinc	7440-66-6		ug/l	**63.1**	J	**26.2**	J	< 3.30	U	**3.74**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS02		MW-BS02		MW-BS03		MW-BS03		MW-BS04		MW-BS04		MW-BS10		MW-BS10	
			Sample Date	11/12/2019		11/12/2019		11/15/2019		11/15/2019		11/13/2019		11/13/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**40.3**	J	**82.8**		< 19.3	U	**240**		< 19.3	U	**32.2**	J	< 19.3	U	**70.7**	
Antimony	7440-36-0		ug/l	**3.91**		**3.76**		**1.07**	J	**1.26**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**27**		**26.3**		**89.3**		**89.2**		**3.24**	J	**5.04**		**2.99**	J	**3.16**	J
Barium	7440-39-3	2000	ug/l	**8.7**		**9.21**		**61.8**		**65**		**12.2**		**13.3**		**5.83**		**6.83**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**22400**		**21400**		**54300**		**54300**		**15400**		**16000**		**15800**		**15700**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	**6.72**		**7.18**		< 0.300	U	**0.607**	J	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**0.634**	J	**2.44**		< 0.300	U	**2.36**		**0.712**	J	**2.1**		**0.331**	J	< 2.00	U
Iron	7439-89-6	14000	ug/l	**105**		**290**		**2610**		**3290**		**986**		**14600**		**102**		**239**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**1.83**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**11100**	J	**9950**	J	**19800**		**20500**		**5460**		**5710**		**5920**		**5950**	
Manganese	7439-96-5	300	ug/l	**122**		**120**		**978**		**992**		**275**		**497**		**328**		**344**	
Molybdenum	7439-98-7	100	ug/l	**3.26**		**5.58**		**3.08**	J	**2.7**	J	**3.99**		**4.55**		**19.1**		**18.8**	
Nickel	7440-02-0		ug/l	**10.5**		**11**		**12.4**		**13.1**		< 0.600	U	**7.56**		< 0.600	U	< 0.600	U
Potassium	7440-09-7		ug/l	**11700**	J	**10200**	J	**5750**		**6000**		**2110**		**2140**		**2500**		**2520**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	**0.52**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**43800**		**41600**		**34400**		**34200**		**9180**		**9330**		**13300**		**13400**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.154**		**0.187**		**0.493**		**0.502**		< 0.010	U	< 0.010	U	**0.224**		**0.226**	
Uranium-238	7440-61-2	30	ug/l	**21.3**		**25.8**		**66.1**		**69.1**		< 0.067	U	**0.215**		**30.6**		**31.3**	
Calc U-235/U-238			ug/l	**0.0072300**		**0.0072481**		**0.0074584**		**0.0072648**						**0.0073203**		**0.0072204**	
Vanadium	7440-62-2		ug/l	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	**9.57**	J	**13.7**	J	< 3.30	U	**5.58**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS12		MW-BS12		MW-BS13		MW-BS13		MW-BS14		MW-BS14		MW-BS15		MW-BS15	
			Sample Date	11/15/2019		11/15/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/18/2019		11/18/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**1980**		**2240**		**109**		**536**		**33.6**	J	**22.1**	J	< 19.3	U	**22**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**4.33**		**1.3**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**49.6**		**54**		< 2.00	U	**2.48**	J	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**32**		**37**		**37.2**		**54.7**		**48.5**		**45.6**		**23.8**		**25.8**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**27900**		**29900**		**76500**		**91700**		**8320**		**9230**		**106000**		**119000**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	**5.38**	J	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**0.582**	J	**0.626**	J	**10.7**		**17.4**	
Copper	7440-50-8	1300	ug/l	**1.06**	J	**1.67**	J	**0.909**	J	**2.27**		**0.503**	J	< 2.00	U	**1.1**	J	**1.72**	J
Iron	7439-89-6	14000	ug/l	< 33.0	U	**92.4**	J	**150**		**611**		< 33.0	U	< 33.0	U	**124**		**211**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	**0.807**	J	**3.69**		< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**64.3**		**73.3**		**23400**		**24500**		**3070**		**2940**		**34000**		**36400**	
Manganese	7439-96-5	300	ug/l	< 1.00	U	**6.34**		**83**		**112**		**6.29**		**10.5**		**533**		**735**	
Molybdenum	7439-98-7	100	ug/l	**9.16**		**9.69**		**2.75**		**2.84**		**17.1**		**16.2**		**5.71**		**5.75**	
Nickel	7440-02-0		ug/l	**0.839**	J	**1.07**	J	**1.78**	J	**3.55**		**2.75**		**2.68**		**5.39**		**6.74**	
Potassium	7440-09-7		ug/l	**5570**		**6000**		**28400**		**27900**		**45700**		**41900**		**14700**		**15500**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**17400**		**18700**		**47500**		**49000**		**45900**		**46300**		**81300**		**91200**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.0452**	J	**0.0466**	J	**0.423**		**0.485**		< 0.010	U	< 0.010	U	**0.0391**	J	**0.0419**	J
Uranium-238	7440-61-2	30	ug/l	**6.28**		**6.38**		**56.6**		**64.8**		**0.102**	J	< 0.200	U	**5.36**		**5.84**	
Calc U-235/U-238			ug/l	**0.0071975**		**0.0073041**		**0.0074735**		**0.0074846**						**0.0072948**		**0.0071747**	
Vanadium	7440-62-2		ug/l	**32.1**		**34.6**		< 3.30	U	**3.66**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	**9.36**	J	**16.9**	J	**64.9**		< 3.30	U	< 3.30	U	**6.49**	J	**9.24**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS17		MW-BS17		MW-BS21		MW-BS21		MW-BS22		MW-BS22		MW-BS25		MW-BS25 (dup)	
			Sample Date	11/11/2019		11/11/2019		11/15/2019		11/15/2019		11/13/2019		11/13/2019		11/15/2019		11/15/2019	
			Fraction	D		T		D		T		D		T		D		D	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**46.1**	J	**94.5**		< 19.3	U	**710**		**22.1**	J	**29.2**	J	**839**		**893**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**3.03**	J	**3.9**	J	**2.77**	J	**2.87**	J	**3.28**	J	**2.98**	J	**2.43**	J	**2.59**	J
Barium	7440-39-3	2000	ug/l	**22.6**		**23.4**		**49**		**53**		**24.5**		**23.7**		**542**	J	**525**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**24500**		**23200**		**44300**		**45200**		**50500**		**49800**		**289000**		**280000**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**0.856**	J	**0.895**	J	< 0.300	U	**0.363**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**0.398**	J	**0.406**	J	**0.447**	J	< 2.00	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Iron	7439-89-6	14000	ug/l	**258**		**355**		**72.1**	J	**729**		**69.5**	J	**48.4**	J	**54.9**	J	**59.6**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**0.922**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**6850**		**6250**		**11900**		**12200**		**9960**		**9340**		**237**		**287**	
Manganese	7439-96-5	300	ug/l	**613**		**579**		**145**		**159**		< 1.00	U	**1.11**	J	< 1.00	U	< 1.00	U
Molybdenum	7439-98-7	100	ug/l	**1.14**		**1.17**		**3.11**		**3.13**		**0.541**	J	< 1.00	U	**3.32**		**3.28**	
Nickel	7440-02-0		ug/l	< 2.00	U	**0.777**	J	< 0.600	U	**0.937**	J	< 0.600	U	< 0.600	U	**1.34**	J	**1.28**	J
Potassium	7440-09-7		ug/l	**3570**		**3430**		**4120**		**4090**		**3390**		**3250**		**11500**		**11700**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**10800**		**11000**		**19400**		**19000**		**8070**		**7610**		**27500**		**27200**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.01**	J	< 0.010	U	**0.0498**	J	**0.0523**	J	**0.0947**		**0.0878**		< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**1.41**	J	**1.25**	J	**7.05**		**7.42**		**12.9**		**12.1**		**0.324**		**0.333**	
Calc U-235/U-238			ug/l	**0.0070922**				**0.0070638**		**0.0070485**		**0.0073411**		**0.0072562**					
Vanadium	7440-62-2		ug/l	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	**5.49**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

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Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS25		MW-BS25 (dup)		MW-BS26		MW-BS26		MW-BS28		MW-BS28		MW-BS31		MW-BS31	
			Sample Date	11/15/2019		11/15/2019		11/19/2019		11/19/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019	
			Fraction	T		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**966**		**1010**		**22.7**	J	**126**		< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**2.43**	J	**2.63**	J	**2.51**	J	**2.8**	J	**2.3**	J	**2.26**	J	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**472**	J	**504**		**170**		**181**		**21.7**		**22.1**		**37.8**		**36.7**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**266000**		**272000**		**62100**		**67700**		**128000**		**132000**		**46800**		**47000**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**1.16**		**1.14**		< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	< 2.00	U	< 2.00	U	**0.347**	J	**1.01**	J	**0.788**	J	< 0.300	U	**0.446**	J	< 0.300	U
Iron	7439-89-6	14000	ug/l	**78.6**	J	**83.7**	J	**315**		**683**		**247**		**258**		**5920**		**5690**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**818**		**783**		**17200**		**18200**		**36800**		**37000**		**20900**		**20800**	
Manganese	7439-96-5	300	ug/l	**7.62**		**6.67**		**254**		**282**		**901**		**900**		**1210**		**1270**	
Molybdenum	7439-98-7	100	ug/l	**3.33**		**3.39**		< 1.6	U	< 1.68	U	**2.83**		**2.7**		**0.285**	J	**0.3**	J
Nickel	7440-02-0		ug/l	**1.28**	J	**1.52**	J	**0.944**	J	**1.32**	J	**3.97**		**3.94**		< 0.600	U	< 0.600	U
Potassium	7440-09-7		ug/l	**10800**		**11400**		**7130**		**7260**		**12000**		**12000**		**11600**		**11600**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**25800**		**26300**		**29500**		**30000**		**44900**		**45700**		**19500**		**19900**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	**0.204**		**0.206**		< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.727**		**0.646**		< 0.067	U	< 0.067	U	**28.2**		**28.4**		< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l									**0.0072340**		**0.0072535**					
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	**3.94**	J	< 3.30	U	< 20.0	U	< 3.30	U	**3.87**	J	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS32		MW-BS32		MW-BS34		MW-BS34		MW-BS35		MW-BS35		MW-BS36		MW-BS36	
			Sample Date	11/12/2019		11/12/2019		11/15/2019		11/15/2019		11/12/2019		11/12/2019		11/15/2019		11/15/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**52.7**		**377**		< 19.3	U	**43.3**	J	**288**		**3250**		**34.3**	J	**45.1**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**6.52**		**4.88**	J	**142**		**139**		< 2.00	U	**2.78**	J	**12.5**		**12.9**	
Barium	7440-39-3	2000	ug/l	**153**		**158**		**39.3**		**40.7**		**27.3**		**40.9**		**56.6**		**52.9**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**108000**		**107000**		**14900**		**15200**		**17100**		**16400**		**22000**		**19900**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	**9.87**	J	**3.33**	J	**3.45**	J
Cobalt	7440-48-4	6.0	ug/l	**1.23**		**1.55**		**1.43**		**1.49**		< 0.300	U	**1.1**		**2.75**		**2.79**	
Copper	7440-50-8	1300	ug/l	**0.313**	J	**1.55**	J	< 0.300	U	< 2.00	U	**0.453**	J	**3.99**		**0.305**	J	< 0.300	U
Iron	7439-89-6	14000	ug/l	**10100**		**11100**		**1340**		**1440**		**604**		**3360**		**6540**	J	**4230**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**1.05**	J	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**40600**		**38300**		**6450**		**6300**		**5990**		**6050**		**8570**		**7970**	
Manganese	7439-96-5	300	ug/l	**755**		**784**		**551**		**548**		**49.6**		**88**		**225**	J	**167**	J
Molybdenum	7439-98-7	100	ug/l	**0.991**	J	**1.03**		**4.62**		**4.31**		**4.66**		**5.41**		**1.74**		**1.92**	
Nickel	7440-02-0		ug/l	< 2.08	U	**2.94**		< 0.600	U	< 0.600	U	< 0.600	U	**3.1**		**2.12**		**2.18**	
Potassium	7440-09-7		ug/l	**8140**		**7540**		**4150**		**4090**		**4600**		**5220**		**5200**		**6450**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**44200**		**40400**		**17000**		**16700**		**14900**		**14900**		**20800**	J	**21100**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	**0.775**	J	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.786**		**0.794**		**0.103**	J	**0.153**	J	< 0.0670	U	**0.191**	J	< 0.200	U	< 0.314	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 20.0	U	**8.69**	J	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	**4.56**	J	< 3.30	U	< 3.30	U	< 3.30	U	**11**	J	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS37		MW-BS37		MW-BS38		MW-BS38		MW-BS39		MW-BS39		MW-BS40		MW-BS40	
			Sample Date	11/15/2019		11/15/2019		11/12/2019		11/12/2019		11/13/2019		11/13/2019		11/11/2019		11/11/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock		Bedrock	
Analyte	Cas No.	Limit	Unit													5			
Aluminum	7429-90-5		ug/l	< 19.3	U	**20.8**	J	**25.3**	J	< 19.3	UJ	**133**		**1520**		**146**		**432**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 5.00	U	< 5.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**2.05**	J	**2.27**	J	**2.94**	J
Barium	7440-39-3	2000	ug/l	**81.5**		**93.7**		**46.9**		**45.2**		**21.1**		**31.6**		**118**		**118**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**28600**		**35100**		**19600**		**18500**		**11500**		**12600**		**43500**		**41000**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	**7.11**	J	< 3.00	U	< 3.00	U	< 3.00	U	**3.63**	J	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**2.06**		**2.31**		**2.55**	
Copper	7440-50-8	1300	ug/l	< 0.300	U	< 2.00	U	**0.354**	J	< 0.300	U	**1.2**	J	**11.2**		**2.65**		**5.08**	
Iron	7439-89-6	14000	ug/l	**1690**		**4870**	J	**846**		**871**		**405**		**4040**		**1700**		**1880**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**1.27**	J	< 0.500	U	**0.671**	J
Magnesium	7439-95-4		ug/l	**12300**		**13900**		**7090**	J	**6370**	J	**5550**		**5770**		**18800**	J	**16300**	J
Manganese	7439-96-5	300	ug/l	**124**		**206**		**83.7**	J	**70.7**	J	**4.39**	J	**33.9**		**129**		**120**	
Molybdenum	7439-98-7	100	ug/l	**0.593**	J	**0.571**	J	**0.327**	J	**0.271**	J	**12.2**		**12.3**		**1.3**		**1.32**	
Nickel	7440-02-0		ug/l	**0.702**	J	**0.944**	J	< 0.600	U	< 0.600	U	**3.13**		**5.87**		< 2.00	U	**1.78**	J
Potassium	7440-09-7		ug/l	**12600**		**12100**		**3640**		**3520**		**34500**		**32300**		**5140**		**5010**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**28200**		**26200**	J	**19300**		**18000**		**48800**		**51200**		**28300**		**27900**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	**0.123**	J	< 0.0670	U	< 0.0670	U	< 0.067	U	< 0.247	U	**0.0722**	J	**0.0772**	J
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 20.0	U	< 3.30	U	< 3.30	U	**7.96**	J	< 20.0	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**5.56**	J	**3.51**	J	**4.28**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-BS46		MW-BS46		SW-2A		SW-2A		EW-1		EW-1		GZW-7-1		GZW-7-1	
			Sample Date	11/18/2019		11/18/2019		11/14/2019		11/14/2019		11/18/2019		11/18/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Bedrock		Bedrock		Bedrock		Bedrock		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**1.38**	J	**2.09**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	**71**		**72.7**		< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**94**		**94**		**2.84**	J	**3.11**	J	**30.2**		**31**		**4.84**		**4.46**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**27100**		**27500**		**20700**		**20900**		**34500**		**35100**		**17900**		**17500**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	**0.454**	J	**3.41**		**3.41**		< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	< 0.300	U	< 0.300	U	**0.774**	J	< 2.00	U	< 0.300	U	**0.324**	J	**18.5**		**18**	
Iron	7439-89-6	14000	ug/l	**788**		**841**		**214**		**642**		**2360**		**2400**		< 33.0	U	< 33.0	U
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**0.518**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**9660**		**9840**		**6240**		**6350**		**12700**		**12900**		**4240**		**4240**	
Manganese	7439-96-5	300	ug/l	**93.6**		**95.7**		**129**		**138**		**386**		**388**		< 1.00	U	< 1.00	U
Molybdenum	7439-98-7	100	ug/l	**0.261**	J	**0.294**	J	**9.87**		**9.48**		< 1.00	U	< 1.00	U	< 1.02	U	< 1.00	U
Nickel	7440-02-0		ug/l	< 0.600	U	< 0.600	U	**1.14**	J	**2.4**		**7.13**		**7.16**		**0.712**	J	**0.663**	J
Potassium	7440-09-7		ug/l	**5110**		**5180**		**1810**		**1820**		**6340**		**6470**		**3450**		**3280**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**23400**		**23600**		**14400**		**14500**		**22800**		**23000**		**26200**		**25200**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	**0.014**	J	**0.0153**	J	< 0.010	U	< 0.010	U	**0.147**		**0.141**	
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	**1.91**		**2.12**		**0.781**		**0.807**		**71.8**		**69.2**	
Calc U-235/U-238			ug/l					**0.0073298**		**0.0072170**						**0.0020474**		**0.0020376**	
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	**14.6**	J	< 3.30	U	< 3.30	U	**3.33**	J	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	GZW-7S		GZW-7S		GZW-8-1		GZW-8-1		GZW-9-1		GZW-9-1		GZW-9-2		GZW-9-2	
			Sample Date	11/13/2019		11/13/2019		11/11/2019		11/11/2019		11/12/2019		11/12/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	**25.6**	J	**72.1**		< 19.3	UJ	**25.8**	J	< 19.3	U	**27.8**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**4.41**		**4.12**		**17.1**		**16.9**		**20.6**		**21**		**15.6**		**15**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**19300**		**19300**		**30000**		**27700**		**21500**		**21300**		**20300**		**19500**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	**0.725**	J	< 0.300	U	< 0.300	U	**4.28**		**4.21**	
Copper	7440-50-8	1300	ug/l	**14.1**		**12.8**		**0.519**	J	**0.698**	J	**0.596**	J	**0.325**	J	**0.384**	J	**0.921**	J
Iron	7439-89-6	14000	ug/l	< 33.0	U	< 33.0	U	**50.4**	J	**150**		< 33.0	UJ	**37**	J	**501**		**656**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**4690**		**4480**		**8090**		**7010**		**5140**		**4680**		**5450**		**5200**	
Manganese	7439-96-5	300	ug/l	**1.13**	J	**1.88**	J	**11.8**		**50.2**		**1.38**	J	**1.7**	J	**1140**		**1120**	
Molybdenum	7439-98-7	100	ug/l	**3.29**		**3.35**		**1.16**		**1.31**		**0.226**	J	< 1.00	U	**0.446**	J	**0.413**	J
Nickel	7440-02-0		ug/l	**0.948**	J	**0.838**	J	< 2.00	U	**2.65**		< 2.00	U	**0.705**	J	**2.92**		**2.77**	
Potassium	7440-09-7		ug/l	**3230**	J	**2820**	J	**3680**		**3400**		**2310**		**2390**		**3090**		**2940**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**23000**		**23900**		**29100**		**30300**		**48300**		**48600**		**11000**	J	**10500**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.14**		**0.144**		< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**67.3**		**67**		< 0.067	U	< 0.067	U	< 0.0670	U	< 0.0670	U	< 0.067	U	**0.0709**	J
Calc U-235/U-238			ug/l	**0.0020802**		**0.0021493**													
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**4.52**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	HA-09		HA-09		HA-11		HA-11		HB-10		HB-10		HB-10S		HB-10S	
			Sample Date	11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/12/2019		11/12/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**86.1**		**486**		**143**		**808**		< 19.3	U	**28.8**	J	**34.4**	J	**125**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**2.27**	J	**2.18**	J	**8.57**		**9.76**		< 2.00	U	< 2.00	U	**17.2**		**17.7**	
Barium	7440-39-3	2000	ug/l	**2.77**	J	**5.16**		**12.5**		**14.7**		**27.4**		**27.8**		**30.7**		**32.8**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**4940**		**5070**		**2480**		**2770**		**10600**		**11000**		< 80.0		< 8810	U
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	**0.321**	J	**2.97**		**3.36**		**7.3**		**7.85**		**17.7**		**17.4**	
Copper	7440-50-8	1300	ug/l	**0.437**	J	< 2.00	U	< 0.300	U	< 2.00	U	**1.09**	J	< 2.00	U	**0.523**	J	**1.26**	J
Iron	7439-89-6	14000	ug/l	**106**		**596**		**7790**		**9240**		**229**		**333**		**14200**		**14900**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**0.591**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**854**		**1000**		**798**		**1000**		**2630**		**2710**		**2310**		**2210**	
Manganese	7439-96-5	300	ug/l	**1.64**	J	**7.9**		**261**		**295**		**351**		**378**		**832**		**791**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 1.00	U	**1.9**		**2**		**4.49**		**4.71**	
Nickel	7440-02-0		ug/l	< 0.600	U	**0.891**	J	**0.702**	J	**1.18**	J	**1.59**	J	**1.63**	J	< 3.25	U	**3.45**	
Potassium	7440-09-7		ug/l	**785**		**946**		**728**		**880**		**3050**		**3110**		**3060**		**3190**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**4990**		**5050**		**4780**		**5110**		**16700**		**16800**		**12500**		**12800**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	**0.13**	J	**0.0826**	J	**0.184**	J+	< 0.200	U	**0.231**		**0.201**		**0.323**	
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	**7.82**	J	**8.48**	J	< 3.30	U	**4.09**	J	**3.33**	J	< 3.30	U	**4.41**	J	**3.79**	J
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**3.57**	J	< 3.30	U	**5.09**	J	**4.69**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	HB-11		HB-11		HB-12		HB-12		HB-620		HB-620 (dup)		HB-620		HB-620 (dup)	
			Sample Date	11/12/2019		11/12/2019		11/11/2019		11/11/2019		11/11/2019		11/11/2019		11/11/2019		11/11/2019	
			Fraction	D		T		D		T		D		D		T		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**48**	J	**68.8**		< 19.3	U	< 19.3	U	**236**	J	**203**	J	**50.4**	J	**55.1**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**14**		**14.8**		**3.5**	J	**3.38**	J	**15.9**	J	**16.4**	J	**12.8**	J	**13.3**	J
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	< 80.0	NJ	< 80.0	UJ	**17200**		**17800**		**20000**		**21800**	J	**18200**		**17900**	J
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**2.38**		**2.31**		**0.387**	J	**0.383**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**1.83**	J	**1.79**	J	**5.75**		**6.2**		**1.14**	J	**0.963**	J	**0.346**	J	**0.427**	J
Iron	7439-89-6	14000	ug/l	**73.4**	J	**138**		< 33.0	U	**51.2**	J	**197**	J	**146**	J	**55**	J	**48.9**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**2340**	J	**2030**	J	**7480**		**6810**		**5170**	J	**5260**	J	**4510**	J	**4460**	J
Manganese	7439-96-5	300	ug/l	**374**		**403**		**2.87**	J	**3.26**	J	**4.74**	J	**4.17**	J	**1.28**	J	**1.18**	J
Molybdenum	7439-98-7	100	ug/l	**1.83**		**1.89**		**56**		**56.5**		**3.12**		**2.96**		**3.38**		**3.32**	
Nickel	7440-02-0		ug/l	**5.87**		**5.93**		< 2.00	U	**1.35**	J	< 2.00	U	< 2.00	U	**0.784**	J	**0.73**	J
Potassium	7440-09-7		ug/l	**1760**		**1750**		**2240**		**2190**		**2820**		**2980**	J	**2620**		**2560**	J
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**9790**		**8920**		**18800**		**19100**		**18400**	J	**18700**	J	**15800**	J	**15300**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.0100	U	< 0.0100	U	**0.86**		**0.888**		< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.185**	J	**0.217**	J	**432**		**440**		**0.186**	J	**0.169**	J	**0.0798**	J	**0.0721**	J
Calc U-235/U-238			ug/l					**0.0019907**		**0.0020182**									
Vanadium	7440-62-2		ug/l	**4.23**	J	< 3.30	U	< 20.0	U	< 3.30	U	< 20.0	U	< 20.0	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	HBPZ-2R		HBPZ-2R		ML-1-1		ML-1-1		ML-1-2		ML-1-2		ML-3-1		ML-3-1	
			Sample Date	11/11/2019		11/11/2019		11/13/2019		11/13/2019		11/18/2019		11/18/2019		11/19/2019		11/19/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**28.9**	J	**241**		< 19.3	U	< 19.3	U	**192**		**578**		< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**1.51**	J	**1.58**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**2.02**	J	**2.72**	J	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**3.08**	J	**3.77**	J	**11.6**		**12.2**		**17.2**		**19.8**		**4.64**		**4.74**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**0.445**	J	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**17400**		**18400**		**16500**		**17200**		**30300**		**31500**		**7990**		**7930**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**0.818**	J	**0.796**	J	< 0.300	U	< 0.300	U	**0.616**	J	**1.04**		< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**13.9**		**16.5**		**0.676**	J	< 2.00	U	**3.08**		**21.1**		**0.681**	J	**0.582**	J
Iron	7439-89-6	14000	ug/l	**37.9**	J	**311**		< 33.0	U	< 33.0	U	**319**		**862**		< 33.0	U	**34.2**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**0.773**	J	**5.34**		**3.22**		< 0.500	U
Magnesium	7439-95-4		ug/l	**5910**	J	**5110**	J	**4230**		**4330**		**7510**		**7790**		**2120**		**2100**	
Manganese	7439-96-5	300	ug/l	**14**		**15.3**		< 1.00	U	< 1.00	U	**54.6**		**113**		**6.96**		**34.6**	
Molybdenum	7439-98-7	100	ug/l	**275**	J	**211**	J	**0.665**	J	**0.668**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Nickel	7440-02-0		ug/l	< 2.51	U	**2.66**		< 0.600	U	< 0.600	U	**1.57**	J	**2.4**		**0.75**	J	**0.785**	J
Potassium	7440-09-7		ug/l	**2740**		**2670**		**2520**		**2640**		**3560**		**3710**		**2230**		**2200**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**17700**		**17600**		**14400**		**14500**		**24300**		**24600**		**9160**		**9160**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 2.00	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	**1.11**	J	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**2.15**		**2.28**		< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**1050**		**1130**		< 0.067	U	< 0.067	U	**0.244**		**0.963**		< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l	**0.0020476**		**0.0020177**													
Vanadium	7440-62-2		ug/l	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**8.09**	J	**6.68**	J
Zinc	7440-66-6		ug/l	< 3.30	U	**4.38**	J	< 3.30	U	< 3.30	U	**8.38**	J	**34.9**		< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-1		MW-1 (dup)		MW-1		MW-1 (dup)		MW-2		MW-2		MW-8A		MW-8A	
			Sample Date	11/14/2019		11/14/2019		11/14/2019		11/14/2019		11/11/2019		11/11/2019		11/13/2019		11/13/2019	
			Fraction	D		D		T		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**43.1**	J	< 19.3	U	**46.9**	J	**28.2**	J	**22.4**	J	**58.6**		< 19.3	U	**41.9**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**3.17**	J	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**14.5**		**13.7**		**14.2**		**14**		**15.2**		**15.3**		**9.24**		**9.54**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**10100**		**10100**		**9740**		**9810**		**11500**		**10700**		**17200**		**17800**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**1.83**		**1.82**		**1.81**		**1.78**		**0.366**	J	**0.322**	J	**0.437**	J	**0.491**	J
Copper	7440-50-8	1300	ug/l	**1.21**	J	**1.08**	J	**0.989**	J	**0.966**	J	**0.913**	J	**0.445**	J	**7.01**		**9.77**	
Iron	7439-89-6	14000	ug/l	**39.1**	J	< 33.0	U	**54.1**	J	**33**	J	**81.3**	J	**283**		< 33.0	U	**60.8**	J
Lead	7439-92-1		ug/l	**0.737**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**1.28**	J
Magnesium	7439-95-4		ug/l	**2670**		**2730**		**2600**		**2620**		**3790**		**3470**		**3980**		**4180**	
Manganese	7439-96-5	300	ug/l	**6.13**		**4.28**	J	**11.1**	J	**7.18**	J	**3.05**	J	**3.24**	J	**3.73**	J	**4.94**	J
Molybdenum	7439-98-7	100	ug/l	**9.69**		**12.2**	J	**8.77**		**9.89**	J	**0.603**	J	**0.539**	J	**42.7**		**42.8**	
Nickel	7440-02-0		ug/l	**1.87**	J	**1.94**	J	**1.78**	J	**1.94**	J	< 2.00	U	**1.39**	J	**1.16**	J	**1.44**	J
Potassium	7440-09-7		ug/l	**2100**		**2030**		**2040**		**2020**		**2550**		**2440**		**2620**		**2740**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**0.374**	J	< 0.300	U
Sodium	7440-23-5		ug/l	**94500**	J	**86400**	J	**94700**	J	**90300**	J	**12600**		**12100**		**20400**		**21300**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 2.00	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	**0.437**		**0.541**	
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	**0.231**		**0.168**	J	**218**		**250**	
Calc U-235/U-238			ug/l													**0.0020046**		**0.0021640**	
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**4.56**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S01		MW-S01		MW-S02		MW-S02 (dup)		MW-S02		MW-S02 (dup)		MW-S03		MW-S03	
			Sample Date	11/15/2019		11/15/2019		11/14/2019		11/14/2019		11/14/2019		11/14/2019		11/12/2019		11/12/2019	
			Fraction	D		T		D		D		T		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	**28.8**	J	< 19.3	U	< 19.3	U	**25.9**	J	**23.5**	J	< 19.3	UJ	**20.1**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 5.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**25.5**		**25.3**		**8.89**		**9.05**		**9.39**		**8.94**		**35**		**36.4**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**21200**		**22000**		**11600**		**11700**		**12200**		**12000**		**16200**		**17100**	
Chromium	7440-47-3	100	ug/l	**5.61**	J	**8.58**	J	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**7.92**		**7.97**		**0.443**	J	**0.445**	J	**0.457**	J	**0.46**	J	**24.2**		**23.1**	
Copper	7440-50-8	1300	ug/l	**8.52**		**9.23**		**18**		**19.4**		**22.1**		**20.3**		**1.81**	J	**1.57**	J
Iron	7439-89-6	14000	ug/l	< 33.0	U	**52.1**	J	< 33.0	U	< 33.0	U	< 33.0	U	< 33.0	U	**103**		**193**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**6400**		**6440**		**1460**		**1470**		**1520**		**1470**		**2660**		**2540**	
Manganese	7439-96-5	300	ug/l	**1.02**	J	**1.69**	J	**1.92**	J	**1.93**	J	**2.32**	J	**2.38**	J	**136**		**131**	
Molybdenum	7439-98-7	100	ug/l	**2.36**		**2.49**		**0.263**	J	**0.274**	J	**0.265**	J	**0.258**	J	< 0.200	U	< 0.200	U
Nickel	7440-02-0		ug/l	**5.51**		**5.51**		**0.889**	J	**0.935**	J	**0.917**	J	**0.881**	J	**4.16**		**3.95**	
Potassium	7440-09-7		ug/l	**2550**		**2550**		**2100**		**2130**		**2180**		**2110**		**13800**		**13100**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**48100**		**49700**		**24500**	J	**24700**	J	**25400**	J	**24400**	J	**36400**		**41200**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	**0.0101**	J	< 0.010	U	< 0.0100	U	< 0.0100	U
Uranium-238	7440-61-2	30	ug/l	**0.409**		**0.465**		**3.67**		**3.42**		**4.23**		**3.74**		**0.0743**	J	**0.107**	J
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**5.15**	J	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S04		MW-S04		MW-S06		MW-S06		MW-S07		MW-S07		MW-S08		MW-S08	
			Sample Date	11/13/2019		11/13/2019		11/14/2019		11/14/2019		11/11/2019		11/11/2019		11/13/2019		11/13/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	**22.6**	J	< 19.3	U	**27.1**	J	**88.5**		**685**		**394**		**366**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**1.14**	J	**1.16**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**2.57**	J
Barium	7440-39-3	2000	ug/l	**15.7**		**14.5**		**15.5**		**15.6**		**24.3**		**27.6**		**6.06**		**10.1**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**6530**		**6360**		**17900**		**18700**		**21400**		**20700**		**3460**		**3330**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**0.343**	J	< 0.300	U	**0.848**	J
Copper	7440-50-8	1300	ug/l	**0.84**	J	< 2.00	U	**0.343**	J	< 2.00	U	**0.788**	J	**2.26**		**0.795**	J	< 2.00	U
Iron	7439-89-6	14000	ug/l	< 33.0	U	< 33.0	U	< 33.0	U	< 33.0	U	**97**	J	**714**		< 33.0	U	**497**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**0.596**	J	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**545**		**521**		**4420**		**4610**		**5470**		**5220**		**515**		**552**	
Manganese	7439-96-5	300	ug/l	**1.05**	J	**1.29**	J	**1.12**	J	**1.81**	J	**3.28**	J	**12.4**		**32.2**		**357**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 1.00	U	< 0.200	U	**0.222**	J	< 0.200	U	< 1.00	U
Nickel	7440-02-0		ug/l	**0.678**	J	< 0.600	U	**0.905**	J	**0.947**	J	**4.18**		**4.8**		**1.11**	J	**1.43**	J
Potassium	7440-09-7		ug/l	**2630**		**2410**		**2760**		**2870**		**3550**		**3520**		**6890**	J	**6060**	J
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**4760**		**4960**		**19900**		**20900**		**21900**		**21900**		**27100**		**27400**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	**0.926**	J	< 0.600	U	< 0.600	U	< 0.600	U	**0.892**	J
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	**0.0923**	J	**0.147**	J	**0.738**		**1.2**		< 0.067	U	< 0.212	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 20.0	U	< 3.30	U	< 3.30	U	**8.92**	J
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**3.73**	J	**4.6**	J	**6.99**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S09		MW-S09 (dup)		MW-S09		MW-S09 (dup)		MW-S11		MW-S11		MW-S12		MW-S12 (dup)	
			Sample Date	11/12/2019		11/12/2019		11/12/2019		11/12/2019		11/13/2019		11/13/2019		11/14/2019		11/14/2019	
			Fraction	D		D		T		T		D		T		D		D	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**104**		**73.9**		**742**		**827**		< 19.3	U	**36.7**	J	**45.2**	J	**45.1**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**16.5**		**16**		**22**		**21.2**		**6.19**		**6.47**		**13.7**		**14**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**15700**		**15500**		**16300**		**15300**		**2630**		**2680**		**3630**		**3700**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	**1.51**		**1.65**		< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**0.693**	J	**0.421**	J	**1.59**	J	**1.39**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Iron	7439-89-6	14000	ug/l	**131**		**100**		**1130**		**1140**		< 33.0	U	**34.9**	J	< 33.0	U	< 33.0	U
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**0.502**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**4000**	J	**3860**	J	**3770**		**3390**	J	**727**		**755**		**925**		**966**	
Manganese	7439-96-5	300	ug/l	**2.85**	J	**2.6**	J	**19.4**	J	**20.2**		**1.83**	J	**2.02**	J	**1.51**	J	**1.64**	J
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Nickel	7440-02-0		ug/l	< 2.00	U	< 2.00	U	**2.6**		**2.16**		< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Potassium	7440-09-7		ug/l	**2780**		**2930**		**3140**		**3140**		**2530**		**2630**		**2390**		**2390**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**40700**	J	**41000**	J	**39300**	J	**36600**	J	**2900**		**2950**		**7210**		**7150**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.0100	U	< 0.0100	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.0706**	J	**0.101**	J	**0.257**		**0.277**		< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	**4.22**	J	**4.56**	J	< 3.30	U	< 3.30	U	**5.92**	J	**6.5**	J	**3.61**	J	**5.56**	J
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	**3.92**	J	**3.63**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location Sample Date Fraction Formation	MW-S12 11/14/2019 T Overburden		MW-S12 (dup) 11/14/2019 T Overburden		MW-S14 11/12/2019 D Overburden		MW-S14 11/12/2019 T Overburden		MW-S15 11/15/2019 D Overburden		MW-S15 11/15/2019 T Overburden		MW-S16 11/12/2019 D Overburden		MW-S16 (dup) 11/12/2019 D Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**220**		**230**		**125**		**3160**		**185**		**188**		**21.5**	J	**133**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**14.5**		**14.8**		**2.88**	J	**25.7**		**580**		**581**		**5.16**		**5.58**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	**0.213**	J	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**3620**		**3630**		< 80.0		< 6040	U	**58600**		**62500**		**17500**		**18100**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	**5.63**	J	**3.21**	J	**3.35**	J	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	**2.11**		**12.3**		**12.1**		< 0.300	U	**0.331**	J
Copper	7440-50-8	1300	ug/l	< 0.300	U	< 2.00	U	**0.316**	J	**4.41**		**1.49**	J	**1.28**	J	**21.4**		**24.5**	
Iron	7439-89-6	14000	ug/l	**35.3**	J	**46.7**	J	**95.1**	J	**3220**		**476**		**513**		< 33.0	UJ	**167**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**1.9**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**952**		**957**		**1470**		**2180**		**12500**		**12500**		**4130**		**4240**	J
Manganese	7439-96-5	300	ug/l	**2.95**	J	**2.92**	J	**3.31**	J	**57.9**		**1080**		**1150**		**2.99**	J	**5.06**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	**3.6**		**3.56**	
Nickel	7440-02-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	**5.53**		**12.5**		**12.1**		< 2.00	U	< 2.00	U
Potassium	7440-09-7		ug/l	**2430**		**2390**		**781**		**1630**		**6540**		**6450**		**2780**		**2930**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**7350**		**7090**		**6830**		**6690**		**452000**	J	**476000**	J	**26500**		**27600**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	**0.95**	J	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	**0.195**		**0.217**	
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	< 0.0670	U	**0.748**		< 0.067	U	< 0.067	U	**94.3**		**103**	
Calc U-235/U-238			ug/l													**0.0020679**		**0.0021068**	
Vanadium	7440-62-2		ug/l	< 20.0	U	< 20.0	U	**3.83**	J	**6.96**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	**4.75**	J	**10.9**	J	**8.27**	J	**7.9**	J	**4.33**	J	**5.07**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S16		MW-S16 (dup)		MW-S17		MW-S17		MW-S18		MW-S18		MW-S19		MW-S19	
			Sample Date	11/12/2019		11/12/2019		11/12/2019		11/12/2019		11/11/2019		11/11/2019		11/11/2019		11/11/2019	
			Fraction	T		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**188**	J	**130**	J	**29**	J	**119**		**361**		**345**		**20.9**	J	**106**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**1.09**	J	**1.17**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**15.1**		**15.9**		< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**5.8**		**5.66**		**20.7**		**21.6**		**20.2**		**20.4**		**3.95**	J	**4.21**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**17300**		**17900**		**21900**		**22600**		**29500**		**29200**		**2630**		**2320**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**0.363**	J	< 0.300	U	< 0.300	U	< 0.300	U	**1.76**		**1.64**		< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**26.4**		**24.5**		**0.681**	J	**0.408**	J	**1.48**	J	**2.89**		**0.549**	J	**0.32**	J
Iron	7439-89-6	14000	ug/l	**232**	J	**149**	J	**47.6**	J	**178**		**6290**		**6090**		< 33.0	U	**108**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**3740**		**3720**	J	**5940**	J	**5290**	J	**1060**		**1040**		**306**		**295**	
Manganese	7439-96-5	300	ug/l	**6.01**		**5.03**		**1.37**	J	**3.89**	J	**240**		**234**		< 1.00	U	**1.89**	J
Molybdenum	7439-98-7	100	ug/l	**3.75**		**3.71**		< 0.200	U	< 1.00	U	**36.7**		**36.6**		< 0.200	U	< 0.200	U
Nickel	7440-02-0		ug/l	**1.77**	J	**1.84**	J	< 2.00	U	**1.19**	J	**5.09**		**4.85**		< 2.26	U	< 0.600	U
Potassium	7440-09-7		ug/l	**2870**		**2790**		**3060**		**3060**		**2120**		**2220**		**8880**		**8520**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**25100**		**25300**		**24300**		**24400**		**1700**		**1850**		**2770**		**2710**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.21**		**0.201**		< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**100**		**98.8**		**0.296**		**0.46**		**0.848**		**0.849**		< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l	**0.0021000**		**0.0020344**													
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 20.0	U	**3.56**	J	< 20.0	U	**5.19**	J
Zinc	7440-66-6		ug/l	**4.38**	J	**5.57**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S20		MW-S20		MW-S21		MW-S21		MW-S22		MW-S22		MW-S23		MW-S23	
			Sample Date	11/12/2019		11/12/2019		11/14/2019		11/14/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**111**		**982**		< 19.3	U	< 19.3	U	**273**		**2240**		**71.7**		**2030**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 8.17	U	**8.72**		< 2.00	U	< 2.00	U	< 2.00	U	**3.6**	J	**3.38**	J	**5.89**	
Barium	7440-39-3	2000	ug/l	**20.2**		**24**		**1.59**	J	**1.74**	J	**15.4**		**28.2**		**15.8**		**26.6**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	**0.25**	J	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**29800**		**28700**		**3530**		**3640**		**8600**		**9040**		**4520**		**4860**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	**3.77**	J	< 3.00	U	< 3.00	U	< 3.00	U	**4.98**	J	< 3.00	U	**17**	
Cobalt	7440-48-4	6.0	ug/l	**1.44**		**2.15**		< 0.300	U	< 0.300	U	**0.863**	J	**8.83**		**0.543**	J	**2.03**	
Copper	7440-50-8	1300	ug/l	< 0.300	U	**2.09**		**0.533**	J	< 0.300	U	**1.03**	J	**4.36**		**0.953**	J	**3.34**	
Iron	7439-89-6	14000	ug/l	**13200**		**13700**		< 33.0	U	< 33.0	U	**305**		**2590**		**67**	J	**2550**	
Lead	7439-92-1		ug/l	< 0.500	U	**0.827**	J	< 0.500	U	< 0.500	U	< 0.500	U	**1.51**	J	< 0.500	U	**1.01**	J
Magnesium	7439-95-4		ug/l	**1250**		**1370**		**576**		**576**		**1820**		**2430**		**367**		**947**	
Manganese	7439-96-5	300	ug/l	**549**	J	**489**	J	< 1.00	U	**1.95**	J	**20.4**		**183**		**3.98**	J	**48.6**	
Molybdenum	7439-98-7	100	ug/l	**1.02**		**1.23**		< 0.200	U	< 0.200	U	< 0.200	U	< 1.00	U	**0.455**	J	**1.63**	
Nickel	7440-02-0		ug/l	< 0.600	U	**1.74**	J	< 0.600	U	< 0.600	U	**2.9**		**5.56**		**0.948**	J	**4.81**	
Potassium	7440-09-7		ug/l	**1760**		**1920**		**557**		**570**		**4230**		**4460**		**10500**		**9670**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**6500**		**6420**		**3190**		**3140**		**24700**		**26900**		**44500**		**46800**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	**0.74**	J	< 0.700	U	**0.957**	J
Uranium-235	15117-96-1	30	ug/l	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.311**		**0.483**		< 0.067	U	< 0.067	U	< 0.067	U	**0.429**		**0.0738**	J	**0.441**	
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 20.0	U	**5.54**	J	**4.45**	J	**3.93**	J	< 3.30	U	**14**	J	**4.78**	J	**13.6**	J
Zinc	7440-66-6		ug/l	< 3.30	U	**3.61**	J	< 3.30	U	< 3.30	U	< 3.30	U	**7.98**	J	**27.4**		**35.6**	

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S24		MW-S24		MW-S26		MW-S26		MW-S27		MW-S27		MW-S28		MW-S28	
			Sample Date	11/13/2019		11/13/2019		11/15/2019		11/15/2019		11/13/2019		11/13/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**42.1**	J	**169**		**368**		**732**		**49.2**	J	**60.3**		**46.7**	J	**5290**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	**1.14**	J	**1.15**	J	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	**2.32**	J	< 2.00	U	< 2.00	U	< 2.00	U	**6.2**	
Barium	7440-39-3	2000	ug/l	**7.96**		**8.86**		**181**		**191**		**19.3**		**19.8**		**3.29**	J	**33.5**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	**0.268**	J
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	**0.628**	J	**0.69**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**22300**		**21500**		**17300**		**18200**		**21600**		**23000**		**5100**		**5860**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	**3.54**	J	**4.32**	J	< 3.00	U	< 3.00	U	< 3.00	U	**11.4**	
Cobalt	7440-48-4	6.0	ug/l	**1.05**		**1.33**		**10.5**		**11.9**		< 0.300	U	< 0.300	U	< 0.300	U	**2.88**	
Copper	7440-50-8	1300	ug/l	**28.1**		**34.2**		**5.34**		**6.93**		**0.458**	J	< 2.00	U	**0.402**	J	**6.49**	
Iron	7439-89-6	14000	ug/l	**59.9**	J	**276**		**241**		**2250**		**83.2**	J	**96.9**	J	**52.6**	J	**5240**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**3.35**	
Magnesium	7439-95-4		ug/l	**9580**		**11500**		**4250**		**4530**		**4990**		**5130**		**1050**		**2460**	
Manganese	7439-96-5	300	ug/l	**23.4**		**30.8**		**804**		**894**		**2.95**	J	**3.26**	J	**2.21**	J	**122**	
Molybdenum	7439-98-7	100	ug/l	**356**		**373**		< 0.200	U	**0.288**	J	**0.268**	J	**0.254**	J	< 0.200	U	**0.779**	J
Nickel	7440-02-0		ug/l	**2.05**		**2.48**		**13.5**		**14.1**		**1.32**	J	**1.29**	J	< 0.600	U	**6.42**	
Potassium	7440-09-7		ug/l	**2670**		**2940**		**3430**		**3590**		**2900**		**3090**		**927**		**2240**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**19100**		**20600**		**188000**	J	**196000**	J	**25100**		**26300**		**5150**		**5500**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	**1.53**	J
Uranium-235	15117-96-1	30	ug/l	**5.06**		**5.35**		< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**2360**		**2670**		< 0.067	U	< 0.200	U	< 0.200	U	**0.0815**	J	< 0.067	U	**0.591**	
Calc U-235/U-238			ug/l	**0.0021441**		**0.0020037**													
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**3.56**	J	< 20.0	U
Zinc	7440-66-6		ug/l	**4.45**	J	**5.28**	J	**28.3**		**29.2**		< 3.30	U	< 3.30	U	**7.55**	J	**21.7**	

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S29		MW-S29		MW-S30		MW-S30		MW-S32		MW-S32		MW-S35		MW-S35	
			Sample Date	11/13/2019		11/13/2019		11/15/2019		11/15/2019		11/13/2019		11/13/2019		11/12/2019		11/12/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**25.2**	J	**165**		< 19.3	U	**37.1**	J	< 19.3	U	**597**		< 19.3	UJ	< 19.3	UJ
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	**1.14**	J	**1.2**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**3.01**	J	**2.76**	J	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 5.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**4.53**		**4.9**		**16.3**		**16.9**		**15.8**		**20**		**121**		**127**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**5250**		**5360**		**21000**		**20500**		**17400**		**18200**		**85700**		**82200**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**8.67**		**9.07**		< 0.300	U	< 0.300	U	**1.73**		**2.81**		< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	< 0.300	U	< 2.00	U	**0.341**	J	< 0.300	U	**0.789**	J	**2.16**		**0.395**	J	< 0.300	U
Iron	7439-89-6	14000	ug/l	< 33.0	U	**141**		< 33.0	U	**50.6**	J	**35.8**	J	**855**		< 33.0	UJ	**33.9**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**0.661**	J	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**812**		**877**		**5520**		**5550**		**5770**		**6050**		**15500**		**15800**	
Manganese	7439-96-5	300	ug/l	**1.21**	J	**3.18**	J	< 1.00	U	**1.38**	J	< 1.00	U	**19.5**		**1.86**	J	**2.42**	J
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	**0.337**	J	**0.384**	J	< 0.200	U	< 0.200	U
Nickel	7440-02-0		ug/l	**1.22**	J	**1.23**	J	**1.13**	J	**1.2**	J	**1.28**	J	**2.49**		< 2.74	U	**2.7**	
Potassium	7440-09-7		ug/l	**2670**		**2890**		**3000**		**3050**		**3380**		**3730**		**6080**		**5690**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**15300**		**16200**		**21100**		**20400**		**11500**		**11600**		**161000**		**161000**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	< 0.067	U	**0.0677**	J	< 0.067	U	**0.164**	J	< 0.0670	U	< 0.0670	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	**4.44**	J	**5.27**	J	< 3.30	U	< 3.30	U	< 3.30	U	**3.87**	J	**4.09**	J	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**3.83**	J	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S36		MW-S36		MW-S37		MW-S37		MW-S38		MW-S38		MW-S39		MW-S39	
			Sample Date	11/11/2019		11/11/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	**40.4**	J	**176**		**1380**		< 19.3	U	**49.7**	J	**164**	J	< 19.3	UJ
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	**2.51**	J	**3.51**	J	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**103**		**101**		**15.6**		**23.2**		**26.7**		**27.4**		**39.1**		**37.4**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	**0.402**	J	**0.448**	J	< 0.300	U	< 0.300	U	**0.469**	J	**0.613**	J	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**47200**		**44600**		**26100**		**27600**		**27900**		**29400**		**28700**		**28600**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**14**		**16.8**		**1.38**		**2.11**		**14.3**		**15.9**		**5.09**		**4.94**	
Copper	7440-50-8	1300	ug/l	**1.66**	J	**1.26**	J	**0.5**	J	**2.06**		**0.882**	J	< 2.00	U	**0.577**	J	< 0.300	U
Iron	7439-89-6	14000	ug/l	< 33.0	U	**111**		**318**		**1710**		< 33.0	U	**74.3**	J	**196**	J	< 33.0	UJ
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**0.837**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**11100**		**9590**		**5920**		**6330**		**7010**		**7250**		**5130**		**5180**	
Manganese	7439-96-5	300	ug/l	**3140**		**3160**		**75.4**		**93.8**		**3760**		**3830**		**10.7**	J	**7.05**	J
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	**0.235**	J	**0.439**	J	< 1.00	U	**0.211**	J	**0.201**	J	< 0.200	U	< 0.200	U
Nickel	7440-02-0		ug/l	**10.9**		**11.1**		**1.46**	J	**2.92**		**19.4**		**20.6**		**3.65**	J	**3.26**	J
Potassium	7440-09-7		ug/l	**7460**		**6990**		**5130**		**5680**		**4200**		**4460**		**5900**		**5790**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**198000**		**218000**		**28900**		**29400**		**17600**		**18400**		**84400**		**83400**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	**0.836**	J	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.112**	J	**0.0902**	J	**0.615**		**0.808**	J+	< 0.200	U	**0.146**	J	**0.114**	J	**0.0819**	J
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 20.0	U	< 3.30	U	< 3.30	U	**4.9**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	**6.04**	J	**6.29**	J	< 3.30	U	**5.18**	J	**3.68**	J	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-S40		MW-S40		MW-SD01		MW-SD01		MW-SD02		MW-SD02		MW-SD06		MW-SD06	
			Sample Date	11/14/2019		11/14/2019		11/14/2019		11/14/2019		11/12/2019		11/12/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**25.5**	J	**47.4**	J	< 19.3	U	**219**		< 19.3	UJ	**764**		< 19.3	U	**124**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 5.00	U	**2.31**	J	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**24.5**		**25.8**		**15.3**		**16**		**21.3**		**30.5**		**35.4**		**35.8**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	**0.453**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**25300**		**25700**		**14400**		**14200**		**19700**		**20700**		**29900**		**30100**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**0.816**	J	**0.895**	J	**2.02**		**2.16**		< 0.300	U	**0.637**	J	**0.641**	J	**0.773**	J
Copper	7440-50-8	1300	ug/l	**0.618**	J	< 2.00	U	**2.47**		**3.27**		**2.56**		**7.16**		**2.02**		**2.57**	
Iron	7439-89-6	14000	ug/l	**1260**		**1560**		< 33.0	U	**292**		< 33.0	UJ	**923**		< 33.0	U	**188**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**0.678**	J	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**5390**		**5430**		**2970**		**3030**		**7410**		**7450**		**10000**		**10100**	
Manganese	7439-96-5	300	ug/l	**15100**		**16200**		**2.36**	J	**7.86**		**3.78**	J	**15.8**		**2.07**	J	**5.48**	
Molybdenum	7439-98-7	100	ug/l	< 1.00	U	< 1.00	U	**25.9**		**25.1**		< 0.200	U	< 0.200	U	< 1.00	U	< 1.00	U
Nickel	7440-02-0		ug/l	**7.19**		**8**		**1.13**	J	**1.36**	J	< 2.05	U	**3.15**		**1.88**	J	**1.91**	J
Potassium	7440-09-7		ug/l	**4080**		**4130**		**3370**		**3360**		**3350**		**3870**		**5670**		**5770**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**24000**		**24500**		**25900**		**25200**		**30300**		**33200**		**23900**		**23400**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	**0.0162**	J	**0.017**	J	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	**0.11**	J	**7.24**		**7.83**		< 0.0670	U	**0.391**		**1.15**		**1.22**	
Calc U-235/U-238			ug/l					**0.0022376**		**0.0021711**									
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**4.33**	J	**4.01**	J	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**4.5**	J	**11.1**	J	< 3.30	U	**3.72**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD10		MW-SD10		MW-SD13		MW-SD13		MW-SD17		MW-SD17		MW-SD26		MW-SD26	
			Sample Date	11/12/2019		11/12/2019		11/12/2019		11/12/2019		11/12/2019		11/12/2019		11/18/2019		11/18/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	UJ	**209**		**112**		**360**		< 19.3	UJ	**106**		< 19.3	U	**20.9**	J
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	**1.1**	J	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 5.00	U	**2.07**	J	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**2.13**	J	**2.24**	J
Barium	7440-39-3	2000	ug/l	**12.2**		**12.6**		**8.1**		**9.84**		**17.8**		**18.5**		**22.3**		**22.3**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**13800**		**13600**		**22100**		**20000**		**19800**		**19800**		**37300**		**37100**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	**0.409**	J	**0.583**	J	< 0.300	U	< 0.300	U	**1.08**		**1.11**	
Copper	7440-50-8	1300	ug/l	**0.351**	J	**0.511**	J	**1.97**	J	**1.05**	J	**0.44**	J	**0.555**	J	**0.709**	J	**0.525**	J
Iron	7439-89-6	14000	ug/l	< 33.0	UJ	**234**		**114**		**388**		< 33.0	UJ	**185**		< 33.0	U	**47.7**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**2810**		**2880**		**3320**		**3070**		**4930**		**4640**		**5760**		**5760**	
Manganese	7439-96-5	300	ug/l	< 1.00	U	**4.25**	J	**3.86**	J	**9.58**		**1.32**	J	**3.9**	J	**1**	J	**1.33**	J
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	**4.19**		**3.99**		< 0.200	U	< 0.200	U	**0.273**	J	**0.265**	J
Nickel	7440-02-0		ug/l	**0.86**	J	**1.26**	J	< 2.00	U	**1.84**	J	< 2.00	U	**1.6**	J	**2.38**		**2.32**	
Potassium	7440-09-7		ug/l	**1830**		**1860**		**2500**		**2380**		**3580**		**3550**		**3550**		**3570**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**20800**		**22500**		**16900**		**16800**		**22800**		**21900**		**23400**		**23600**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.0100	U	< 0.0100	U	< 0.0100	U	< 0.0100	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.0670	U	**0.0805**	J	< 0.0670	U	< 0.0670	U	< 0.0670	U	**0.142**	J	**0.109**	J+	**0.129**	J+
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	**5.14**	J	**3.32**	J	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	**7.89**	J	< 3.30	U	< 3.30	U	**5.43**	J	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD27		MW-SD27		MW-SD29		MW-SD29		MW-SD30		MW-SD30		MW-SD32		MW-SD32	
			Sample Date	11/12/2019		11/12/2019		11/14/2019		11/14/2019		11/12/2019		11/12/2019		11/15/2019		11/15/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	UJ	< 19.3	UJ	< 19.3	U	**382**		< 19.3	UJ	< 19.3	UJ	**51.9**		**2050**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 5.00	U	< 2.00	U	< 2.00	U	**2.15**	J	< 2.00	U	< 2.00	U	< 2.00	U	**5.05**	
Barium	7440-39-3	2000	ug/l	**22**		**21.7**		**11.3**		**13**		**20**		**19.2**		**14.7**		**28.8**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	**0.306**	J	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**25200**		**26600**		**21800**		**21800**		**22700**		**22600**		**14200**		**14800**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	**4.4**	J
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	**0.329**	J	**0.731**	J	< 0.300	U	< 0.300	U	< 0.300	U	**2.99**	
Copper	7440-50-8	1300	ug/l	**0.441**	J	< 0.300	U	**0.495**	J	< 2.00	U	< 0.300	U	< 0.300	U	**0.621**	J	**5.58**	
Iron	7439-89-6	14000	ug/l	< 33.0	UJ	< 33.0	UJ	< 33.0	U	**471**		< 33.0	UJ	< 33.0	UJ	**77.2**	J	**2450**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**1.58**	J
Magnesium	7439-95-4		ug/l	**6240**		**5830**		**6860**		**7140**		**5950**	J	**4990**	J	**3890**		**4190**	
Manganese	7439-96-5	300	ug/l	< 1.00	U	< 1.00	U	**3.28**	J	**15.2**		< 1.00	U	< 1.00	U	**5.44**		**102**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	**19.1**		**18.2**		< 0.200	U	< 0.200	U	**0.25**	J	**0.518**	J
Nickel	7440-02-0		ug/l	< 2.00	U	**0.96**	J	**1.21**	J	**1.46**	J	**9.36**		**9.39**		**1.95**	J	**4.7**	
Potassium	7440-09-7		ug/l	**3410**		**3380**		**3520**		**3550**		**2970**		**2870**		**2500**		**3180**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**31500**		**30500**		**31300**		**31700**		**31700**		**28900**		**12100**		**12400**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U	< 0.0100	U	< 0.0100	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.0670	U	< 0.0670	U	< 0.067	U	**0.0748**	J	< 0.0670	U	< 0.0670	U	< 0.067	U	**0.283**	
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	**4.44**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**4.49**	J
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**7.84**	J

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD34		MW-SD34		MW-SD35		MW-SD35		MW-SD36		MW-SD36 (dup)		MW-SD36		MW-SD36 (dup)	
			Sample Date	11/14/2019		11/14/2019		11/13/2019		11/13/2019		11/18/2019		11/18/2019		11/18/2019		11/18/2019	
			Fraction	D		T		D		T		D		D		T		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	**41.3**	J	**685**		**234**		**231**		**2350**		**2160**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**2.48**	J	< 2.00	U	< 2.00	U	**2.34**	J	**2.9**	J	**2.86**	J	**5.86**		**5.47**	
Barium	7440-39-3	2000	ug/l	**26.4**		**27**		**51.9**		**54**		**61.9**		**59.1**		**62.4**		**61**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**106000**	J	**88800**	J	**32100**		**30500**		**47200**		**45300**		**48800**		**47000**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**4.59**	J	**3.08**	J	**1.11**		**1.57**		< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	< 0.300	U	< 2.00	U	**0.922**	J	< 2.00	U	< 0.300	U	**0.351**	J	**1.1**	J	**0.892**	J
Iron	7439-89-6	14000	ug/l	**6030**		**4090**		**17900**		**17900**		**13700**		**13300**		**33200**		**30000**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**0.683**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**33900**	J	**26200**	J	**11600**		**10600**		**10900**		**10600**		**13500**		**13200**	
Manganese	7439-96-5	300	ug/l	**715**	J	**437**	J	**772**	J	**758**	J	**587**		**570**		**988**		**941**	
Molybdenum	7439-98-7	100	ug/l	< 1.00	U	< 1.00	U	**0.358**	J	< 1.00	U	**0.926**	J	**0.944**	J	< 1.03	U	**0.912**	J
Nickel	7440-02-0		ug/l	**8.81**	J	**7.45**	J	**0.796**	J	**1.65**	J	< 0.600	U	< 0.600	U	**0.736**	J	**0.744**	J
Potassium	7440-09-7		ug/l	**10700**		**10300**		**6290**		**5710**		**6570**		**6520**		**6580**		**6410**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**39100**	J	**34700**	J	**13400**		**13500**		**20000**		**19700**		**19500**		**19100**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.0865**		**0.0953**		< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**11.8**		**12.8**		< 0.067	U	< 0.200	U	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l	**0.0073305**		**0.0074453**													
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	**18.2**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD37		MW-SD37		MW-SD38		MW-SD38		MW-SD39		MW-SD39		MW-SD40		MW-SD40 (dup)	
			Sample Date	11/18/2019		11/18/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		T		D		D	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**2.34**	J	**2.51**	J	< 5.00	U	< 5.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**26.5**		**29.4**		**45.5**		**46.5**		**136**		**142**		**58.1**		**58.4**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	**0.48**	J	**0.475**	J	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**30400**		**31200**		**21900**		**22300**		**62700**		**66200**		**34500**		**35100**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**1.54**		**1.62**		**2.33**		**2.33**		**10.5**	J	**9.38**	J	**1.03**		**1.04**	
Copper	7440-50-8	1300	ug/l	**0.323**	J	**0.358**	J	< 0.300	U	**0.599**	J	**0.576**	J	< 2.00	U	< 0.300	U	< 0.300	U
Iron	7439-89-6	14000	ug/l	**2990**		**3150**		**3250**		**3340**	J	**154**		**163**		**39.2**	J	**36.7**	J
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**9920**		**9860**		**8510**		**8710**		**17200**		**15500**		**14400**		**14500**	
Manganese	7439-96-5	300	ug/l	**227**		**240**		**308**		**311**		**2160**		**2280**		**218**		**222**	
Molybdenum	7439-98-7	100	ug/l	**0.387**	J	**0.399**	J	< 0.200	U	< 0.200	U	< 0.200	U	**0.575**	J	< 0.200	U	< 0.200	U
Nickel	7440-02-0		ug/l	**5.32**		**5.36**		**4.41**		**4.48**		**28.7**		**28.1**		**2.57**		**2.52**	
Potassium	7440-09-7		ug/l	**4710**		**5050**		**5220**		**5320**		**7260**		**7440**		**9840**		**9510**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**15500**		**16000**		**22500**		**23000**	J	**137000**		**141000**		**15800**	J	**15800**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.0853**	J	**0.0811**	J+	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	**0.491**		**0.502**	
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	**3.51**	J	< 3.30	U	< 3.30	U	< 3.30	U	**4.44**	J	**4.51**	J	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD40		MW-SD40 (dup)		MW-SD41		MW-SD41 (dup)		MW-SD41		MW-SD41 (dup)		MW-SD42A		MW-SD42A	
			Sample Date	11/14/2019		11/14/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019	
			Fraction	T		T		D		D		T		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	**54**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**58.3**		**59**		**10.7**		**11.1**		**11.3**		**11.1**		**20.2**		**20.6**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**34400**		**34700**		**23300**		**23800**		**23900**		**23700**		**27600**		**28600**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	**4.01**	J	**4.65**	J	**3.49**	J	**5.1**	J	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**1.1**		**1.08**		**2.38**		**2.45**		**2.69**		**2.62**		**3.23**		**3.65**	
Copper	7440-50-8	1300	ug/l	**0.353**	J	< 0.300	U	**0.335**	J	**0.415**	J	**0.543**	J	**0.442**	J	**0.398**	J	**0.955**	J
Iron	7439-89-6	14000	ug/l	**65.6**	J	**62.6**	J	**129**		**132**		**149**		**148**		**887**		**848**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**14300**		**14500**		**7760**		**8050**		**7950**		**7890**		**6290**		**6240**	
Manganese	7439-96-5	300	ug/l	**221**		**226**		**55.9**		**56.9**		**63.7**		**62.8**		**1030**		**1130**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	**0.412**	J	**0.397**	J	**0.415**	J	**0.407**	J	**0.309**	J	**0.285**	J
Nickel	7440-02-0		ug/l	**2.41**		**2.38**		**3.83**		**4.36**		**3.81**		**4.48**		**8.44**		**9.68**	
Potassium	7440-09-7		ug/l	**10100**		**9510**		**3300**		**3380**		**3410**		**3330**		**4990**		**5010**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**15700**	J	**15900**	J	**18600**	J	**19100**	J	**18900**	J	**18800**	J	**21300**	J	**22500**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.496**		**0.523**		**0.448**		**0.446**		**0.479**		**0.459**		< 0.200	U	< 0.236	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD43		MW-SD43		MW-SD44		MW-SD44		MW-SD45		MW-SD45		MW-SD46		MW-SD46 (dup)	
			Sample Date	11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/14/2019		11/14/2019		11/18/2019		11/18/2019	
			Fraction	D		T		D		T		D		T		D		D	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	**531**		< 19.3	U	**1090**		< 19.3	U	**33.9**	J	**29.7**	J	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	**1.46**	J	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	**2.15**	J	**3.26**	J	**12**		< 2.00	U	< 2.00	U	**2.12**	J	**2.08**	J
Barium	7440-39-3	2000	ug/l	**10.7**		**14.2**		**46.9**		**115**		**20.9**		**19.8**		**68.4**		**68.2**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	**0.514**		< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**27000**		**27900**		**22700**		**23500**		**25300**		**23100**		**28700**	J	**25800**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**0.724**	J	**0.899**	J	**2.5**		**3.19**		**4.86**		**4.49**		**3.38**		**3.43**	
Copper	7440-50-8	1300	ug/l	**0.358**	J	< 2.00	U	< 0.300	U	**2.2**		**0.471**	J	< 2.00	U	**0.33**	J	< 0.300	U
Iron	7439-89-6	14000	ug/l	**1260**	J	**605**	J	**5180**		**10800**		< 33.0	U	**63.5**	J	**3490**		**3640**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	**1.84**	J	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**9790**		**9870**		**8470**		**8570**		**6920**		**6410**		**9860**		**9880**	
Manganese	7439-96-5	300	ug/l	**62.8**		**70.2**		**309**		**327**		**1590**		**1640**		**148**		**150**	
Molybdenum	7439-98-7	100	ug/l	**0.218**	J	< 0.200	U	**0.58**	J	**0.699**	J	< 0.200	U	< 0.200	U	**0.549**	J	**0.469**	J
Nickel	7440-02-0		ug/l	**1.92**	J	**2.5**		**5.03**		**7.41**		**7.39**	J	**6.51**	J	< 0.600	U	< 0.600	U
Potassium	7440-09-7		ug/l	**6020**		**5790**		**7890**		**8220**		**4150**		**3780**		**6380**		**6040**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**15200**		**14600**		**18300**		**18400**		**24500**		**22300**		**24200**		**24500**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	**0.796**	J	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**0.118**	J	**0.188**	J	**0.099**	J	**0.562**		**0.118**	J	**0.131**	J	< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	**3.97**	J	**12**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-SD46		MW-SD46 (dup)		MW-SM13		MW-SM13		MW-SM46		MW-SM46		MW-T10		MW-T10	
			Sample Date	11/18/2019		11/18/2019		11/11/2019		11/11/2019		11/15/2019		11/15/2019		11/14/2019		11/14/2019	
			Fraction	T		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**27.6**	J	**26.5**	J	**697**		**21.8**	J	< 19.3	U	< 19.3	U	< 19.3	U	**123**	
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**2.23**	J	**2.16**	J	< 2.00	U	< 2.00	U	**2.53**	J	**2.88**	J	**12.8**		**13**	
Barium	7440-39-3	2000	ug/l	**66.2**		**64.9**		**81**		**10.1**		**58.1**		**58.1**		**5.29**		**6.03**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**25500**	J	**25000**		**14600**		**13500**		**28800**		**28600**		**12800**		**12500**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	**3.17**	J	**3.18**	J	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**3.61**		**3.68**		**47.2**		**40.5**		**0.817**	J	**0.788**	J	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**0.38**	J	**0.312**	J	**4.58**		**3.29**		< 0.300	U	**0.34**	J	< 0.300	U	< 2.00	U
Iron	7439-89-6	14000	ug/l	**3610**		**3440**		**875**		**93.2**	J	**9660**		**10200**		**68.1**	J	**211**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**9760**		**9680**		**2420**		**2050**		**10900**		**11000**		**4160**		**4040**	
Manganese	7439-96-5	300	ug/l	**149**		**144**		**32.4**		**12.5**		**190**		**193**		**249**		**287**	
Molybdenum	7439-98-7	100	ug/l	**0.546**	J	**0.515**	J	**0.397**	J	**0.242**	J	< 0.200	U	< 0.200	U	**12.2**		**11.2**	
Nickel	7440-02-0		ug/l	< 0.600	U	< 0.600	U	**10.4**		**8.45**		**3.7**		**3.69**		< 0.600	U	< 0.600	U
Potassium	7440-09-7		ug/l	**6290**		**6410**		**2640**		**2330**		**4630**		**4690**		**1910**		**1860**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**24000**		**23500**		**39200**		**36700**		**22300**	J	**22400**	J	**12900**		**12500**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	**0.243**		**0.136**	J	< 0.067	U	< 0.067	U	< 0.067	U	**0.0763**	J
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 20.0	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	**4.15**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	MW-T24		MW-T24		OW-2		OW-2		OW-3		OW-3		P-1		P-1	
			Sample Date	11/13/2019		11/13/2019		11/11/2019		11/11/2019		11/13/2019		11/13/2019		11/18/2019		11/18/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	**112**		**3300**		**457**		**465**		< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	**3.29**	J	< 2.00	U	**2.26**	J	**2.04**	J	**2.64**	J	**2.31**	J	**2.21**	J
Barium	7440-39-3	2000	ug/l	**92.3**		**106**		**97.2**		**92.8**		**36.6**		**37.8**		**14.4**		**14.7**	
Beryllium	7440-41-7		ug/l	< 0.200	U	**0.41**	J	**0.394**	J	**0.497**	J	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**149000**		**165000**		**14600**		**13800**		**7360**		**8030**		**33200**		**34300**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	**6.97**	J	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**1.37**		**2.92**		**0.605**	J	**0.568**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**1.52**	J	**12.5**		**0.519**	J	**0.374**	J	< 0.300	U	< 2.00	U	**0.423**	J	**0.396**	J
Iron	7439-89-6	14000	ug/l	**122**		**3830**		< 33.0	U	< 33.0	U	< 33.0	U	**135**		< 33.0	U	**44.9**	J
Lead	7439-92-1		ug/l	< 0.500	U	**4.6**		< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**35300**		**35100**		**3170**		**3130**		**1400**		**1520**		**8930**		**9100**	
Manganese	7439-96-5	300	ug/l	**1270**		**1460**		**81.8**		**77.8**		**1.75**	J	**2.12**	J	**1.1**	J	**4.44**	J
Molybdenum	7439-98-7	100	ug/l	**7.03**		**6.87**		< 0.200	U	< 0.200	U	**0.423**	J	< 1.00	U	**0.28**	J	**0.275**	J
Nickel	7440-02-0		ug/l	**3.01**		**6.38**		**5.19**		**4.73**		< 0.600	U	< 0.600	U	**1.1**	J	**1.05**	J
Potassium	7440-09-7		ug/l	**7060**		**7170**		**6940**		**7000**		**2280**		**2480**		**3230**		**3290**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**80000**		**88800**		**87000**		**97000**		**135000**		**136000**		**17500**		**17700**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	**0.78**	J	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	**0.0673**	J	**0.139**		< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	**25.9**		**59.7**		**0.0781**	J	**0.0774**	J	< 0.067	U	< 0.067	U	**0.0863**	J+	**0.132**	J+
Calc U-235/U-238			ug/l	**0.0025985**		**0.0023283**													
Vanadium	7440-62-2		ug/l	< 3.30	U	**9.18**	J	< 20.0	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	**11.6**	J	**39**		**3.41**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

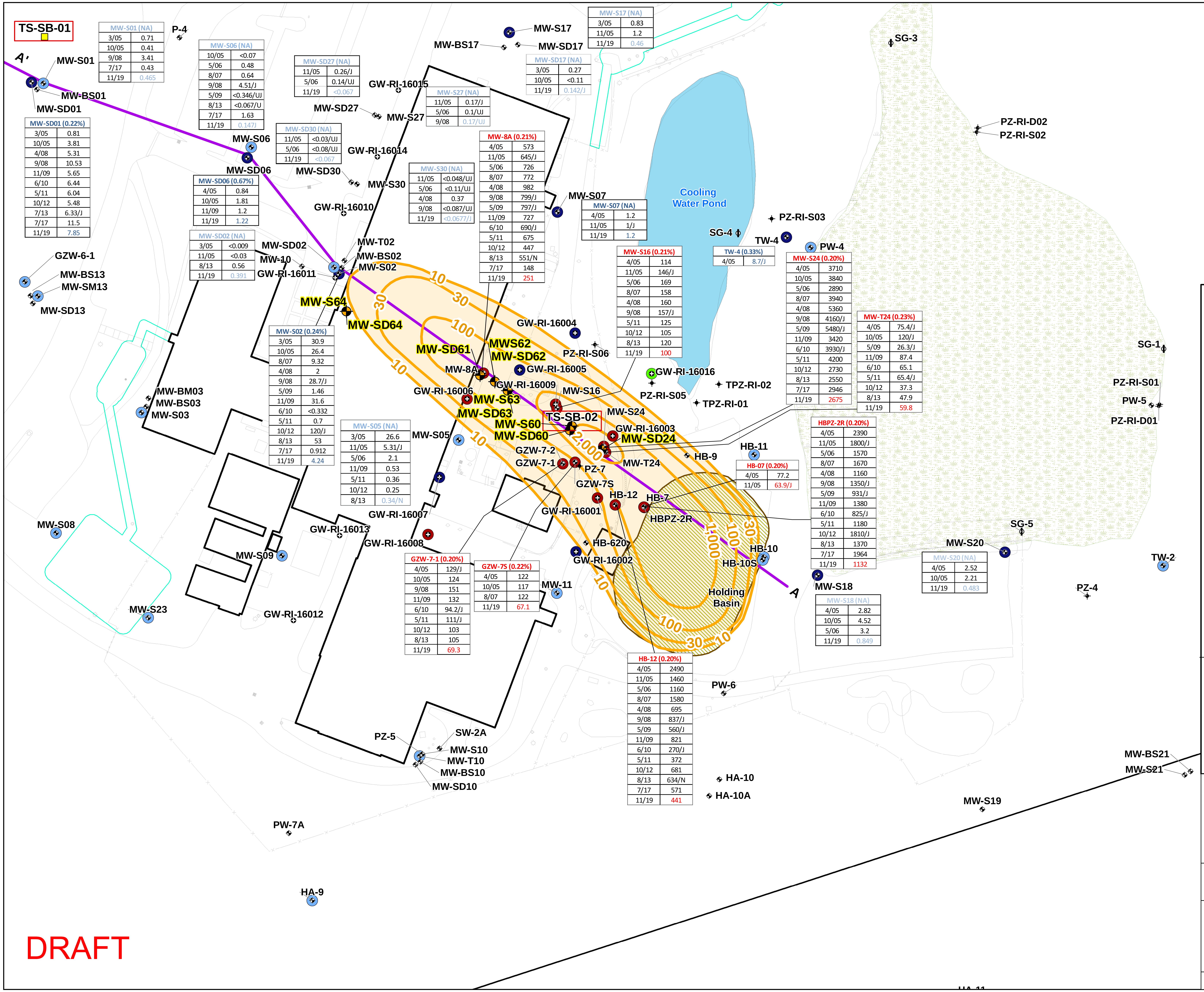
			Sample Location	P-1A		P-1A		P-2		P-2		P-3		P-3		P-4		P-4	
			Sample Date	11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/15/2019		11/13/2019		11/13/2019	
			Fraction	D		T		D		T		D		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Barium	7440-39-3	2000	ug/l	**16.9**		**15.5**		**15.9**		**16.1**		**15.2**		**15.4**		**23.6**		**21.4**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**27000**		**25600**		**17800**		**18000**		**18600**		**18300**		**26800**		**25600**	
Chromium	7440-47-3	100	ug/l	**3.51**	J	**3.43**	J	< 3.00	U	< 3.00	U	**3.52**	J	**3.38**	J	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	**0.514**	J	**0.497**	J	**0.481**	J	**0.346**	J	**0.591**	J	**0.464**	J	**0.56**	J	< 2.00	U
Iron	7439-89-6	14000	ug/l	< 33.0	U	**54.4**	J	< 33.0	U	**142**	J	**53.3**	J	**101**		< 33.0	U	< 33.0	U
Lead	7439-92-1		ug/l	**3.77**		**6.53**		< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**6160**		**5760**		**4430**		**4480**		**5040**		**5120**		**6500**		**6130**	
Manganese	7439-96-5	300	ug/l	**12.1**		**12.7**		< 1.00	U	**1.72**	J	< 1.00	U	**1.04**	J	< 1.00	U	**1**	J
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	< 0.200	U	**0.876**	J	**0.976**	J	**0.41**	J	**0.388**	J	**0.219**	J	< 1.00	U
Nickel	7440-02-0		ug/l	**2.84**		**2.68**		**0.985**	J	**0.934**	J	**2.41**		**2.24**		**1.18**	J	**0.901**	J
Potassium	7440-09-7		ug/l	**3340**		**3150**		**2990**		**2990**		**3170**		**3160**		**3460**		**3170**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**27200**	J	**25700**	J	**36700**		**36800**	J	**34800**	J	**34600**	J	**31900**		**33100**	
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	< 0.067	U	< 0.200	U	< 0.067	U	< 0.200	U
Calc U-235/U-238			ug/l																
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	**3.59**	J	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**3.52**	J	< 3.30	U

Table 2.3 - Total and Dissolved Metals - Sitewide Sampling Results - November 2019
Nuclear Metals, Inc. Superfund Site - West Concord, Massachusetts

			Sample Location	PT-09		PT-09		PT-11P		PT-11P		PW-6		PW-6 (dup)		PW-6		PW-6 (dup)		SW-1		SW-1	
			Sample Date	11/18/2019		11/18/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/13/2019		11/14/2019		11/14/2019	
			Fraction	D		T		D		T		D		D		T		T		D		T	
			Formation	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
Analyte	Cas No.	Limit	Unit																				
Aluminum	7429-90-5		ug/l	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U	< 19.3	U
Antimony	7440-36-0		ug/l	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U	< 1.00	U
Arsenic	7440-38-2	10	ug/l	**2.18**	J	**2.38**	J	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	**2.06**	J
Barium	7440-39-3	2000	ug/l	**26.7**		**25.7**		**36.1**		**34.4**		**28.6**		**27.8**		**26.5**		**27.3**		**23.8**		**25.2**	
Beryllium	7440-41-7		ug/l	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U
Cadmium	7440-43-9		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Calcium	7440-70-2		ug/l	**18000**		**18400**		**24300**		**24200**		**23600**		**24200**		**22900**		**23200**		**21400**		**21100**	
Chromium	7440-47-3	100	ug/l	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U
Cobalt	7440-48-4	6.0	ug/l	**1.47**		**1.47**		**0.679**	J	**0.683**	J	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Copper	7440-50-8	1300	ug/l	< 0.300	U	< 0.300	U	**0.701**	J	< 2.00	U	**0.537**	J	**0.656**	J	< 2.00	U	< 2.00	U	**67.4**		**118**	
Iron	7439-89-6	14000	ug/l	**2250**		**2350**		< 33.0	U	< 33.0	U	**3140**		**2790**		**6080**		**4880**		**2850**		**13600**	
Lead	7439-92-1		ug/l	< 0.500	U	< 0.500	U	< 0.500	U	< 0.500	U	**2.67**		**2.46**		**6.63**		**6.52**		< 0.500	U	< 0.500	U
Magnesium	7439-95-4		ug/l	**6060**		**5870**		**5790**		**5960**		**5830**		**5930**		**5380**		**5520**		**5790**		**5690**	
Manganese	7439-96-5	300	ug/l	**358**		**344**		< 1.00	U	< 1.00	U	**121**		**124**		**137**		**134**		**94.5**		**97.2**	
Molybdenum	7439-98-7	100	ug/l	< 0.200	U	**0.211**	J	< 0.200	U	< 0.200	U	< 0.200	U	< 0.200	U	< 1.00	U	< 0.200	U	**0.49**	J	**2.22**	
Nickel	7440-02-0		ug/l	**2.69**	J	**2.36**	J	**2.68**		**2.64**		**1.37**	J	**1.14**	J	**1.21**	J	**1.14**	J	**1.01**	J	**0.946**	J
Potassium	7440-09-7		ug/l	**3910**		**3800**		**3990**		**4170**		**2990**	J	**3100**		**2720**	J	**2770**		**3060**		**3010**	
Selenium	7782-49-2		ug/l	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U	< 2.00	U
Silver	7440-22-4		ug/l	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U	< 0.300	U
Sodium	7440-23-5		ug/l	**13700**		**14300**		**98600**		**99600**		**26600**		**27100**		**27000**		**27700**		**28300**	J	**28100**	J
Thallium	7440-28-0		ug/l	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U	< 0.600	U
Thorium	7440-29-1	0.33	ug/l	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U	< 0.700	U
Uranium-235	15117-96-1	30	ug/l	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U	< 0.010	U
Uranium-238	7440-61-2	30	ug/l	< 0.067	U	**0.0766**	J	< 0.200	U	**0.107**	J	< 0.067	U	< 0.067	U	< 0.200	U	< 0.067	U	< 0.067	U	< 0.067	U
Calc U-235/U-238			ug/l																				
Vanadium	7440-62-2		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U
Zinc	7440-66-6		ug/l	< 3.30	U	< 3.30	U	< 3.30	U	< 3.30	U	**427**		**429**		**476**		**466**		< 3.30	U	< 3.30	U

Notes:

J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the result may be biased high.
U	The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
UJ	The analyte was analyzed for but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
(dup)	Duplicate sample.
ug/l	Micrograms per liter
Limit	Based on EPA MCL in Overburden and Bedrock except for Thorium (ILCR value), Cobolt (HI value), Copper (Overburden Action Level). Barium MCL is Bedrock only. Shaded cells exceed limit and apply to total metal concentrations only.
Bold	Analyte detected above the laboratory reporting limit (detect).
T	Total metal concentration
D	Dissolved metal concentration.



MW-S01 (NA)	
3/05	0.71
10/05	0.41
9/08	3.41
7/17	0.43
11/19	0.465

MW-SD01 (0.22%)	
3/05	0.81
10/05	3.81
4/08	5.31
9/08	10.53
11/09	5.65
6/10	6.44
5/11	6.04
10/12	5.48
7/13	6.33/J
7/17	11.5
11/19	7.85

MW-S06 (NA)	
10/05	<0.07
5/06	0.48
8/07	0.64
9/08	4.51/J
5/09	<0.346/UJ
8/13	<0.067/U
7/17	1.63
11/19	0.147J

MW-SD06 (0.67%)	
4/05	0.84
10/05	1.81
11/09	1.2
11/19	1.22

MW-SD02 (NA)	
3/05	<0.009
11/05	<0.03
8/13	0.56
11/19	0.391

MW-SD27 (NA)	
11/05	0.26/J
5/06	0.14/UJ
11/19	<0.067

MW-SD30 (NA)	
11/05	<0.03/UJ
5/06	<0.08/UJ
11/19	<0.067

MW-S27 (NA)	
11/05	0.17/J
5/06	0.1/UJ
9/08	0.17/UJ

MW-S30 (NA)	
11/05	<0.048/UJ
5/06	<0.11/UJ
4/08	0.37
9/08	<0.087/UJ
11/19	<0.0677/J

MW-8A (0.21%)	
4/05	573
11/05	645/J
5/06	726
8/07	772
4/08	982
9/08	799/J
5/09	797/J
11/09	727
6/10	690/J
5/11	675
10/12	447
8/13	551/N
7/17	148
11/19	251

MW-S17 (NA)	
3/05	0.83
11/05	1.2
11/19	0.46

MW-SD17 (NA)	
3/05	0.27
10/05	<0.11
11/19	0.142/J

MW-S07 (NA)	
4/05	1.2
11/05	1/J
11/19	1.2

MW-S16 (0.21%)	
4/05	114
11/05	146/J
5/06	169
8/07	158
4/08	160
9/08	157/J
5/11	125
10/12	105
8/13	120
11/19	100

TW-4 (0.33%)	
4/05	8.7/J

MW-S24 (0.20%)	
4/05	3710
10/05	3840
5/06	2890
8/07	3940
4/08	5360
9/08	4160/J
5/09	5480/J
11/09	3420
6/10	3930/J
5/11	4200
10/12	2730
8/13	2550
7/17	2946
11/19	2675

MW-T24 (0.23%)	
4/05	75.4/J
10/05	120/J
5/09	26.3/J
11/09	87.4
6/10	65.1
5/11	65.4/J
10/12	37.3
8/13	47.9
11/19	59.8

MW-S02 (0.24%)	
3/05	30.9
10/05	26.4
8/07	9.32
4/08	2
9/08	28.7/J
5/09	1.46
11/09	31.6
6/10	<0.332
5/11	0.7
10/12	120/J
8/13	53
7/17	0.912
11/19	4.24

MW-S05 (NA)	
3/05	26.6
11/05	5.31/J
5/06	2.1
11/09	0.53
5/11	0.36
10/12	0.25
8/13	0.34/N

HBPZ-2R (0.20%)	
4/05	2390
11/05	1800/J
5/06	1570
8/07	1670
4/08	1160
9/08	1350/J
5/09	931/J
11/09	1380
6/10	825/J
5/11	1180
10/12	1810/J
8/13	1370
7/17	1964
11/19	1132

HB-07 (0.20%)	
4/05	77.2
11/05	63.9/J

GZW-7-1 (0.20%)	
4/05	129/J
10/05	124
9/08	151
11/09	132
6/10	94.2/J
5/11	111/J
10/12	103
8/13	105
11/19	69.3

GZW-7S (0.22%)	
4/05	122
10/05	117
8/07	122
11/19	67.1

HB-12 (0.20%)	
4/05	2490
11/05	1460
5/06	1160
8/07	1580
4/08	695
9/08	837/J
5/09	560/J
11/09	821
6/10	270/J
5/11	372
10/12	681
8/13	634/N
7/17	571
11/19	441

MW-S18 (NA)	
4/05	2.82
10/05	4.52
5/06	3.2
11/19	0.849

MW-S20 (NA)	
4/05	2.52
10/05	2.21
11/19	0.483

Legend

- ⌖ Monitoring Well
- ✦ Piezometer
- ɸ Staff Gauge
- ⊕ Groundwater Profiling Location
- 🟨 Proposed Soil Sample Location
- ⊕ Proposed Monitoring Well
- ▨ Holding Basin Source Control Area
- ▭ Septic Fields
- ▨ Wetlands
- 🟦 Surface Water
- — Uranium Contour in Overburden Groundwater, November 2019 (µg/L)
- — Cross Section A-A"

Most Recent Total Uranium

- ● < 1 µg/L
- ● 1.01 - 10 µg/L
- ● 10.01 - 20 µg/L
- ● 20.01 - 30 µg/L
- ● > 30.01 µg/L MCL Exceedance in Overburden

Historical Total Uranium (µg/L)

HBPZ-2R (0.20%)	
Date	Total Uranium (µg/L)
8/13	1370
7/17	1964
11/19	1132

(0.21%) Represents the U-235% in the most recent sample data through November 2019

Notes:
1. Although concentrations shown are for total uranium, results shown are primarily depleted uranium (U-235% <0.6%).
2. Tabular summaries at wells downgradient of elevated total uranium are displayed for illustrative purposes only.
3. µg/L = micrograms per liter.
4. U = Not detected at or above the method detection limit shown.
5. J = Estimated value.
6. N = Indicates presumptive evidence of a compound. This flag is usually used for a tentatively identified compound, where the identification is based on a mass spectral library search.
7. Most Recent concentration text color within tabular summaries on figure coded by concentration ranges listed above.

Depleted Uranium in Overburden Groundwater - Data Through November 2019 and Proposed Monitoring Wells

Nuclear Metals Inc. Superfund Site
Concord, Massachusetts

Feet
0 20 40 80 120 160

Geosyntec consultants

de maximis, inc.

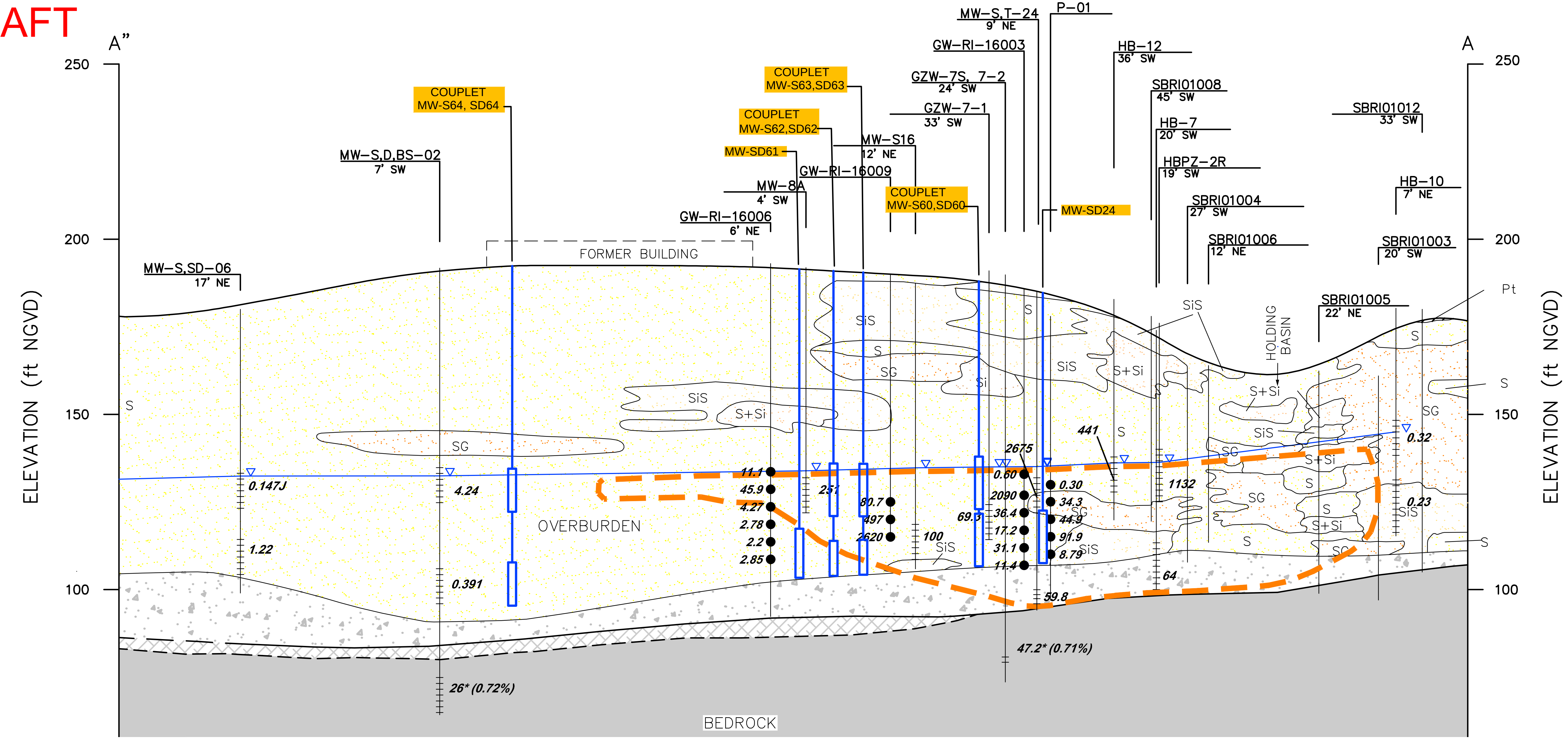
Figure
2-5

Acton, Massachusetts

JUNE-2020

G:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 2-5 Depleted Uranium in OB GW_v2.mxd

DRAFT



* – NATURAL ISOTOPIC SIGNATURE

LEGEND:

OVERBURDEN

▨	SG – SAND AND GRAVEL
▨	S – SAND
▨	SiS – SILTY SAND
▨	S+Si – SAND AND SILT
▨	Si – SILT
▨	TILL
▨	FRACTURED BEDROCK
▨	BEDROCK
▽	GROUNDWATER LEVEL
┼	SCREEN INTERVAL
●	GROUNDWATER PROFILE SAMPLE
124	TOTAL URANIUM CONCENTRATION (µg/L)
‒ ‒	TOTAL URANIUM > 30 µg/L
ft NGVD	FEET NATIONAL GEODETIC VERTICAL DATUM
(0.25%)	REPRESENTS THE U-235% IN THE MOST RECENT SAMPLE DATA THROUGH NOVEMBER 2019

PROPOSED WELL

COUPLET
MW-S64, SD64

APPROXIMATE SCREENED INTERVAL (SCREEN INTERVALS WILL BE SELECTED BASED ON FIELD OBSERVATIONS)

HORIZONTAL SCALE:
0 30' 60'

0 15' 30'
VERTICAL SCALE:

NOTES:
1. REFER TO FIGURE 2-5 FOR CROSS SECTION LOCATION.
2. URANIUM DATA PRESENTED IS THE MOST RECENT AT EACH LOCATION THROUGH NOVEMBER 20197.
3. ALTHOUGH CONCENTRATIONS SHOWN ARE FOR TOTAL URANIUM, RESULTS SHOWN ARE PRIMARILY DEPLETED URANIUM (U-235% <0.6%)

Depleted Total Uranium Distribution and Proposed Monitoring Wells in Cross Section

NUCLEAR METALS INC. SUPERFUND SITE
CONCORD, MASSACHUSETTS

Geosyntec consultants

ACTON, MASSACHUSETTS | JUNE 2020

Figure
2-6

T:\Projects_CADD\N\NMI (Nuclear Metals Superfund Site)\FIGURES\2020 SECTIONS\BR0090B-F002 (SECT A w PROP WELL).dwg

MW-BS32 (NA)	
11/19	0.794

MW-BS15 (0.72%)	
8/07	19.9
11/07	18/J
4/08	16
9/08	13.6
5/09	12.5/J
11/09	12.8
6/10	11.5
5/11	9.61/J
10/12	12.7
7/13	12.6
11/17	9.3
11/19	5.9

MW-BM15 (NA)	
04/05	N/A
11/05	N/A
08/07	19.9
11/07	0.13/J
04/08	0.17
09/08	0.001
11/19	<0.067/U

MW-BS26 (NA)	
04/05	<0.065
10/05	<0.03
09/08	<0.045
11/19	<0.067/U

GZW-8-2 (0.84)	
04/05	1
10/05	0.16
11/19	0.7

MW-BS22 (0.73%)	
04/05	23.8
10/05	16.3
11/19	12.2

MW-BS25 (NA)	
04/05	0.12
10/05	<0.049
11/19	0.72

ML-1-3 (0.74%)	
04/05	8.6
10/05	14.6
11/19	10.4

ML-3-3 (0.74%)	
04/05	19.1
10/05	7
11/19	28.3/J

GZW-11-2 (NA)	
04/05	0.79/J
10/05	0.97
11/19	0.76

MW-BS01 (0.73%)	
04/05	6.4
10/05	7.5
04/08	4.3
09/08	5.6
11/19	5.5

MW-BS17 (0.71%)	
03/05	1.6
10/05	2.1
11/19	1.25J

MW-BS02 (0.72%)	
3/05	2.11
10/05	106
5/06	122
8/07	134
9/08	134/J
11/09	138
6/10	131/J
5/11	131/J
10/12	146/J
8/13	132
11/19	26

MW-BS31 (NA)	
04/05	NA
11/05	NA
08/07	0.87
11/07	0.78/J
09/08	<0.17/UJ
05/11	<0.253/U
10/12	<0.2/UJ
07/13	<0.067/U
11/19	<0.077/U

MW-BS14 (NA)	
11/07	3.93/J
4/08	3.02
9/08	3.62
11/09	3.98
6/10	4.32
5/11	3.41/J
10/12	3.73/J
7/13	3.88/J
11/19	<0.15/UJ

MW-BS35 (NA)	
11/19	0.191J

MW-BS13 (0.75%)	
04/05	9.6
11/05	0.35/J
05/06	1.7
09/08	7.1
11/19	65.3

MW-BS28 (0.73%)	
11/05	34.6/J
5/06	29.2
8/07	36.3
4/08	33.1
9/08	33.7
5/09	35.5/J
11/09	38.3
6/10	39.9
5/11	30.5/J
10/12	34.5
7/13	34.5
7/17	37.2
11/19	28.6

GZW-7-2 (0.71%)	
4/05	45
10/05	50.1
8/07	77.5
9/08	97.3/J
5/09	84.4/J
11/09	53.8
6/10	49.1
5/11	50.2/J
10/12	47.6/J
8/13	43.4
11/19	47.2

GZW-10-2 (0.72%)	
4/05	64/J
11/05	59.5/J
8/07	71.3
9/08	73.8
11/09	75.3
6/10	67.8
5/11	66.3
10/12	67.2
7/13	76.9
11/19	71.1

MW-BS04 (NA)	
04/05	1.2
10/05	0.98
11/19	0.23

MW-BS03 (0.73%)	
4/05	218/J
11/05	204/J
8/07	195
9/08	142
5/09	179/J
11/09	154
6/10	135
5/11	151
10/12	82.6
8/13	151/N
7/17	56.7
11/19	69.6

MW-BM03 (0.73%)	
8/07	17.6
11/07	48.3/J
9/08	107
5/09	90.8/J
11/09	6.52
6/10	97.8
5/11	143/J
10/12	116
8/13	143/N
11/19	45.3

MW-BS10 (0.68%)	
4/05	5.53/J
10/05	28.6
5/06	39.9
8/07	44.9
9/08	39.8
5/09	41.6/J
6/10	35
5/11	34.4
10/12	28.4
7/13	32.2
11/19	31.5

SW-2A (0.72%)		
08/07	21.3	249'
08/07	6.7	490'
11/19	2.14	

MW-BS21 (0.7%)	
4/05	7.05/J
11/05	7.25/J
5/06	14.1
7/17	18.2
11/19	7.5/J

MW-BS12 (0.73%)	
04/05	7.1
11/05	4.7/J
05/06	1.5
11/19	6.4

Legend

⌖	Monitoring Well
✦	Piezometer
ɸ	Staff Gauge
▨	Wetlands
🟦	Surface Water
▭	Nuclear Metals Inc. Property Boundary
▭	Septic Fields
▪ ▪ ▪ ▪	Uranium MCL Exceedance (>30 µg/L)
━	Cross Section B-B'

Most Recent Total Uranium

●	< 1 µg/L
●	1.01 - 10 µg/L
●	10.01 - 20 µg/L
●	20.01 - 30 µg/L
●	> 30.01 µg/L MCL Exceedance in Overburden

Historical Total Uranium (µg/L)

MW-BS17 (0.71%)	
Date	**Total Uranium (µg/L)**
03/05	**1.6**
10/05	**2.1**
11/19	**1.4**

Notes:
1. The uranium concentrations shown represent total uranium. Uranium in bedrock groundwater is characterized as isotopically natural (U-235% > 0.6%).
2. Percentages in the headers of the concentration tables for each well represent the U-235 to U-238 ratio in the most recent sample collected. Most recent concentration text color is coded by concentration ranges listed above.
3. < = less than laboratory method detection limit.
4. J = estimated detection below method quantitation limit.
5. MCL = Maximum Contaminant Level.
6. The B-B' cross section is presented on Figure 2-9.

Total Uranium Concentrations in Bedrock Groundwater Historical Data through November 2019

Nuclear Metals Inc. Superfund Site
Concord, Massachusetts

0 45 90 180 270 360 Feet

Geosyntec consultants

de maximis, inc.

Figure

2-7.1

Acton, Massachusetts

JUNE-2020

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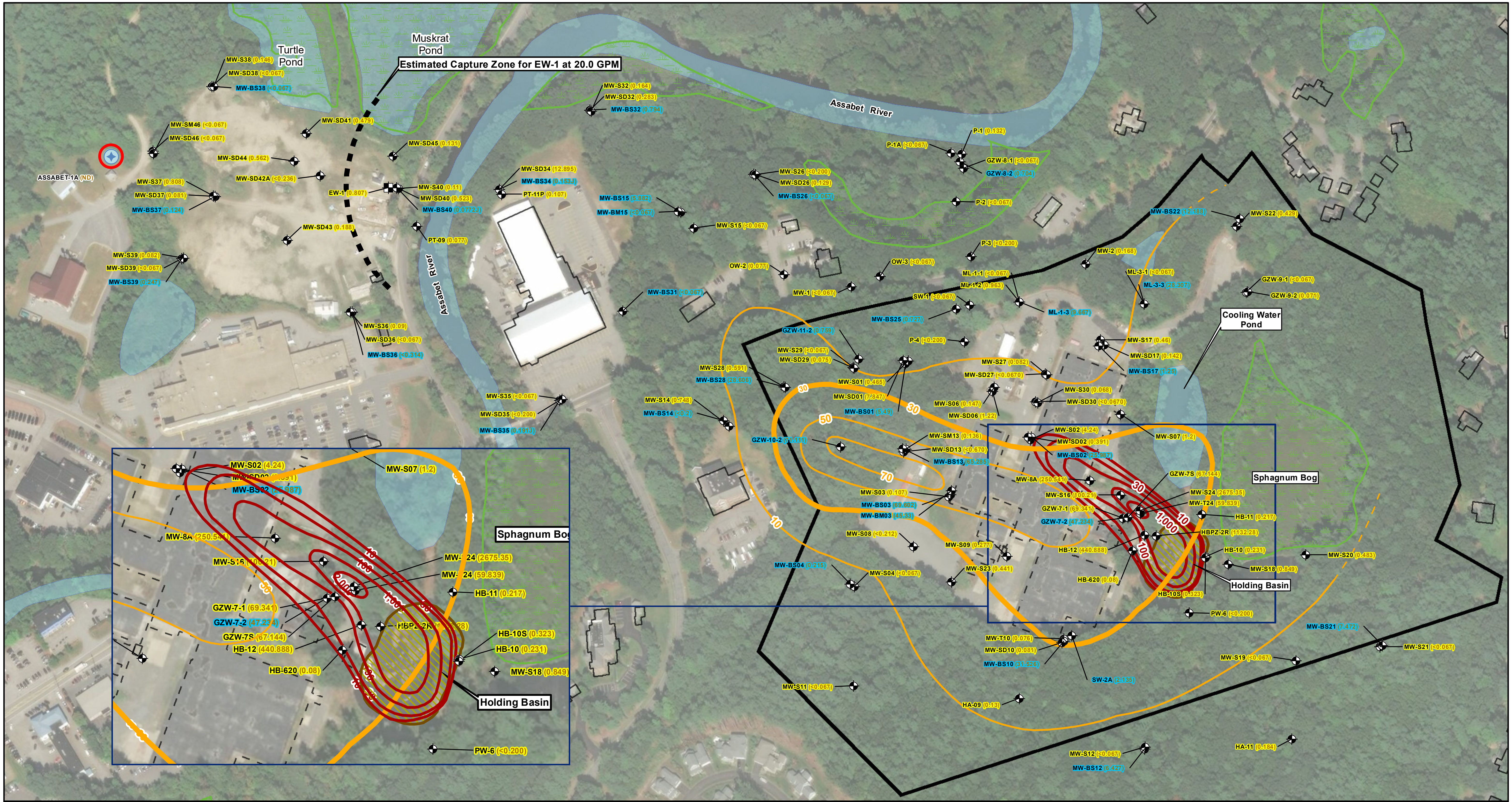


Legend

- Monitoring Well
- Extraction Well
- Active Public Water Supply Well
- 🟩 Wetlands
- Surface Water
- Site Boundary
- Former Building Concrete Foundation
- Building Outline
- Uranium ISO Contour in Bedrock November 2019 (µg/L)
- Estimated Uranium ISO Concentration Contour in Bedrock November 2019 ug/L
- Uranium Contour in Overburden Groundwater, November 2019 (µg/L)

DRAFT

(99.1) Uranium Distribution November 2019 (µg/L)

MW-S32 Overburden Monitoring Well

MW-BS32 Bedrock Monitoring Well

N

0 200 Feet

Uranium Distribution in Overburden and Bedrock Groundwater November 2019

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants

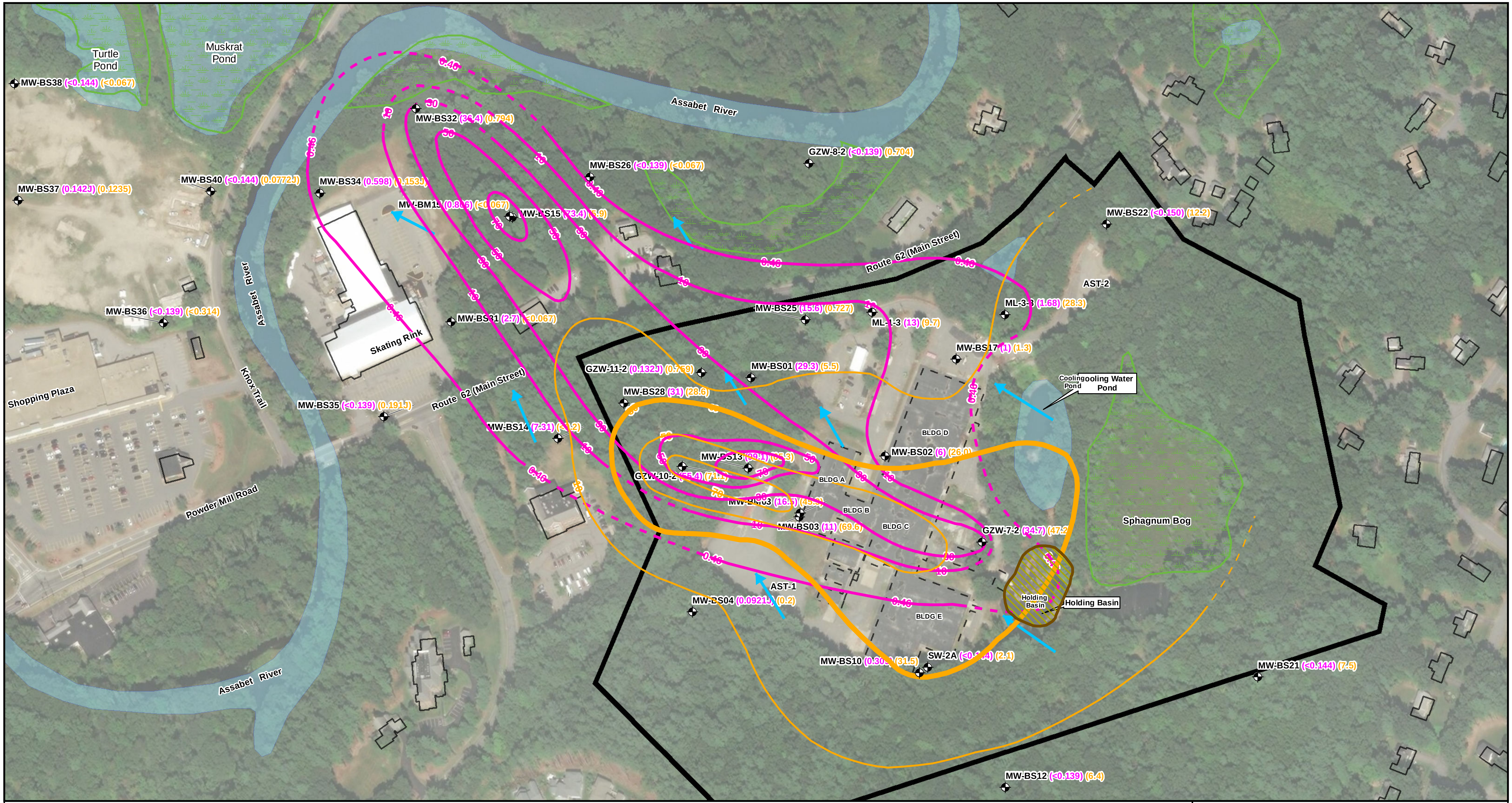
de maximis, inc.

Acton, Massachusetts

June 2020

Figure 6b

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 6b – Uranium in OB and BDRK_v2.mxd 2/26/2020 10:45:24 AM



Legend

- Bedrock Monitoring Well
- Site Boundary
- Building Outline
- Former Building Concrete Foundation
- Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations
- Surface Water
- Wetlands
- Uranium ISO Contour in Bedrock November 2019 (µg/L)
- Estimated Uranium ISO Concentration Contour in Bedrock November 2019 ug/L
- 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
- Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
- 0.57 1,4-Dioxane Concentrations November 2019 (µg/L)
- 76.9 Uranium Concentrations November 2019 (µg/L)

DRAFT

Note:
1. The uranium concentrations shown represent total uranium. Uranium in bedrock groundwater is characterized as isotopically natural (U-235% > 0.6%).
2. < = less than laboratory method detection limit.
3. J = estimated detection below method quantitation limit.

N

0 220 Feet

Uranium and 1,4-Dioxane Concentrations in Bedrock Groundwater - November 2019

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants
de maximis, inc.

Acton, Massachusetts
June 2020

Figure 2.7

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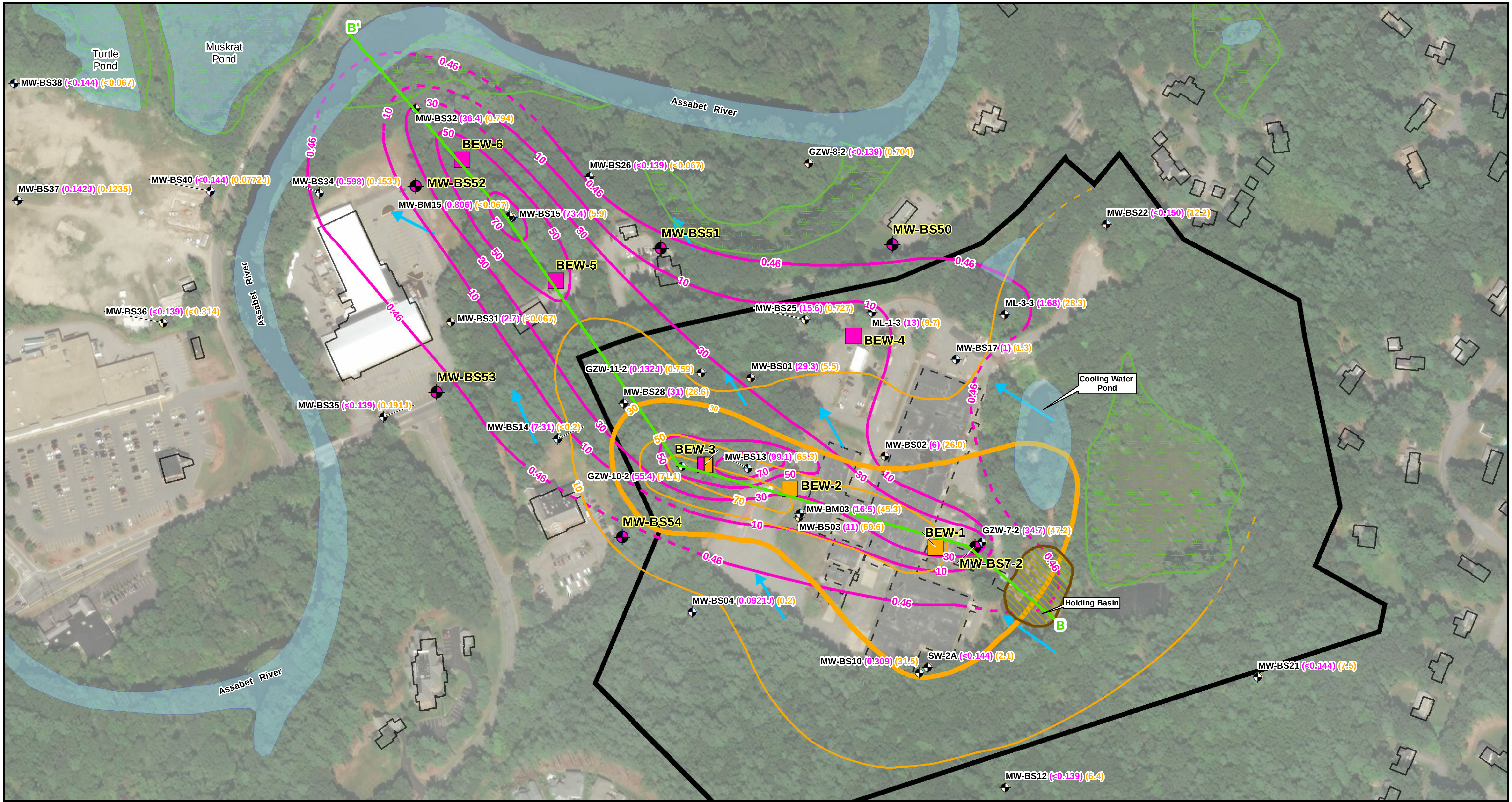


Legend

⊕	Bedrock Monitoring Well	▭	Site Boundary	—	Cross Section B-B'
🟧	Proposed Open Bedrock Well for Uranium Rebound Testing	—	Building Outline	—	Uranium ISO Contour in Bedrock November 2019 (µg/L)
🟪	Proposed Open Bedrock Well for 1,4-Dioxane Rebound Testing	- - -	Former Building Concrete Foundation	- - -	Estimated Uranium ISO Concentration Contour in Bedrock November 2019 ug/L
▮▮	Proposed Open Bedrock Well for 1,4-Dioxane and Uranium Rebound Testing	→	Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations	—	1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
⊕	Proposed Bedrock Monitoring Well	🟩	Wetlands	- - -	Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
		▭	Surface Water		

0.57 1,4-Dioxane Concentrations November 2019 (µg/L)

76.9 Uranium Concentrations November 2019 (µg/L)

Note:
1. The uranium concentrations represent isotopically natural uranium.

DRAFT

N

0 220 Feet

Proposed Bedrock Wells for Uranium Rebound and 1,4-dioxane Delineation and Rebound Testing

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants

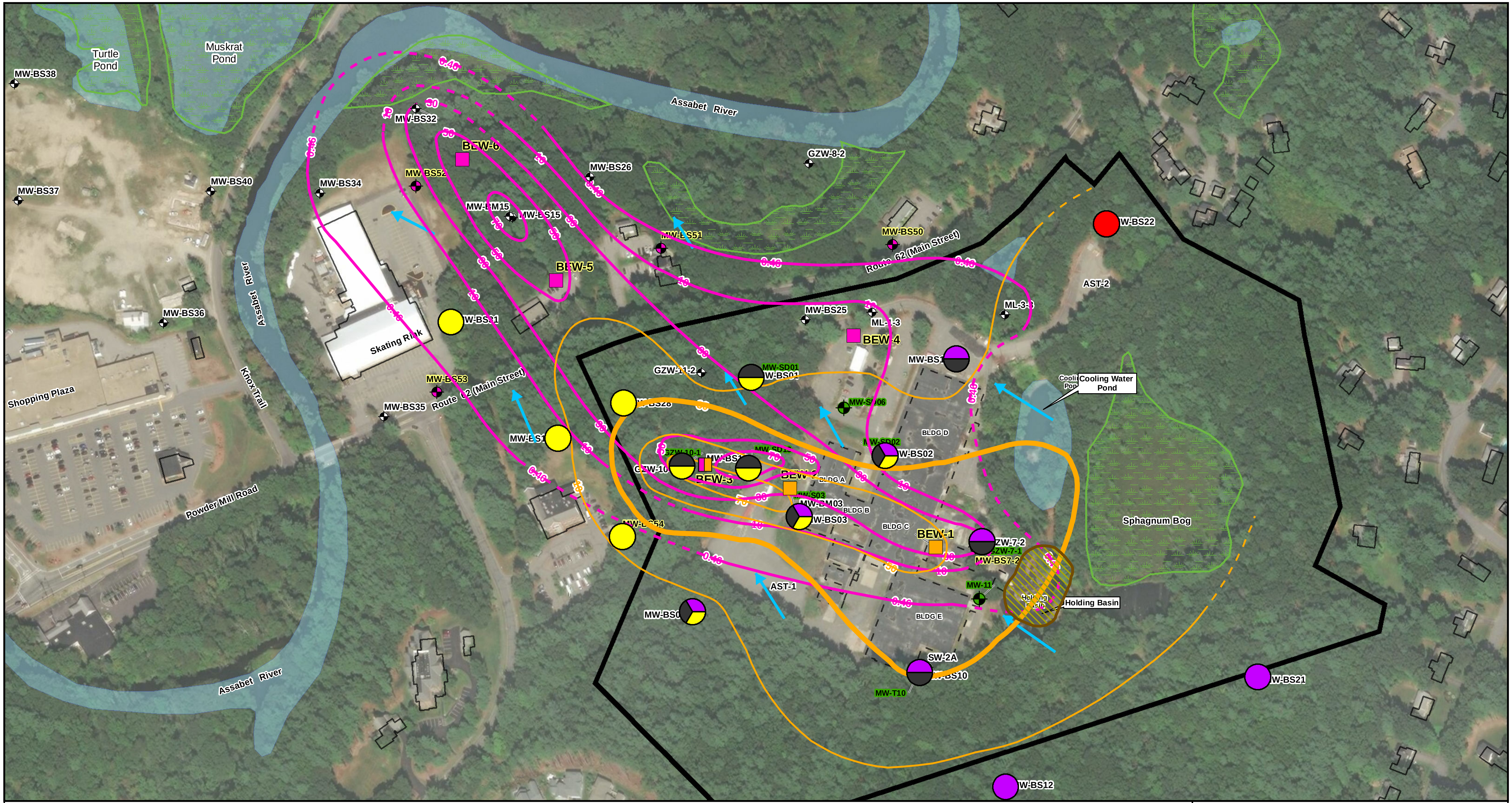
de maximis, inc.

Acton, Massachusetts

June 2020

Figure 3-3

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 3-3 - Proposed Bedrock Wells for Uranium Rebound and 1,4-dioxane Delineation and Rebound Testing.mxd 2/21/2020 3:58:31 PM



Legend

- ⌖ Bedrock Monitoring Well
- 🟧 Proposed Open Bedrock Well for Uranium Rebound Testing
- 🟪 Proposed Open Bedrock Well for 1,4-Dioxane Rebound Testing
- Proposed Open Bedrock Well for 1,4-Dioxane and Uranium Rebound Testing
- Proposed Bedrock Monitoring Well
- Proposed Manual Water Level Monitoring Locations Drilling and Rebound Testing
- Site Boundary
- Wetlands
- Surface Water
- Building Outline
- Former Building Concrete Foundation
- Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations
- Uranium ISO Contour in Bedrock November 2019 (µg/L)
- 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
- Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
- 0.57 1,4-Dioxane Concentrations November 2019 (µg/L)
- 76.9 Uranium Concentrations November 2019 (µg/L)
- 🟥 Ambient/Background Electronic Water Level Monitoring Location
- 🟪 Proposed Electronic Water Level Monitoring Locations for BEW-1 Drilling and Rebound Testing
- ⬛ Proposed Electronic Water Level Monitoring Locations for BEW-2 Drilling and Rebound Testing
- 🟨 Proposed Electronic Water Level Monitoring Locations for BEW-3 Drilling and Rebound Testing

DRAFT

N

0 220 Feet

Drilling and Pumping Monitoring Locations for Bedrock Uranium Rebound Testing

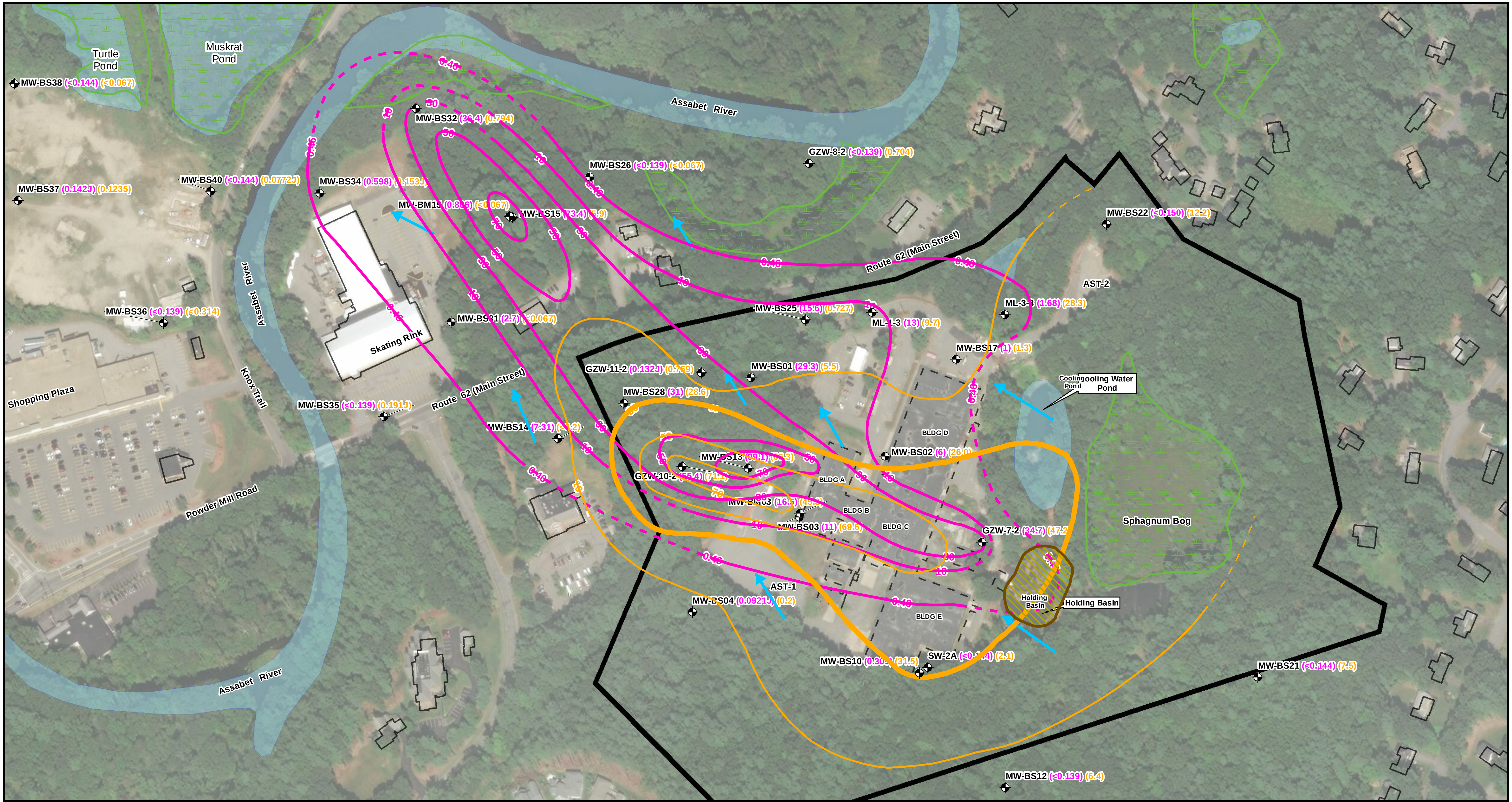
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants
de maximis, inc.

Acton, Massachusetts
June 2020

Figure
3-4

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 3-4 - Drilling and Pumping Water Level Monitoring Locations for Bedrock Uranium Rebound Testing.mxd 2/21/2020 4:02:00 PM



Legend

⊕	Bedrock Monitoring Well	▭	Surface Water	━	Uranium ISO Contour in Bedrock November 2019 (µg/L)
▬	Site Boundary	🟩	Wetlands	‐ ‐	Estimated Uranium ISO Concentration Contour in Bedrock November 2019 ug/L
─	Building Outline			━	1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
‐ ‐	Former Building Concrete Foundation			‐ ‐	Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
→	Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations				

0.57 1,4-Dioxane Concentrations November 2019 (µg/L)

76.9 Uranium Concentrations November 2019 (µg/L)

Note:
1. The uranium concentrations shown represent total uranium. Uranium in bedrock groundwater is characterized as isotopically natural (U-235% > 0.6%).
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DRAFT

Uranium and 1,4-Dioxane Concentrations in Bedrock Groundwater - November 2019

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants
de maximis, inc.

Acton, Massachusetts
June 2020

Figure
6

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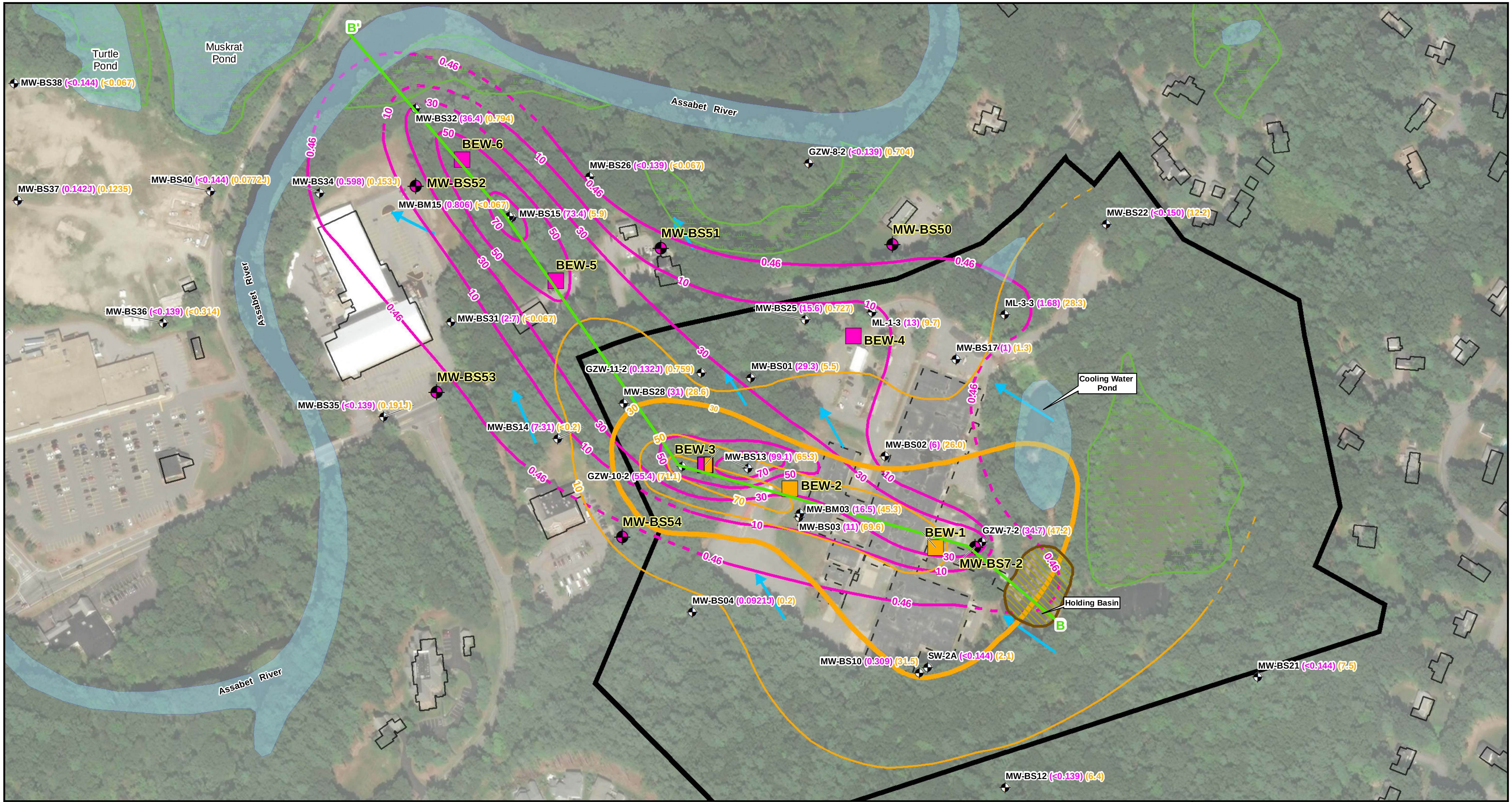


Legend

⊕ Bedrock Monitoring Well

🟧 Proposed Open Bedrock Well for Uranium Rebound Testing

🟪 Proposed Open Bedrock Well for 1,4-Dioxane Rebound Testing

🟪🟧 Proposed Open Bedrock Well for 1,4-Dioxane and Uranium Rebound Testing

⊕ Proposed Bedrock Monitoring Well

▭ Site Boundary

— Building Outline

- - Former Building Concrete Foundation

→ Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations

🟩 Wetlands

▭ Surface Water

— Cross Section B-B'

— Uranium ISO Contour in Bedrock November 2019 (µg/L)

- - Estimated Uranium ISO Concentration Contour in Bedrock November 2019 ug/L

— 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)

- - Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)

0.57 1,4-Dioxane Concentrations November 2019 (µg/L)

76.9 Uranium Concentrations November 2019 (µg/L)

DRAFT

Note:
1. The uranium concentrations represent isotopically natural uranium.

N

0 220 Feet

Proposed Bedrock Wells for Uranium Rebound and 1,4-dioxane Delineation and Rebound Testing

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants

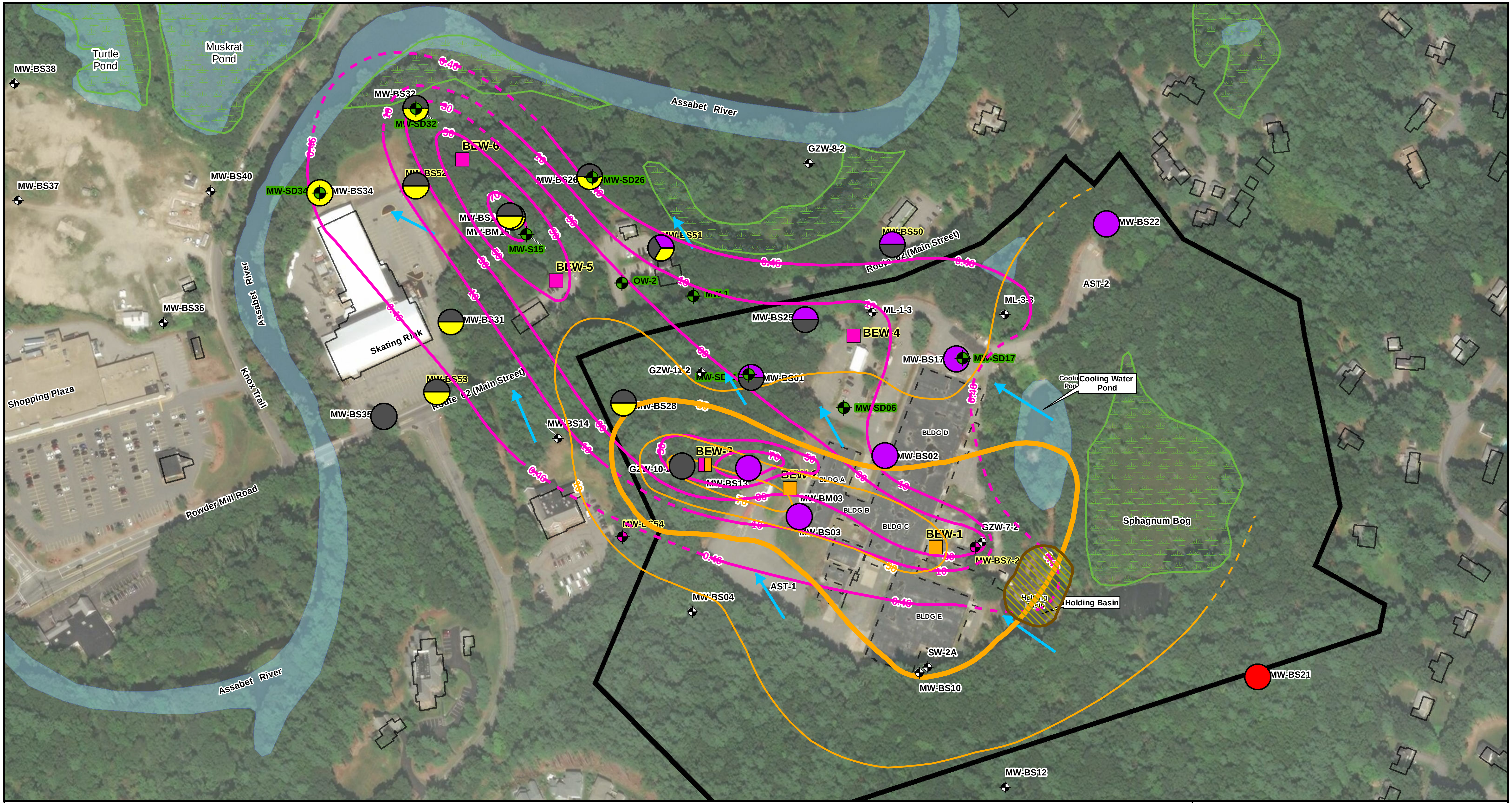
de maximis, inc.

Acton, Massachusetts

June 2020

Figure
7

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 3-3 - Proposed Bedrock Wells for Uranium Rebound and 1,4-dioxane Delineation and Rebound Testing.mxd 2/21/2020 3:58:31 PM



⊕ Bedrock Monitoring Well

🟧 Proposed Open Bedrock Well for Uranium Rebound

🟪 Proposed Open Bedrock Well for 1,4-Dioxane Rebound

Proposed Open Bedrock Well for 1,4-Dioxane and Uranium Rebound Testing

⊕ Proposed Bedrock Monitoring Well

⊕ Proposed Manual Water Level Monitoring Locations Drilling and Rebound Testing

Site Boundary

Wetlands

Surface

Building

Former Building Concrete

Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations

Uranium ISO Contour in Bedrock November 2019 (µg/L)

1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)

Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)

0.57 1,4-Dioxane Concentrations November 2019 (µg/L)

76.9 Uranium Concentrations November 2019 (µg/L)

🟥 Ambient/Background Electronic Water Level Monitoring Location

🟪 Proposed Electronic Water Level Monitoring Locations for BEW-4 Drilling and Rebound Testing

⬛ Proposed Electronic Water Level Monitoring Locations for BEW-5 Drilling and Rebound Testing

🟨 Proposed Electronic Water Level Monitoring Locations for BEW-6 Drilling and Rebound Testing

DRAFT

Drilling and Pumping Monitoring Locations for Bedrock 1,4-Dioxane Rebound Testing

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants

de maximis, inc.

Acton, Massachusetts

June 2020

Figure 9

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 9 - 14Dioxane Pie Charts.mxd 2/24/2020 12:21:06 PM

Final Remedial Design Work Plan
Appendix E

NUCLEAR METALS, INC. SUPERFUND SITE

CONCORD, MASSACHUSETTS

Remedial Design Work Plan - Appendix E

In Situ Sequestration
Treatability Study Work Plan

Prepared for:

de maximis, inc.

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Prepared by:

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289 Great Road, Suite #202

Acton, MA 01720

September 2020

TABLE OF CONTENTS

TABLE LIST

FIGURE LIST

ATTACHMENTS

LIST OF ACRONYMS

°C	degrees Celsius
µm	micron
µg/L	micrograms per liter
bgs	below ground surface
CD	consent decree
DO	dissolved oxygen
DPT	direct push technology
DU	depleted uranium
FS	feasibility study
FSP	field sampling plan
g	grams
GPS	global positioning system
Hazen	Hazen Research, Inc
HB	holding basin
HCl	hydrochloric acid
HNO3	nitric acid
ICP-MS	inductively coupled plasma mass spectrometry
ICP-OES	inductively coupled plasma optical emission spectroscopy
ISS	in situ stabilization
L	liter
M	molar
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mL	milliliter
mM	millimolar
NMI	Nuclear Metals Inc.
PDI	pre-design investigation
ppb	parts per billion
PVC	polyvinylchloride
PV	pore volume
QA/QC	quality assurance/quality control
QEMSCAN	Quantitative Evaluation of Minerals by SCANning electron microscopy
RA	Remedial Action
RD	Remedial Design
RDWP	remedial design work plan

LIST OF ACRONYMS Cont'd

ROI	radius of influence
RSO	Radiation Safety Officer
SMP	sodium monophosphate
SOP	standard operating procedure
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
STPP	sodium tripolyphosphate
TS	treatability study
U	isotopically natural uranium
Uranium	high-concentration DU
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VBW	vertical barrier wall
wt %	weight percent
XRD	X-ray diffraction
ZVI	solid zero valent iron

1. INTRODUCTION

The Consent Decree (CD) and the Statement of Work (SOW) provided as Appendix B to the CD describe the Remedial Design (RD)/Remedial Action (RA) activities to be performed for the Nuclear Metals, Inc. (NMI) Superfund Site (Site). These activities include in situ sequestration (ISS) of depleted uranium in Holding Basin (HB) soils and overburden groundwater and ISS of isotopically natural uranium in bedrock groundwater. Section 3.4(a) of the SOW requires performance of Pre-Design Investigations (PDIs) and Treatability Studies (TS) to support the ISS component of the remedy. The RD work plan (RDWP) to which this TS work plan is an attachment, provides Site background and the vision for ISS being implemented at the Site.

This TS work plan describes laboratory testing that will identify the product(s) and dose(s) for ISS amendments that will be used at the Site. The amendment and dose determined from treatability testing will be field tested as described in Appendix B, and collectively, the results from the TS and PDIs for uranium ISS will inform the RD. As described in this work plan, separate studies are needed to evaluate and select treatment amendment for high-concentration uranium impacted soils within the HB (TS ISS-1), uranium impacted overburden groundwater downgradient of the HB (TS ISS-2), and uranium in bedrock (TS ISS-3). Because of the varying uranium concentration, geochemical conditions and physical limitation (e.g., overburden versus bedrock) within different areas of the Site, a likely outcome of the TS is different ISS amendments and doses for separate areas of the Site.

With respect to geochemistry, treatability testing and remediation of impacted groundwater, there is no difference between depleted uranium in overburden and isotopically natural uranium in bedrock. Thus, the singular term “uranium” is used in this TS Work Plan for both depleted uranium in overburden groundwater and isotopically natural uranium in bedrock groundwater.

The following sections of this TS work plan provide a discussion of the background and objectives for these studies and a scope of work for each component of the TS.

2. BACKGROUND AND OBJECTIVES

Apatite II[1] was successfully demonstrated to sequester high-concentration uranium in overburden groundwater during the Feasibility Study (FS) pilot test program conducted in 2014. The pilot test used columns filled with 100% Apatite II. Results showed >99% uranium removal from the aqueous phase; the predominant sequestering mechanism was precipitation of sparingly soluble calcium uranyl phosphate minerals. Documentation of this pilot test is found in *Field and Laboratory Media Testing, for Depleted Uranium Sequestration in Overburden Groundwater*.[2] The treatability testing described herein is focused on evaluating the effectiveness of appropriate

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[1] Apatite II is the tradename of a meta-stable fish-bone-derived hydroxyapatite product produced by PIMS NW, Inc. (http://pimsnw.com).

[2] Geosyntec, 2014, Field and Laboratory Media Testing, for Depleted Uranium Sequestration in Overburden Groundwater, The Nuclear Metals Superfund Site, Concord, Massachusetts. Geosyntec, September, 2014.

concentrations of Apatite II and other amendments suitable for injection (as a solution or an aqueous suspension) into the subsurface. Because Apatite II is being tested at lower concentrations in this phase of testing, amendment performance may deviate from the results of the FS pilot study. Three additional amendments will also be tested during this TS.

Four amendments will be evaluated as part of this TS: solid preformed apatite (Apatite II), solid zero valent iron (ZVI), soluble sodium monophosphate (SMP), and soluble sodium tripolyphosphate (STPP, a phosphate polymer). The TS will identify the most effective amendment for removing aqueous-phase uranium, determine the minimum required dose for each amendment, and evaluate the longevity and stability of the sequestered uranium. Information regarding these amendments, including advantages and disadvantages, is presented in the amendment selection matrix below:

Amendment Selection Matrix

Amendment	Description	Advantages	Disadvantages	Target Media
#1 Apatite II (PIMS NW, Inc.)	Ground fishbone product. Calcium phosphate	Demonstrated to work effectively during FS. Approved by the United States Environmental Protection Agency (USEPA) in Site Record of Decision (ROD)	Preplanning is important to obtain sufficient supply when needed. Particle size results in uncertainty with ability to achieve significant radius of influence. Can increase phosphorous concentration in groundwater. Can contain trace quantities of arsenic. Contains organic matter – potential to induce reducing conditions.	Holding Basin Overburden Bedrock
#2 Soluble phosphate polymer: Sodium tripolyphosphate (STPP)	Tripolyphosphate consists of 3 orthophosphate molecules linked together ($Na_5P_3O_{10}$) In contact with water, this slowly hydrolyzes and releases orthophosphate	In theory, more soluble and slower to react with calcium than SMP (#3), thereby avoiding immediate precipitation at the injection point and allowing better distribution into the aquifer. Inexpensive	In practice, can form an amorphous gel with calcium that may have lower solubility than SMP (#3). Very slow to react and release orthophosphate. Significant reactive uncertainty with calcium and uranium; final solid phases formed may not be ideal (due to higher solubility of these phases than with SMP). Can contain significant quantities of arsenic depending upon purity and source.	Bedrock
#3 Soluble Orthophosphate: Sodium monophosphate (SMP)	Sodium monophosphate salt (Na_3PO_4)	Rapidly reacts with calcium to precipitate calcium phosphate (Apatite) in situ and also reacts with uranium to precipitate uranium phosphates.	Rapid reaction with calcium can limit distribution in aquifer. May not be sufficiently retained in aquifer due to limited sorption to soil. Uncertainty with respect to the final solid phases formed, some amorphous uranium phosphates may dominate solids. Can contain significant arsenic depending upon purity and source.	Overburden

Amendment	Description	Advantages	Disadvantages	Target Media
#4 Zero Valent Iron (ZVI)	Granular (micro- or nanoscale) ZVI from Connolly or Hepure, or other supplier	Reacts with water to form iron corrosion products that will sorb uranium; will also consume dissolved oxygen and drive system reducing, resulting in precipitation of low-solubility U(IV) solids. Micro- or nanoscale forms are injectable. Arsenic may be retained on ZVI. ZVI not likely to introduce arsenic.	Reactions with soluble uranium require that the ZVI surface remains reactive – soluble ions such as calcium, bicarbonate, and sulfate can react on its surface and passivate (reduce reactivity) of ZVI. As corrosion occurs, reactive surfaces are consumed, and treatment capacity becomes limited; potential for desorption of uranium due to displacement by other ions that may sorb to the iron surface. Can generate hydrogen, resulting in accumulation of hydrogen in soil vapor.	Holding Basin Overburden Bedrock

Apatite II has been shown in previous evaluations at NMI to be effective in sequestering uranium from overburden groundwater via formation of low-solubility uranium phosphate mineral phases (e.g., chernikovite, $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$). Additionally, apatite may sequester uranium via substitution within the apatite phase and formation of poorly crystalline calcium-uranium-phosphate precursor phases. Apatite II is a unique form of calcium phosphate because it contains nanocrystalline apatite in a bulk structure that is generally more amorphous (less crystalline) than other phosphate sources. This combination provides high solubility and surface reactivity as well as seed crystals for precipitation of metal-apatite phases such as chernikovite (uranyl phosphate) and autunite (calcium uranyl phosphate). Poor crystallinity makes the solubility of the Apatite II higher than other solid sources of phosphate. Apatite II reacts with uranium through direct sorption and dissolution of the primary apatite mineral to form secondary uranium-bearing phosphate mineral phases.

Our expectation is that Apatite II will continue to show the best results and be the most practical amendment (the amendment with the least uncertainty in terms of treatment effectiveness and permanence) for full-scale application. However, the other amendments may perform better in certain systems and may also be used in combination with Apatite II depending upon their performance. For example, STPP has been used in tailing systems and groundwater for in situ uranium treatment (Gillow et al. 2013[3]), and ZVI has been shown to effectively sequester uranium

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[3] Gillow, J., Griffin, A., Christoffersen, L., Divine, C., Hay, M., and DeDycker, P. 2013. Control of tailings seepage through reactive chemical amendments. Proceedings of the International Mine Water Association Conference, 2013.

(Gu et al. 1998[4], Morrison et al. 2002[5]); however, challenges with both amendments have been identified and are discussed in the sections below.

This TS work plan includes implementation of three separate treatability studies, one for each of the media targets for ISS (**Figure 1**). The USEPA *Guidance for Conducting Treatability Studies under CERCLA Final,*[6] as supplemented for RD by the *Remedial Design/Remedial Action Handbook*,[7] was considered in developing this TS work plan. The TS will be conducted according to a schedule that is complimentary with other PDI tasks. For example, certain portions of the overburden injectability pilot testing will not be conducted until sufficient TS testing is completed. Completing the TS before injection testing will eliminate the possibility of pilot injection testing a specific amendment at a specific dose that has not been shown to be effective in a laboratory setting.

Three separate procedures are presented below, one procedure for each of the following:

- TS ISS-1 Holding Basin Soils
- TS ISS-2 Overburden Groundwater
- TS ISS-3 Bedrock Groundwater

3. TS ISS-1: AMENDMENT TESTING FOR SEQUESTRATION OF URANIUM IN HOLDING BASIN SOILS

3.1 Purpose

TS ISS-1 will evaluate the performance of two ISS treatments (Apatite II and ZVI) at sequestering uranium in impacted HB soils under both aerobic and anaerobic geochemical conditions. These conditions are intended to simulate the potential for perturbations to groundwater redox conditions due to planned isolation of impacted HB soils through a vertical barrier wall (VBW) and capping. Anaerobic conditions and stagnant hydraulic gradients are expected to develop in saturated soils contained by the VBW and cap due to a combination of microbial processes and minimal infiltration of aerobic groundwater. Correspondingly, the mobility of uranium in groundwater is expected to decrease following containment of HB soil as the existing highly soluble uranium (VI), present under aerobic conditions, is transformed to sparingly soluble uranium (IV) under reducing conditions, which precipitates as insoluble reduced uranium minerals (e.g., uraninite). However, slight leakage of oxidizing groundwater through the cap and/or VBW is possible and may

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[4] Gu, B., Liang, L., Dickey, M.J., Yin, X., and Dai, S. 1998. Reductive precipitation of uranium (VI) by zero-valent iron. Environmental Science and Technology 32(21): 3366-3373.

[5] Morrison, S.J., Carpenter, C.E., Metzler, D.R., Bartlett, T.R., and Morris, S.A. 2002. Design and performance of a permeable reactive barrier for containment of uranium, arsenic, selenium, vanadium, molybdenum, and nitrate at Monticello, Utah. In D.L. Naftz, S.J. Morrison, J.A. Davis, and C.C. Fuller, Eds., Handbook of Groundwater Remediation Using Permeable Reactive Barriers: Applications to Radionuclides, Trace Metals, and Nutrient. San Diego, CA: Academic Press. 371 pp.

6 USEPA. 1992. Guidance for Conducting Treatability Studies under CERCLA Final. EPA/540/R-92/071a. October.

7 USEPA. 1995. Remediation Design/Remedial Action Handbook. EPA 540/R-95/059. June.

remobilize uranium via oxidative dissolution of uranium (IV) solid phases. Although unlikely, a cap/containment failure could result in infiltration of a large amount of aerobic groundwater to contact the uranium impacted soils. TS ISS-1 will evaluate whether Apatite II or ZVI is the most effective amendment to sequester leached uranium under both aerobic and anaerobic conditions compared to an unamended control test.

A flow chart of the treatability testing scheme for the HB (TS ISS-1) is shown on **Figure 1A**.

3.2 Scope

3.2.1 Soil Sample Collection

A great deal of historical soil sampling and analysis of uranium-impacted soils beneath the HB have been conducted, and these data were used to develop a three-dimensional (3D) model of uranium-impacted soils. This 3D model was used to select soil sample collection locations and depths for acquiring soils for the TS. The historical data used to create the 3D model were collected during HB characterization studies conducted during or after 1998 (after the HB excavation) included as part of the remedial investigation. These data are described fully in the 2014 FS Report.[8]

Soil sampling locations were selected to target saturated and unsaturated soil samples with the highest uranium concentrations. Consideration was also given to locations that facilitate drill rig access and a broad distribution of uranium mass (i.e., multiple elevated detections of uranium in adjacent vertical profile samples).

A maximum of five unsaturated and five saturated 10-foot soil borings will be advanced and screened for suitability for this TS. Soil borings SB-TS-01001 through SB-TS-01010 target soils with historically elevated uranium concentrations and are shown on **Figure 2**. Coordinates and target sample collection depths for each of these locations are shown on **Figure 2**. Boring locations will be identified using a handheld global positioning system (GPS) unit such as a Trimble GeoExplorer. At each location, a minimum 4-inch-diameter drill casing will be advanced using a track-mounted sonic drill rig to a maximum depth of 65 feet below the elevation of the top of the HB liner by a licensed driller under the oversight of a Geosyntec field engineer or geologist. Each soil boring will be continuously sampled to the target sample interval depth identified on **Figure 2.** All efforts will be made to avoid using water during drilling activities to avoid altering the sample geochemistry.

In 2002, the United States Environmental Protection Agency (USEPA) placed approximately 6 feet of clean fill in the bottom of the HB to grade the floor and allow an impermeable liner to gravity drain any rainwater to a culvert at the northern end of the HB. Several unsaturated zone borings identified in **Figure 2** begin at the clean fill/native soil interface; if more than 1 foot of clean fill is observed at the top of these target sample intervals, then the target sample interval will

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[8] de maximis, 2014. Feasibility Study Report, Nuclear Metals, Inc. Superfund Site, Concord Massachusetts. November.

be extended deeper to collect 10-feet of native soil. As shown in **Table 1**, a minimum volume of approximately 17 liters (L) of HB soil will be needed for TS ISS-1.

After setting up the drill rig at a boring location, an exclusion zone will be established around the drill rig, soil staging area, and soil logging areas. The extracted soil cores will be prescreened for radiological activity levels at the drill site and then screened in the on-site laboratory. The following is the sample protocol for the on-site laboratory:

1. The sonic drill core liner will be cut open and soils will initially be screened with a handheld radiation survey unit to ensure radiation levels are safe to handle as determined by a qualified health physics technician and approved by the on-site Radiation Safety Officer (RSO).

2. If the soil core is safe to handle without further controls, the soils in the core will be described using the Unified Soil Classification System (USCS). If the soil is deemed unsafe, protocols will be followed as directed by the health physics technician.

3. The soil core will be screened again using the handheld radiation survey instrument, and the count rate per minute of the core will be logged over the length of the core.

4. If the soil core is collected above the target sample interval for that location (Figure 2), a maximum of one, 1-L subsample per 5 feet may be collected from the portion of the core exhibiting the highest radiological activity and submitted to the on-site laboratory for analysis. The remaining soil will be set aside until the on-site laboratory results are received.

5. While advancing the first boring, the subsample submitted to the on-site laboratory will be evaluated to develop a calibration curve relating readings from the handheld radiation survey instrument to the uranium concentrations measured at the on-site laboratory. The calibration curve will range from a minimum concentration of no greater than 10 milligrams per kilogram (mg/kg) to a maximum concentration of no less than 500 mg/kg. From this curve, the count rate per minute on the handheld radiation survey instrument that correlates to a uranium concentration of 100 mg/kg will be estimated. Additional subsamples beyond what is described may be necessary to construct the full calibration curve. An RSO will be consulted to help select any additional samples for the calibration curve.

6. If the soil core is from the 10-foot target sample interval (identified in Figure 2), those portions of the sample interval with radiation activity levels greater than the predetermined value that equates to greater than 100 mg/kg uranium shall be divided into a maximum of five subsamples with no subsample consisting of less than 1 L of soil. For the first boring, it may be necessary to first collect and analyze a subsample of soil from the target sample interval with the highest screened activity in order to develop the calibration curve described above. If no portion of the target sample interval exhibits radiological activity above the "elevated uranium value," then two 1-L samples of soil should be collected from the two portions of the target sample interval exhibiting the highest radiological activity

levels and submitted to the on-site laboratory for analysis. The remaining soil will be set aside until the on-site laboratory results are received.

7. Soil samples will be collected in zip top plastic bags. To better preserve the sample's geochemistry during transport to the lab, air will be expelled from the bag to the greatest extent possible prior to sealing the zip top. Using a new, clean pair of nitrile gloves, each zip top plastic bag containing the soil sample will then be placed into a second zip top plastic bag, sealed, labeled appropriately (sample identification number, sample collection date, time of collection, and sampler initials), and placed into a sample cooler. The sample cooler will then be brought to the on-site radiation screening laboratory, where an aliquot of the sample will be analyzed for preliminary total uranium concentration. Following screening and preliminary sampling, soil samples will be sealed in zip top plastic bags to limit unnecessary exposure to the atmosphere and preserve sample geochemistry.

8. Soil borings in the saturated and unsaturated zones shall be advanced following the order identified on **Figure 2**. The drill tooling will be decontaminated between each boring following the procedures outlined in the decontamination standard operating procedure (SOP) (NMI-007, in the Field Sampling Plan [FSP]). After receiving the on-site laboratory results for samples from the three primary borings, the total volume of the subsamples with uranium concentrations greater than 100 mg/kg in each saturation zone shall be measured. If the total volume exceeds 30 L, those samples shall be submitted to the treatability testing laboratory. If less than 30 L of soil with uranium concentration greater than 100 mg/kg have been collected, then additional borings shall be advanced at the secondary locations identified in **Figure 2** or as step-outs from the primary borings with known elevated uranium concentration. This additional sampling shall follow the same procedure described above until a total of 30 L of soil with uranium concentrations greater than 100 mg/kg have been collected from the saturated and unsaturated zones combined.

9. Following collection, the samples will be labeled, placed in coolers with ice, and shipped under standard chain-of-custody procedures (described in NMI-001 of the FSP) to Hazen Research, Inc. (Hazen) of Golden, Colorado, the laboratory conducting the TS. Samples to be stored on-site shall be placed in a refrigerator until packing for shipping is complete. The Hazen laboratory quality assurance/quality control (QA/QC) procedures are included in **Attachment A** of this TS work plan. Soil samples will be shipped to the laboratory under appropriate packing and shipping protocols as determined by the on-site RSO.

10. Soil samples collected from the saturated and unsaturated zones will be homogenized by the laboratory and undergo baseline characterization. Homogenized HB soil was chosen for use in TS ISS-1 because (1) soil texture is similar within the saturated and unsaturated zones and (2) alteration of the redox state of the column influent will overpower any differences in geochemical conditions between the saturated and unsaturated zones. Soils

will be blended via cloth blending, use of a V-blender, or cone-and-quartering techniques.[9] Representative sub-samples of homogenized soil will be collected based on visual inspection. For baseline characterization, the lab will analyze homogenized HB soil for the following:

- Organic and inorganic carbon (combustion analysis)
- Environmentally accessible (acid digestible by EPA Method 3050B) uranium, iron, aluminum, calcium, manganese, molybdenum, and arsenic (inductively coupled plasma mass spectrometry [ICP-MS]/inductively coupled plasma optical emission spectroscopy [ICP-OES])
- Leachable uranium (Synthetic Precipitation Leaching Procedure [SPLP], ICP-MS/ICP-OES) to ensure that the baseline uranium soil content is sufficient to perform testing (i.e., at least 20 mg/kg, with higher concentrations preferable).
- Fe(II) (colorimetry)
- Sulfide (turbidimetry)

11. Soil from depth intervals with the highest uranium concentration from the unsaturated and saturated zones will be composited at the lab for use in the flow-through columns during the TS.

3.2.2 Groundwater Collection

Groundwater with low concentrations of uranium representative of the composition of background groundwater will be collected from MW-S30, an overburden monitoring well upgradient of the HB, for use as the flow-through column influent. Groundwater will be collected using a submersible or peristaltic pump fitted with new tubing and then transferred into new containers (e.g., 5-gallon pail, 55-gallon drum). To minimize aeration of the groundwater sample during collection, the discharge tubing will enter the sample container through a rubber seal and will be submerged beneath the water surface of the container. A small vent hole in the container will allow displaced air to escape the container without mixing with the groundwater sample. Sampling methods will follow the low-flow groundwater sampling SOP (NMI-GW-010 in the FSP). During collection, filtered (0.45 µm) and unfiltered samples will be collected, and general groundwater quality parameters will be measured, including pH, dissolved oxygen (DO), oxidation reduction potential (ORP), turbidity, and specific conductance. A minimum volume of approximately 67 L of groundwater will be collected for use in TS ISS-1 (**Table 1**). Extracted groundwater from MW-S30 will be labeled, packed on ice, and shipped to Hazen under standard chain-of-custody procedures (as described in NMI-001 of the FSP). For baseline characterization, the laboratory will analyze filtered and unfiltered groundwater from MW-S30 at the time of collection and prior to initiation of the column tests for the following:

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[9] United States Bureau of Mines, 1995. Laboratory Procedures for Hydrometallurgical-Processing and Waste-Management Experiments. Information Circular 9431.

- pH
- ORP
- Inorganic carbon (coulometry)
- Nitrate (colorimetry)
- Sulfide (turbidimetry)
- Total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron (ICP-MS/ICP-OES)

Comparison of baseline characterization results between the time of collection and the initiation of column tests will be used to identify changes in groundwater composition (e.g., precipitation, biological consumption) during transport and storage.

3.2.2.1 Groundwater Sample Collection Beneath the Holding Basin

As discussed in the sections above, drilling equipment will be mobilized into the Holding Basin to collect soil samples for treatability studies, including from the saturated zone beneath the Holding Basin. A groundwater sample will be collected from the shallow saturated zone (approximately the upper 10-feet) using a temporary well or a Push-Ahead sampler developed by Cascade Drilling. If the Push-Ahead sampler is used, the sampler will be driven at least 5 feet ahead of the override casing and into the native formation without the use of drilling water that could alter the geochemistry. Prior to the sample collection, the temporary well screen or the Push-Ahead sampler will be purged until field parameters (temperature, dissolved oxygen, oxidation-reduction potential, pH, specific conductance and turbidity) stabilize consistent with low-flow groundwater sampling procedures.

The groundwater sample will be analyzed for the following suite of parameters:

- VOCs via Method 8260
- 1,4-dioxane via Method 8270SIM
- SVOCs via Method 8270
- Total and dissolved uranium with U^{235}/U^{238} speciation via Method 6020A ICP-MS
- Total and Dissolved Metals via Method 6020A (ICP-MS)/6010D (ICP-OES) (Al, As, Sb, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Tl, Th, V, Zn)
- Nitrate/Nitrite via Method 353.2
- Total Phosphorous via Method 365.1
- Orthophosphate via Method SMP4500P-E
- Dissolved Organic Carbon via Method 9060
- Total and Dissolved Cations (Fe, Mn, Ca, Mg, Na, K) via Method 6020A (ICP-MS)/6010D (ICP-OES)
- Anion (Sulfate, Fluoride, and Chloride) via Method 300
- Carbonate and Bicarbonate Alkalinity via Method 310.1

This suite of analytes is consistent with the November 2019 parameters sampled in monitoring wells MW-S24 and HBPZ-2R to allow for a direct comparison of groundwater beneath the Holding Basin and immediately downgradient.

3.2.3 Column Construction

Flow-through columns will be constructed from clear schedule 40 polyvinylchloride (PVC) with threaded end-caps fitted with tubing to deliver column influent and receive column effluent. Columns will measure 3 inches in diameter and 18 inches in length.

Three columns containing homogenized HB soil will be constructed for testing (**Table 2**):

- One column containing unamended soil (control column)
- One column containing soil amended with 1 weight percent (wt %) ZVI
- One column containing soil amended with 1.5 wt % Apatite II

The mass loading of Apatite II and ZVI amendments in the column tests for Holding Basin soils was selected to be representative of a typical bulk mass loading achieved in the field using direct-push technology (DPT) jet injection. The bulk mass loading of injected amendments is a function of the mass of amendment per fracture, the fracture radius of influence (ROI), the vertical spacing between individual fractures at each injection location, and the overlap of ROIs between adjacent injection locations. As described in **Appendix B**, site-specific injection design parameters will be evaluated based on the results of the treatability studies as well as ISS pilot testing in overburden. Assuming typical values for these parameters based on previous experience implementing DPT direct-push jet injection (e.g., up to 1300 lbs of Apatite II per fracture, 15-ft ROI, 3-ft vertical spacing, and 100% overlap), a dry weight mass loading of 1% to 1.5% was selected for the column tests.

ZVI (Hepure Ferox Flow, 125 microns [µm][10]) and Apatite II (PIMS NW, Inc.) will be amended to HB soil based on dry weight percentage. A subsample of homogenized HB soil will be dried to determine the moisture content, which will be used to calculate the amount of ZVI and Apatite II needed for each column. ZVI and Apatite II will be mixed with undried soil prior to column packing.

Columns will be packed with soil using a plastic scoop. The columns will be shaken/tapped/swirled throughout the packing process to get even compaction of the soil into the column and to avoid creating preferential flow paths and voids in the packed columns. The mass of soil added to each column will be recorded.

3.2.4 Column Test

Site background groundwater amended with a conservative tracer (e.g., bromide) will serve as column influent. Columns will be oriented vertically, and column influent will be pumped at 1

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[10] https://hepure.com/products/ferox-flow-zero-valent-iron-powder/

pore volume (PV) per day in an upflow arrangement using a peristaltic pump. Columns will be operated for 4 weeks. During the column test, redox conditions of the column influent will be altered according to the following schedule:

- Week 1: Column influent will be oxidizing, reflecting the redox conditions of the HB prior to VBW and cap installation.[11] Column effluent will be sampled on days 2, 4, and 7.
- Weeks 2-3: Column influent will be amended with organic carbon and nutrients to promote the development of reducing redox conditions within the column. Reducing conditions reflect the expected redox conditions of the HB following installation of the VBW and soil cap. Column effluent will be sampled on days 2, 7, and 14.
- Week 4: Column influent will be oxidizing.[12] A return to oxidizing conditions mimics the infiltration of aerobic groundwater into the anaerobic HB during a potential failure of the VBW or soil cap. Column effluent will be sampled on days 2, 4, and 7.

During the anaerobic phase (weeks 2-3), column influent will be dosed with dissolved organic carbon (glucose) and nutrients (low concentration of ammonium chloride) to stimulate microbial consumption of DO and promote the development of iron-reducing (anaerobic) conditions. Concentrations of DO and nitrate measured in the column influent during baseline characterization will be used to calculate the concentration of glucose required to achieve iron-reducing conditions within the column. This approach is preferred to dosing the column influent with chemical reductants (e.g., bisulfide, dithionite, or ferrous iron) because it produces anaerobic conditions which will more accurately reflect the Site groundwater composition. The column influent will be filtered and sterilized (0.22 µm filtration) to prevent the growth of microbes within the influent container. The expected column effluent during weeks 2-3 will be geochemically reducing; will contain dissolved ferrous iron generated from the Site soil, along with organic acids; and will be a reasonable representation of anaerobic groundwater in the HB after capping and VBW installation. If by week 3 the effluent is not indicative of reducing conditions within the column (e.g., decrease in ORP, increase in dissolved iron), glucose-amended influent will continue to be pumped through the column until reducing conditions develop. Likewise, if by week 4 the effluent is not indicative of a return to oxidizing conditions within the column (return to baseline ORP and dissolved iron concentrations), this phase of the column test will continue until the effluent reflects oxidizing conditions within the column.

Unfiltered samples of column effluent will be collected periodically as described above and analyzed for the following:

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[11] Although the influent groundwater collected from the Site will be aerobic, this water will be sitting in the lab for periods of time and may lose oxygen due to microbial activity. If necessary, the influent solution will be sparged with air to achieve a DO concentration similar to the concentration measured in the field during sample collection.

[12] If necessary, the influent solution will be sparged with air to achieve a DO concentration similar to the concentration measured in the field during sample collection.

- pH
- ORP
- Total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron (ICP-MS/ICP-OES)
- Nitrate (colorimetry)
- Sulfide (turbidimetry)
- Inorganic carbon (coulometry)
- Bromide (ion chromatography)

A summary of samples and analyses that will be conducted during TS ISS-1 is presented in **Table 3**. The Hazen QA/QC procedures are included in **Attachment A** of this TS work plan. Uranium will be monitored to assess the efficacy of soil amendments in sequestering leached uranium from HB soil compared to the unamended column. Calcium and phosphorus will be monitored to assess the dissolution of Apatite II as a source of calcium and phosphate for uranium-phosphate mineral precipitation. Arsenic will be monitored to assess whether trace arsenic present in Apatite II has the potential to impact groundwater quality via dissolution and subsequent release of arsenic from Apatite II solids. Molybdenum will be monitored because it has been detected at elevated levels in the upgradient portion of the uranium plume. In addition to ORP, nitrate, iron (i.e., higher dissolved iron concentrations reflect more reducing conditions), and sulfide will be monitored in select samples as redox indicators. As carbonate enhances uranium mobility in groundwater, inorganic carbon (i.e., total carbonate species) will be monitored to evaluate this effect under the conditions of this study.

Analysis of unfiltered (i.e., "total") column effluent samples was selected because it provides a more conservative estimate of amendment performance than analysis of filtered (i.e., "dissolved") column effluent samples. If total uranium results fall above the target for uranium stabilization (total uranium concentrations >0.030 mg/L) in two consecutive sampling events, these samples will be filtered and analyzed for dissolved constituents in order to understand whether colloidal (micro- or nano-particulate) uranium is contributing to the concentration of total (unfiltered) uranium.

3.3 Outcome

Results from TS ISS-1 will be used to determine if Apatite II or ZVI is the most effective soil amendment for sequestering leached uranium in HB soil under both aerobic and anaerobic conditions. Both amended and unamended column tests will be evaluated based on decreases in effluent uranium concentrations measured during periods of reducing conditions (weeks 2-3) and a return to oxidizing conditions (week 4) relative to the initial period of oxidizing conditions (week 1) in the control column.

3.4 Assumptions

The scope of work for this TS includes the following assumptions:

It is assumed that a track-mounted drilling rig is capable of descending into and ascending out of the HB via the southeast sidewall which has a lower grade than the rest of the HB walls. Confirmation of this assumption will be needed during a Site walk with the driller. If the drilling rig cannot descend and ascend the HB sidewalls, it will most likely be necessary to cut and roll back a portion of the existing cover and to regrade a portion of the HB sidewall to allow access. Following the completion of the investigation program, the soil cap and cover would be repaired. Drill rig access information will be provided separately in the implementation plan.

The HB is currently covered by a thick plastic liner. Prior to drilling, the liner shall be cut, peeled away from the boring location, and held down in such a way to prevent tripping hazards or the liner getting caught in the drill tooling. Following completion of drilling and backfill of the borehole, the hole created in the plastic liner will be repaired.

Any soil or groundwater removed from a boring and not collected as a sample will be returned to the boring or appropriately drummed and stored on-site for future disposal. Soil borings will be backfilled with Site soil or engineered sand and sealed with at least 1-foot of hydrated bentonite chips.

The drill tooling will be decontaminated between each boring following the procedures outlined in the decontamination SOP found in the FSP. Additional decontamination and swab sampling will be required prior to free release of any drilling equipment as identified in the decontamination SOP.

de maximis will provide an RSO to evaluate the radioactivity level of soil and groundwater to be shipped off-site. If the activity levels exceed the threshold for more rigorous packaging and shipping methods, *de maximis* will manage the packaging and shipping.

4. TS ISS – 2: AMENDMENT TESTING FOR OVERBURDEN GROUNDWATER

4.1 Purpose

Treatability studies for overburden groundwater will evaluate the performance of three amendments (Apatite II, ZVI, and SMP [Carus Corporation][13]) for immobilization of uranium. Methods will include (1) a batch reactor study to evaluate the optimum dose rate for each amendment, and (2) a column study to evaluate the efficacy and mechanisms of uranium sequestration under advective flow at the optimal dose rates identified in the batch study. A flow chart of the treatability testing scheme for the overburden groundwater (TS ISS-2) is shown on **Figure 1B**.

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[13] http://www.caruscorporation.com/remediation/products/phosphates

4.2 Scope

4.2.1 Soil Collection

Site soil and groundwater will be collected for use in TS ISS-2.

Soil collection will target both low-uranium-content overburden soil (e.g., not immediately downgradient of the HB) and high-uranium-content overburden soil within the overburden uranium groundwater plume with the lowest potential for natural uranium attenuation (e.g., sand). Soil collection locations were selected based on historical overburden soil uranium concentrations. Two soil borings located for soil collection are shown on **Figure 3**, which also shows the current distribution of uranium in overburden groundwater.

The low-uranium-content soil will be collected at the distal end of the uranium plume where there is little or no uranium sorbed to formation soils. The location is designated as TS-SB-01 (**Figure 3)**. The high-uranium-content overburden soil will be collected from a boring immediately downgradient of the HB near MW-S24 (TS-SB-02 on **Figure 3**) where previous studies have indicated significant uranium sorbed to formation soils. These soils will be collected from the top 20 feet of saturated overburden (approximately 50 to 70 feet below ground surface [bgs]) using a 4-inch-diameter sonic core barrel. The drill tooling will be decontaminated between each boring following the procedures outlined in the decontamination SOP (NMI-007 in the FSP). The recovered soils will be logged for lithology using the USCS. In total, a minimum of approximately 6 L of high-uranium sandy soil and approximately 45 L of low-uranium sandy soil will be collected for use in TS ISS-2 (**Table 1**). Following collection, the samples will be labeled, placed in coolers with ice, and shipped to Hazen under standard chain-of-custody procedures (described in NMI-001 of the FSP). Appropriate packing and shipping methods will be based on evaluation by the on-site RSO.

Soil samples will be homogenized by the laboratory via cloth blending, use of a V-blender, or cone-and-quartering techniques.[14] Representative sub-samples of homogenized soil will be collected based on visual inspection. For baseline characterization, the lab will analyze homogenized soil for the following:

- Organic and inorganic carbon (combustion analysis)
- Environmentally accessible (acid digestible by EPA Method 3050B) uranium, iron, manganese, arsenic, molybdenum, aluminum, and calcium (ICP-MS/ICP-OES)
- Leachable uranium (SPLP)
- Fe(II) (colorimetry)
- Sulfide (turbidimetry)

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[14] United States Bureau of Mines, 1995. Laboratory Procedures for Hydrometallurgical-Processing and Waste-Management Experiments. Information Circular 9431.

If enough uranium is present in the overburden soil (at least 20 mg/kg), a sequential extraction procedure will be performed (described below) to identify the baseline chemical/mineralogical speciation of solid-associated uranium.

4.2.2 Groundwater Collection

Overburden groundwater will be collected from monitoring well MW-S24, which historically and currently has the highest uranium concentration (2,675 micrograms per liter [µg/L] in November 2019), for use in the batch reactors and as the flow-through column influent for the first column study. Background (i.e., low-uranium) overburden groundwater from MW-S30 will be collected for use in the SMP sorption capacity test (described in Section 4.2.3) and as the flow-through column influent for the second column study. Sampling methods will follow low-flow protocols as provided in SOP NMI-GW-010 of the FSP. During groundwater collection, filtered (0.45 µm) and unfiltered samples will be collected, and general groundwater quality parameters will be measured, including pH, DO, ORP, turbidity, and specific conductance. Approximately 626 L of high-uranium groundwater will be collected from well MW-S24, and 58 L of low-uranium groundwater will be collected from background well MW-S30 (**Table 1**). Groundwater will be transferred to new drums using a submersible pump fitted with new tubing. To minimize aeration of the groundwater sample during collection, the discharge tubing will enter the drum through a rubber seal and will be submerged beneath the water surface of the drum. A small vent hole in the drum will allow displaced air to escape the drum without mixing with the groundwater sample. Drums will be labeled and shipped under standard chain-of-custody procedures to Hazen. Appropriate packing and shipping methods will be based on evaluation by the on-site RSO. For baseline characterization, the laboratory will analyze filtered and unfiltered overburden groundwater at the time of collection and prior to initiation of the column and batch tests for the following:

- pH
- ORP
- Inorganic carbon (coulometry)
- Total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron (ICP-MS/ICP-OES)
- Nitrate (colorimetry)
- Sulfide (turbidimetry)

Comparison of baseline characterization results between the time of collection and the initiation of column and batch tests will be used to identify changes in groundwater composition (e.g., precipitation, biological consumption) during transport and storage.

4.2.3 Batch Reactor Test

Batch Reactor Construction

The batch reactor study will be performed using 250 milliliter (mL) glass bottles containing undried overburden soil and overburden groundwater. The soil:liquid ratios for the batch reactors will be determined to (1) ensure sequestration by the amendment is detectable in excess of the control, and (2) prevent dissolution of >10% of the Apatite II amendment in the low-dose condition. Based on the current concentration of uranium in groundwater at well MW-S24 (approximately 2.7 mg/L), a soil:liquid ratio of 1:20 is expected (equivalent to 10 grams [g] of dry soil per 200 mL of liquid).

Three identical reactors containing overburden soil and groundwater will be constructed for each of the following treatments (39 reactors in total) (**Table 2**):

- Unamended control reactor
- Apatite II at 0.5 wt %
- Apatite II at 1.5 wt %
- Apatite II at 3.0 wt %
- Apatite II at 0.5 wt % with guar gum
- Apatite II at 1.5 wt % with guar gum
- Apatite II at 3.0 wt % with guar gum
- ZVI at 0.5 wt %
- ZVI at 1.5 wt %
- ZVI at 3.0 wt %
- SMP at 46 mg/L P
- SMP at 138 mg/L P
- SMP at 277 mg/L P

Guar gum is an injection additive which will likely be required as a carrying fluid during injection of Apatite II; therefore, one set of Apatite II reactors will be amended with guar gum to evaluate the effect of guar gum on remedy performance.

Apatite II (PIMS NW, Inc.) and ZVI (Hepure Ferox Flow [125 µm]) will be dosed based on dry weight percentage. A subsample of homogenized overburden soil will be dried to determine the moisture content, which will be used to calculate the amount of soil and solid treatment amendments (Apatite II and ZVI) on a dry weight percentage needed for each reactor. SMP (Carus Corporation) doses were chosen to give equivalent total phosphorus loading to the Apatite II reactors based on the composition of Apatite II (e.g., ~18 wt.% P).

Once prepared, reactors will be sealed with rubber stoppers. Reactors will be agitated continuously (e.g., placed on a shaker table) for the duration of the study.

<u>Batch Reactor Test</u>

One of the three identical reactors for each condition will be sacrificially sampled at three time points: 3 days, 1 week, and 8 weeks.

At each time point, a subsample of the reactor will be centrifuged, and the supernatant will be analyzed for total U (ICP-MS/ICP-OES). Uranium measured in the supernatant sample consists of dissolved and colloidal uranium, which is equivalent to the fraction of uranium analyzed in the unfiltered column effluent samples in the TS ISS-2 column study (described below). A second subsample will be filtered using a syringe filter (0.45 µm), and the first milliliter of filtrate will be discarded. The remaining filtrate will be analyzed for pH, ORP, inorganic carbon (coulometry), nitrate[15] (coulorimetry), sulfide[15] (turbidimetry), and total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron[13] (ICP-MS/ICP-OES), which represent the dissolved fraction of each constituent. Control tests will be conducted to ensure that any artifacts of filtration on dissolved concentrations (retaining analytes on the filter) are minimal. Sampling and analyses performed during the batch reactor test are summarized in **Table 3**.

Additionally, the sorption capacity of SMP on overburden soil will be determined to evaluate uptake of phosphate by overburden soil in the absence of uranium. Batch reactors containing low-uranium overburden soil and background overburden groundwater from MW-S30 will be amended with increasing concentrations of SMP and allowed to equilibrate for at least 24 hours. Following equilibration, a subsample will be collected, filtered (0.45 µm), and analyzed for total phosphorus (ICP-MS/ICP-OES).

Batch Reactor Outcome

Results from the ISS-2 batch reactor study will be used to determine the best performing dose for each treatment. The best performing dose will be the lowest dose that decreases aqueous uranium concentrations below the maximum contaminant level (MCL) of 30 parts per billion by weight (ppb). If the MCL is not achieved, the dose which results in the largest percent removal of uranium from solution will be deemed the best performing dose. The best performing dose from each treatment will be used in the ISS-2 column study described below.

4.2.4 Column Test

Column Construction

Flow-through columns will be constructed from clear schedule 40 PVC with threaded end-caps fitted with tubing to deliver column influent and receive column effluent. Columns will measure 3 inches in diameter and 18 inches in length, the same column dimensions used in TS ISS-1.

Two column studies will be performed. The first column study will evaluate treatment amendment performance using homogenized, low-uranium overburden soil classified as sand (the same soil as the batch reactor study). Two identical columns containing homogenized overburden soil will be constructed for each of the following conditions (eight columns total) (**Table 2**):

- Unamended soil (control columns)
- Soil amended with Apatite II

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[15] Nitrate, iron, and sulfide will be measured in select samples as redox indicators.

- Soil amended with ZVI
- Unamended soil treated with SMP

Apatite II and ZVI will be amended to columns based on the best preforming dose of the TS ISS-2 batch reactor study on a dry weight percentage. A subsample of homogenized overburden soil will be dried to determine the moisture content, which will be used to calculate the amount of ZVI and Apatite II needed for each column on a dry weight percentage. ZVI and Apatite II will be mixed with overburden soil prior to column packing.

The SMP treatment columns will be packed with unamended soil, and SMP will be loaded on the column via the influent solution prior to starting the column test. Background overburden groundwater from monitoring well MW-S30 will be dosed with SMP based on the best performing dose of the batch reactor study. The SMP-amended groundwater will be pumped through the column for approximately 1 week to load the column with the amendment. Once phosphorus breakthrough is observed (indicated by detection of phosphorus in the column effluent as described below), the column influent will be switched to uranium-rich groundwater from MW-S24 and the column study will commence.

The second column study will be performed to evaluate (1) phosphate transport in overburden soil and (2) the potential for mobilization of uranium from overburden soil due to changing geochemical conditions associated with the phosphorus-based treatments (e.g., changes in ionic strength, pH). Characterization of phosphate mobility in overburden soil will be necessary to design an injection program for the phosphorus-based amendments under consideration (Apatite II and SMP). This column will be constructed with high-uranium content overburden soil (**Table 2**).

Columns will be packed with soil using a plastic scoop. The columns will be shaken/tapped/swirled throughout the packing process to get even compaction of the soil into the column and to avoid creating preferential flow paths and voids in the packed columns. The mass of soil added to each column will be recorded.

Column Testing Procedures

Uranium-rich groundwater from MW-S24 amended with a conservative tracer (e.g., bromide) will serve as column influent for the first column study (treatment evaluation columns). Columns will be oriented vertically, and column influent will be pumped at approximately 2 PVs per day in an upflow arrangement using a peristaltic pump. The preferred flow rate will be determined based on measurement of the uranium breakthrough time of the control column, with a target of observing uranium breakthrough in less than 7 days in the control. The primary column for each treatment will be operated for approximately 7 weeks and will be used for effluent analysis. The secondary column for each treatment will be operated for approximately 6 weeks and will be used for solid-phase analysis. During the column test, the column influent will be altered according to the following schedule:

- Weeks 1-6: Influent for both the primary and secondary columns for each treatment will be sparged with air to promote oxidizing geochemical conditions. Oxidizing conditions reflect the redox conditions of the overburden groundwater. Effluent from the primary column of each treatment will be sampled once per week (6 time points total). Effluent from the secondary columns will not be sampled. Following 6 weeks of influent delivery, the secondary column for each treatment will be discontinued and undergo solid-phase analysis (described below).
- Week 7: Influent for the primary column of each treatment will be amended with sodium carbonate at a concentration representative of groundwater in contact with a cement slurry wall or the highest carbonate concentration expected at the Site.[16] Alkaline conditions reflect geochemical conditions following leaching of alkaline fluids from a cement slurry wall, a remedy being considered for the HB VBW. Effluent from the primary columns will be sampled twice during the week of alkaline fluid delivery.

Unfiltered samples of column effluent will be collected periodically from the primary columns as described above and analyzed for the following:

- pH
- ORP
- Total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron (ICP-MS/ICP-OES)
- Inorganic carbon (coulometry)
- Nitrate (colorimetry)
- Sulfide (turbidimetry)
- Bromide (ion chromatography)

A summary of samples and analyses that will be conducted during the column test is presented in **Table 3**. Uranium will be monitored to assess the efficacy of soil amendments in sequestering uranium from overburden groundwater compared to the unamended column. If early breakthrough of uranium is observed from the SMP columns, SMP will be periodically reapplied to the column at a concentration relevant for practical field implementation (e.g., injectable dose). Calcium and phosphorus will be monitored to assess the dissolution of Apatite II as a source of calcium and phosphate and the abundance of SMP for uranium-phosphate mineral precipitation. Arsenic will be monitored to assess whether trace arsenic present in Apatite II has the potential to impact groundwater quality via dissolution and subsequent release of arsenic from Apatite II solids. Molybdenum will be monitored because it has been detected at elevated levels in the upgradient portion of the uranium plume. In addition to ORP, nitrate, iron (i.e., higher dissolved iron concentrations reflect more reducing conditions), and sulfide will be monitored in select samples as redox indicators. As carbonate enhances uranium mobility in groundwater, inorganic carbon

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[16] Additional studies will be conducted by the VBW contractor to determine the appropriate carbonate concentration for this part of the study.

(i.e., total carbonate species) will be monitored to evaluate this effect under the conditions of this study.

Analysis of unfiltered column effluent samples was selected because it provides a more conservative estimate of amendment performance than analysis of filtered column effluent samples. Additional analysis of dissolved constituents (i.e., those capable of passing through a 0.45 µm filter) may be performed as needed based on the results of unfiltered samples.

After 6 weeks of operation, the secondary column for each treatment will be disassembled, and the soil will be analyzed to quantify the amount of uranium sequestered, the solid-phase speciation of uranium, and the recalcitrance of the solid-phase uranium to leaching under relevant geochemical conditions. Two subsamples will be collected from each secondary column, one near the column influent and one near the column effluent. The eight samples will be analyzed for the following:

- Environmentally accessible (acid digestible by EPA Method 3050B) uranium, calcium, phosphorus, and iron (ICP-MS/ICP-OES).
- Bicarbonate leaching test: a bicarbonate leaching test will be performed to assess the potential for overburden groundwater with elevated inorganic carbon concentrations to mobilize uranium sequestered by each treatment. A subsample of column soil will be equilibrated with background (i.e., low-uranium) overburden groundwater from MW-S30 amended with 70 mg/L sodium bicarbonate solution and adjusted to pH 7.0. This concentration represents the maximum inorganic carbon concentration expected in overburden groundwater, based on historical groundwater data and effluent concentrations in previously conducted column tests.[17] Following at least 24 hours of equilibration, an aliquot will be collected, filtered (0.45 µm), and analyzed for total uranium (ICP-MS/ICP-OES). The results of the leaching test will indicate the degree of recalcitrance of the uranium solids generated by each treatment.
- Four-step sequential extraction: subsamples of column soil will be sequentially extracted by four different solutions, each of which will target a specific fraction of solid-associated uranium. The sequential extraction procedure is based on the Tessier extraction method for trace metals (Tessier et al. 1979)[18] which has been modified to target solid-associated uranium species based the geochemical behavior of uranium (Salome et al. 2017)[19]. Following each extraction step, the soil/extractant mixture will be centrifuged and an aliquot of the supernatant will be collected for analysis. The supernatant will be filtered using a syringe filter (0.45 µm), the first milliliter of filtrate will be discarded, and the

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[17] Lammers, L.N., Rasmussen, H., Adilman, D., deLemos, J.L., Zeeb P., Larson, D.G., Quicksall, A.N. 2017. Groundwater uranium stabilization by metastable hydroxyapatite. Applied Geochemistry 84, 105-113.

[18] Tessier, A., Campbell, P.G.C., Bisson, M., 1979. Sequential extraction procedure for the speciation of particulate trace metals. *Anal. Chem*. 51, 844e851.

[19] Salome, K.R., Beazley, M.J., Webb, S.M., Sobecky, P.A., and Taillefert, M., 2017. Biomineralization of U(VI) phosphate promoted by microbially-mediated phytate hydrolysis in contaminated soils. *Geochim. et Cosmochim. Acta*. 197, 27-42.

remaining filtrate will be analyzed for total uranium, calcium, phosphorus, and iron (ICP-MS/ICP-OES). The remaining supernatant will be discarded, and the solid residue will be washed once with deionized water before continuing to the next extraction step. The extraction solutions and target uranium species are listed below in order from least to most recalcitrant:

- Step 1: Weakly sorbed/exchangeable uranium. 1.0 molar (M) magnesium chloride in 10 millimolar (mM) nitrilotriacetic acid adjusted to pH 4.5, agitated at room temperature for 1 hour. Nitrilotriacetic acid is included in the extraction solution to prevent the precipitation of uranium desorbed from mineral surfaces by magnesium.

- Step 2: Strongly sorbed/weak acid extractable. 1.0 M sodium acetate adjusted to pH 5.0 with acetic acid, agitated at room temperature for 8 hours. Acetic acid will extract strongly sorbed uranium and uranium associated with carbonate minerals.

- Step 3: Iron- and manganese-associated. 40 mM hydroxylamine in 25% (volume/volume) acetic acid, agitated at 96 degrees Celsius (°C) for 6 hours. Hydroxylamine will target iron- and manganese-oxide associated uranium by reductive dissolution of iron and manganese oxides.

- Step 4: Uranium phosphate minerals and recalcitrant fraction. Reverse aqua regia (3 parts nitric acid [HNO_3] to 1 part hydrochloric acid [HCl]). Acid boiled off at 90 °C, and more acid added until digestion is complete. Dissolve salts in 5% HNO_3 for analysis. This extraction step has previously been shown to target uranium-phosphate solids.[20]

The sequential extraction procedure will be calibrated to confirm the target uranium phase for each extraction step. Soils predominantly composed of one solid-associated uranium species (adsorbed uranium, uranium-phosphate minerals, or iron- and manganese-associated uranium) will be prepared as follows:

- Adsorbed uranium: high-uranium groundwater from MW-S24 will be mixed with background (low-uranium) overburden Site soil from the new soil boring at the distal end of the plume (TB SB-01).
- Uranium-phosphate minerals: high-uranium groundwater from MW-S24 will be mixed with Apatite II solids.
- Iron- and manganese-associated uranium: high-uranium groundwater from MW-S24 will be mixed with ZVI solids.

After 8 weeks of reaction, the calibration solids will be analyzed. Low-uranium soil from TS-SB-01 will also be analyzed to serve as a control blank to account for any background uranium present

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[20] Lammers, L.N., Rasmussen, H., Adilman, D., deLemos, J.L., Zeeb P., Larson, D.G., Quicksall, A.N., 2017. Groundwater uranium stabilization by metastable hydroxyapatite. *Applied Geochemistry* 84, 105-113.

in the soil. A subsample of the calibration matrix will be centrifuged, and the supernatant will be discarded. The remaining solids will be washed once in deionized water, and each step of the sequential extraction procedure will be performed in parallel (i.e., not sequentially) on subsamples of the washed solids, following the procedures described above. Total uranium will be measured (ICP-MS/ICP-OES) in the filtered extractant from each extraction step to identify the extraction step that targets the majority of each solid-associated uranium species.

The mass of uranium sequestered by each treatment will be determined by 1) solid phase analysis and 2) mass balance. The mass of environmentally accessible uranium in the column solid after the completion of the column test will be measured and compared to the mass of environmentally available uranium measured during baseline characterization to determine the mass of uranium sequestered by each amendment. Additionally, mass balance calculations using the uranium concentration of the column influent, the uranium concentration of the column effluent, and the total volume flowed through the column will be used to calculate the mass of uranium sequestered on column solids.

Solids for which uranium concentrations are determined to be between 0.1 and 0.5 wt % uranium will be analyzed by X-ray diffraction (XRD) analysis. Up to four solid samples will be dried and analyzed using an automated X-ray diffractometer with copper K-alpha (Cu K-α) X-rays. The diffraction pattern and d-spacings will be matched against a published database (International Center for Diffraction Data Powder Diffraction File-2 [PDF-2]) to determine mineral identity. The goal of this analysis will be to identify the specific predominate uranium mineral in each of the columns that have concentrations of uranium suitable for XRD analysis. If solids contain less than 0.1 wt % uranium or if crystalline uranium phases cannot be resolved by XRD then an alternative approach will be used to identify the uranium minerals formed. The soil samples with the highest concentrations of uranium (up to two samples) will be prepared for Quantitative Evaluation of Minerals by SCANning electron microscopy (QEMSCAN) analysis. Soil will be embedded in epoxy and polished to prepare a smooth surface for the analysis. QEMSCAN combines imaging and high-resolution energy-dispersive X-ray spectroscopy analysis to identify minerals based upon their elemental composition. Although this analytical procedure is significantly more expensive than XRD, if none of the solids contain more than 0.1% uranium, then this procedure is warranted.

For the second column study (evaluation of phosphate transport and uranium leaching), column influent will consist of background (i.e., low-uranium content) overburden groundwater from MW-S30 equilibrated with Apatite II and amended with a conservative tracer (e.g., bromide). Apatite II will be added to the influent container in excess of the solubility (approximately 27 mg/L Apatite II, based on measured concentration of phosphorus in site groundwater equilibrated with Apatite II, Lammers et al., 2017)[21] to maintain a constant influent phosphorus concentration of approximately 5 mg/L. Columns will be oriented vertically, and column influent will be pumped at approximately 1 PV/day in an upflow arrangement using a peristaltic pump.

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[21] Lammers, L.N., Rasmussen, H., Adilman, D., deLemos, J.L., Zeeb P., Larson, D.G., Quicksall, A.N., 2017. Groundwater uranium stabilization by metastable hydroxyapatite. *Applied Geochemistry* 84, 105-113.

The column will be operated for up to 6 weeks. Unfiltered samples of column effluent will be collected once per week and analyzed for the following:

- pH
- ORP
- Total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron (ICP-MS/ICP-OES)
- Inorganic carbon (coulometry)
- Nitrate (colorimetry)
- Sulfide (turbidimetry)
- Bromide (ion chromatography)

Column Test Outcome

Results from the first TS ISS-2 column study will be used to determine the most effective treatment for sequestering uranium in overburden groundwater. Treatments will be evaluated based on the percent decrease in uranium concentration in the column effluent compared to the unamended control column and the recalcitrance of the solid-associated uranium generated by each treatment. Results of the second TS ISS-2 column study will provide information on the mobility of phosphorus in overburden soil, which will inform the design of the injection program if a phosphorus-based amendment is selected. The information gained from the TS will be used to guide design and implementation of PDI ISS-3.

4.3 Assumptions

The scope of work for this TS PDI includes the following assumptions:

- Overburden soil will be available for sampling and accessible using a sonic drilling rig.
- The required volume of groundwater can be collected that contains elevated concentrations of uranium (> 2.5 mg/L).
- de maximis will provide an RSO to evaluate the activity level of soil and groundwater to be shipped off-site. If the activity levels exceed the threshold for more rigorous packaging and shipping methods, de maximis will manage the packaging and shipping.

There will be adequate time for the TS to be finished prior to the requirement to submit the PDI Report.

5. TS ISS – 3: AMENDMENT SELECTION FOR BEDROCK GROUNDWATER

5.1 Purpose

Prior to initiation of the bedrock groundwater treatability testing (TS ISS-3), a bedrock drilling and groundwater pumping program will be conducted as presented in PDI ISS-2 - Bedrock Pumping and Rebound Testing. The purpose of this pumping is to evaluate if enough uranium mass can be removed to lower uranium concentrations in bedrock groundwater, thereby remediating via pumping alone, without the need to add amendments to bedrock. If results of PDI ISS-2 indicate that amendments are needed in bedrock, then TS ISS-3 will be initiated according to the plan presented below and illustrated on Figure 1C.

TS ISS-3 will evaluate the performance of three treatment amendments (Apatite II, STPP, and ZVI) at immobilizing uranium in bedrock groundwater via precipitation of uranium solids. The success of treating uranium in bedrock groundwater will rely on identifying an amendment that is both effective under bedrock groundwater conditions and is able to be injected into the target treatment area. For instance, although solid amendments such as Apatite II and ZVI may be more effective at sequestering uranium in bedrock groundwater due to the longevity of the Apatite II treatment and the performance of ZVI under more reducing conditions, the unknown nature of fracture aperture, density, and overall connectivity, combined with low porosity, will make delivery of solid amendments challenging. In turn, although a soluble amendment, such as STPP, has shorter longevity in bedrock fractures, it would be more easily delivered to the target treatment area. Thus, as a first step in identifying the most suitable treatment amendment for bedrock groundwater, Apatite II, STTP, and ZVI will be evaluated in TS ISS-3 as amendments to treat uranium in bedrock groundwater. All testing will be completed as batch reactor studies as shown on **Figure 1C**.

5.2 Scope

5.2.1 Rock Matrix Collection

Crushed bedrock and groundwater will be collected for use in TS ISS-3.

As described in PDI ISS-2: Pumping and Rebound Analysis for Uranium in Bedrock Groundwater, four to six new bedrock pumping wells will be installed for evaluating the viability of a short-term bedrock pumping remedy. These wells will be installed using air rotary methods, and rock chips will be collected from the upper 20 feet of bedrock at the new well location. Crushed bedrock cuttings produced during the drilling process will be collected in laboratory-supplied containers. A minimum of approximately 2 L of crushed bedrock will be collected for use in TS ISS-3 (**Table 1**). Following collection, the samples will be labeled, placed in coolers with ice, and shipped to Hazen under standard chain-of-custody procedures. Bedrock samples will be homogenized and sieved to separate the sand-sized fraction to be used in TS ISS-3 batch reactors. Bedrock samples will be homogenized via cloth blending, use of a V-blender, or cone-and-quartering techniques. Representative sub-samples of homogenized bedrock will be collected based on visual inspection. To characterize the baseline uranium content and determine if the uranium content of the bedrock is consistent with historical data, the lab will analyze a subsample of this fraction for the following:

- Organic and inorganic carbon (combustion analysis)
- Environmentally accessible (acid digestible by EPA Method 3050B) uranium, iron, aluminum, manganese, molybdenum, arsenic, and calcium (ICP-MS/ICP-OES)
- Fe(II) (colorimetry)
- Sulfide (turbidimetry)
- Leachable uranium (SPLP)

Based on the results of baseline groundwater monitoring, bedrock groundwater will be collected from either GZW-10-2 or MW-BS03 (these wells have the highest concentrations of uranium [~ 70 ug/L] as of November 2019). The uranium distribution in bedrock groundwater is shown on Figure 4. Sampling methods will follow low-flow protocols as provided in SOP NMI-GW-010 of the FSP. During collection, filtered (0.45 µm) and unfiltered samples will be collected, and general groundwater quality parameters will be measured, including pH, DO, ORP, turbidity, and specific conductance. A minimum of approximately 13 L of groundwater will be collected and shipped to the laboratory (**Table 1**). Groundwater samples will be labeled and shipped to Hazen under standard chain-of-custody procedures. For baseline characterization, the laboratory will analyze filtered and unfiltered bedrock groundwater at the time of collection and prior to initiation of batch tests for the following:

- pH
- ORP
- Inorganic carbon (coulometry)
- Nitrate (colorimetry)
- Sulfide (turbidimetry)
- Total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron (ICP-MS/ICP-OES) as a baseline characterization.

Comparison of baseline characterization results between the time of collection and the initiation of batch tests will be used to identify changes in groundwater composition (e.g., precipitation, biological consumption) during transport and storage. The Hazen laboratory QA/QC procedures are included in **Attachment A** to this TS work plan.

5.2.2 Batch Reactor Construction

The batch reactor study will be performed using 250-mL glass bottles containing crushed bedrock and bedrock groundwater. The soil:liquid ratios for the batch reactors will be determined to (1) ensure sequestration by the amendment is detectable in excess of the control and (2) prevent dissolution of greater than 10% of the Apatite II amendment in the low-dose condition. Based on the current maximum uranium concentration in bedrock groundwater of 70 µg/L (November 2019), a soil:liquid ratio of 1:200 is initially assumed (equivalent to 1 g of dry bedrock per 200 mL of liquid). Preliminary tests will be conducted to identify the appropriate soil:liquid ratio for the batch reactor test.

Three identical reactors containing crushed bedrock and groundwater will be constructed for each of the following treatments (39 reactors in total) (**Table 2**):

- Unamended control reactor
- Apatite II at 0.5 wt %
- Apatite II at 1.5 wt %
- Apatite II at 3.0 wt %
- Small particle size ZVI at 0.5 wt %

- Small particle size ZVI at 1.5 wt %
- Small particle size ZVI at 3.0 wt %
- Large particle size ZVI at 0.5 wt %
- Large particle size ZVI at 1.5 wt %
- Large particle size ZVI at 3.0 wt %
- STPP at 46 mg/L P
- STPP at 138 mg/L P
- STPP at 277 mg/L P

Apatite II (PIMS NW, Inc.) and ZVI (Hepure Ferox Flow [125 µm]) will be dosed based on dry weight percentage. A subsample of homogenized, crushed bedrock will be dried to determine the moisture content, which will be used to calculate the amount of crushed bedrock and solid treatment amendments (Apatite II and ZVI) needed for each reactor. Doses of STPP (Carus Corporation) were chosen to give equivalent total phosphorus loading to the Apatite II reactors based on the composition of Apatite II (e.g., ~18 wt.% phosphorus).

Once prepared, reactors will be sealed with a rubber stopper. Reactors will be agitated continuously (e.g., placed on a shaker table) for the duration of the study.

5.2.3 Batch Reactor Test

One of the three identical reactors for each condition will be sacrificially sampled at three time points: 3 days, 1 week, and 8 weeks.

At each time point, a subsample of the reactor will be centrifuged and the supernatant will be analyzed for total uranium (ICP-MS/ICP-OES). Uranium measured in the supernatant sample represents the sum of the dissolved and colloidal fractions of uranium. A second subsample will be filtered using a syringe filter (0.45 µm), and the first milliliter of filtrate will be discarded. The remaining filtrate will be analyzed for pH, ORP, inorganic carbon (coulometry), nitrate[22] (colorimetry), sulfide[22] (turbidimetry) and total uranium, calcium, phosphorus, arsenic, manganese, molybdenum, and iron[22] (ICP-MS/ICP-OES), which represent the dissolved fraction of each constituent. Control tests will be conducted to ensure that any artifacts of filtration on dissolved concentrations (retaining analytes on the filter) are minimal.

The best performing amendment dose will be identified as the lowest dose which is able to decrease aqueous uranium concentrations to below the MCL (30 ppb). If an amendment is not able to achieve the MCL, the best performing dose will be identified as the dose which results in the largest percent decrease in uranium from solution compared to the control reactor. For the best performing dose for each amendment (three samples total), the solids generated in the 8-week reactor will be analyzed to quantify the solid-phase speciation of uranium, as follows:

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[22] Nitrate, iron, and sulfide will be measured in select samples as redox indicators.

Four-step sequential extraction: subsamples of column soil will be sequentially extracted by four different solutions, each of which will target a specific fraction of solid-associated uranium. The sequential extraction procedure is based on the Tessier extraction method for trace metals (Tessier et al. 1979[23]) which has been modified to target solid-associated uranium species based the geochemical behavior of uranium (Salome et al. 2017[24]). Following each extraction step, the soil/extractant mixture will be centrifuged and an aliquot of the supernatant will be collected for analysis. The supernatant will be filtered using a syringe filter (0.45 µm), the first milliliter of filtrate will be discarded, and the remaining filtrate will be analyzed for total uranium, calcium, phosphorus, and iron (ICP-MS/ICP-OES). The remaining supernatant will be discarded, and the solid residue will be washed once with deionized water before continuing to the next extraction step. The extraction solutions and target uranium species are listed below in order from least to most recalcitrant:

- Step 1: Weekly sorbed/exchangeable uranium. 1.0 M magnesium chloride in 10 mM nitrilotriacetic acid adjusted to pH 4.5, agitated at room temperature for 1 hour. Nitrilotriacetic acid is included in the extraction solution to prevent the precipitation of uranium desorbed from mineral surfaces by magnesium.

- Step 2: Strongly sorbed/weak acid extractable. 1.0 M sodium acetate adjusted to pH 5.0 with acetic acid, agitated at room temperature for 8 hours. Acetic acid will extract strongly sorbed uranium and uranium associated with carbonate minerals.

- Step 3: Iron- and manganese-associated. 40 mM hydroxylamine in 25% (volume/volume) acetic acid, agitated at 96 °C for 6 hours. Hydroxylamine will target iron- and manganese-oxide associated uranium by reductive dissolution of iron and manganese oxides.

- Step 4: Uranium phosphate minerals and recalcitrant fraction. Reverse aqua regia (3 parts HNO_3 to 1 part HCl). Acid boiled off at 90 °C, and more acid added until digestion is complete. Dissolve salts in 5% HNO_3 for analysis. This extraction step has previously been shown to target uranium-phosphate solids.[25]

A summary of samples and analyses that will be conducted during the batch reactor test are summarized in **Table 3**.

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[23] Tessier, A., Campbell, P.G.C., Bisson, M., 1979. Sequential extraction procedure for the speciation of particulate trace metals. *Anal. Chem*. 51, 844e851.

[24] Salome, K.R., Beazley, M.J., Webb, S.M., Sobecky, P.A., and Taillefert, M., 2017. Biomineralization of U(VI) phosphate promoted by microbially-mediated phytate hydrolysis in contaminated soils. *Geochim. et Cosmochim. Acta.* 197, 27-42.

[25] Lammers, L.N., Rasmussen, H., Adilman, D., deLemos, J.L., Zeeb P., Larson, D.G., Quicksall, A.N., 2017. Groundwater uranium stabilization by metastable hydroxyapatite. Applied Geochemistry 84, 105-113.

5.3 Outcome

Results from the ISS-3 batch reactor study will be used to determine the best performing dose for each treatment and the best treatment for sequestering uranium in bedrock groundwater. The best performing dose will be the lowest dose that decreases aqueous uranium concentrations below the MCL (30 ppb). If the MCL is not achieved, the dose which results in the largest percent removal of uranium from solution will be deemed the best performing dose.

5.4 Assumptions

The scope of work for this TS includes the following assumptions:

- An adequate volume of groundwater can be obtained from bedrock that contains elevated concentrations of uranium.
- There will be adequate time for the TS to be finished prior to the requirement to submit the PDI Report.
- de maximis will provide an RSO to evaluate the activity level of soil and groundwater to be shipped off-Site. If the activity levels exceed the threshold for more rigorous packaging and shipping methods, de maximis will manage the packaging and shipping.

6. SCHEDULE

A preliminary schedule for the scope of work described above is presented below:

	Months after Work Plan Approval									
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Collect HB Soil and Groundwater	■	■								
Collect Overburden Soil and Groundwater	■	■								
Collect Crushed Bedrock and Bedrock Groundwater	■	■								
TS ISS-1 - Column Test			■	■						
TS ISS-2 - Batch Reactor Test			■	■	■					
TS ISS-2 - Column Test					■	■	■			
TS ISS-3 - Batch Reactor Test			■	■	■					
Prepare Treatability Study Report								■	■	■

7. REPORTING

Results from TS ISS-1, ISS-2, and ISS-3 will be detailed in final reports prepared by Hazen and submitted to Geosyntec. Geosyntec will evaluate and interpret the results from the TS to identify the most suitable amendment for each target treatment area. The status of this TS, and interim results, will be provided to USEPA during routine project meetings and status reports. Results and the outcome of the TS will be incorporated into the 30% RD report.

TABLES

Table 1
Summary of Soil and Groundwater Collection
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-1: Reagent Testing for Sequestration of Uranium in Holding Basin Soils

Column Test

Soil

Sample Location	Number of columns	Mass of soil per column[1] (kg)	Mass of soil needed[2] (kg)	Expected volume of soil needed[3] (L) (*assume dry soil = 1.6 g/cm^3*)
High-uranium Holding Basin soil	3	5.5	26	17

Groundwater

Sample Location	Number of columns	Pore Volume per column[4] (mL)	Duration of study (days)	Expected Volume of groundwater needed[2] (L)
Low-uranium Holding Basin groundwater	3	521	28	67

Treatability Study ISS-2: Reagent Testing for Overburden Groundwater

Batch Reactor Test

Soil

Sample Location	Number of reactors	Expected mass of soil per reactor[1] (kg)	Mass of soil needed[2] (kg)	Expected volume of soil needed[3] (L) (*assume dry soil = 1.6 g/cm^3*)
Low-uranium overburden soil	39	0.01	2	2

Groundwater

Sample Location	Number of reactors	Volume of groundwater per reactor (L)	Expected Volume of groundwater needed[2] (L)
High-uranium overburden groundwater	39	0.2	13

SMP Sorption Capacity Test

Soil

Sample Location	Number of reactors	Expected mass of soil per reactor[1] (kg)	Mass of soil needed[2] (kg)	Expected volume of soil needed[3] (L) (*assume dry soil = 1.6 g/cm^3*)
Low-uranium overburden soil	5	0.01	1	1

Groundwater

Sample Location	Number of reactors	Volume of groundwater per reactor (L)	Expected Volume of groundwater needed[2] (L)
Low-uranium overburden groundwater	5	0.2	3

Column Tests

Soil

Sample Location	Number of columns	Mass of soil per column[1] (kg)	Mass of soil needed[2] (kg)	Expected volume of soil needed[3] (L) (*assume dry soil = 1.6 g/cm^3*)
Low-uranium overburden soil	8	5.5	67	42
High-uranium overburden soil	1	5.5	9	6

Groundwater

Sample Location	Number of columns	Pore volume per column[4] (mL)	Duration of study (days)	Expected Volume of groundwater needed[2] (L)
Low-uranium overburden groundwater (SMP Loading)	2	521	7	22 L for SMP loading
High-uranium overburden groundwater	8	521	49	613
Low-uranium overburden groundwater	1	521	42	33

Table 1
Summary of Soil and Groundwater Collection

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-3: Reagent Testing for Bedrock Groundwater				
Batch Reactor Test				
Bedrock				
Sample Location	**Number of reactors**	**Expected Mass of soil per reactor[1] (kg)**	**Mass of soil needed[2] (kg)**	**Expected volume of rock needed[3] (L)** (*assume dry soil = 1.6 g/cm^3*)
Crushed bedrock	39	0.001	2	2
Groundwater				
Sample Location	**Number of reactors**	**Volume of groundwater per reactor[4] (L)**	**Expected Volume of groundwater needed[2] (L)**	
High-uranium bedrock groundwater	39	0.2	13	

Notes:

1. Based on column dimensions (3 inch diameter, 18 inch length) and a bulk soil density of 2.65 grams per cubic centimeter.
2. Includes 50% contingency and additional sample (1 kg soil or 1 L groundwater) for baseline characterization.
3. If soil is wet, add approximately 30% volume.
4. Based on column dimentions (3 inch diameter, 18 inch length) and a bulk soil porosity of 25%.

kg = kilogram
L = liter
mL = milliliter
SMP = sodium monophosphate

Table 2
Summary of Batch Reactor and Column Tests
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-1: Reagent Testing for Sequestration of Uranium in Holding Basin Soils

Column Test

Column Number	Column Name	Soil	Soil Amendement	Column Influent
1	ISS1-Ap	High-uranium Holding Basin Soil	1.5 wt% Apatite II	Low-uranium Holding Basin groundwater Week 1: aerobic (air-sparged) Weeks 2-3: anaerobic (glucose-amended) Week 4: aerobic (air-sparged)
2	ISS1-ZVI		1.0 wt% ZVI	
3	ISS1-Ctrl		Unamended control	

Treatability Study ISS-2: Reagent Testing for Overburden Groundwater

Batch Reactor Test

Reactor Number	Reactor Name	Expected Batch Reactor Composition	Reactor Amendment	Duration
1-3	ISS2-Ap1	10 g Low-uranium overburden soil 200 mL High-uranium overburden groundwater	0.5 wt% Apatite II	8 weeks
4-6	ISS2-Ap2		1.5 wt% Apatite II	
7-9	ISS2-Ap3		3.0 wt% Apatite II	
10-12	ISS2-ApG1		0.5 wt% Apatite II + guar gum	
13-15	ISS2-ApG2		1.5 wt% Apatite II + guar gum	
16-18	ISS2-ApG3		3.0 wt% Apatite II + guar gum	
19-21	ISS2-SMP1		SMP at 46 mg/L P	
22-24	ISS2-SMP2		SMP at 138 mg/L P	
25-27	ISS2-SMP3		SMP at 277 mg/L P	
28-30	ISS2-ZVI1		0.5 wt% ZVI	
31-33	ISS2-ZVI2		1.5 wt% ZVI	
34-36	ISS2-ZVI3		3.0 wt% ZVI	
37-39	ISS2-Ctrl		Unamended Control	

SMP Soprtion Capacity Test

Reactor Number	Reactor Name	Expected Batch Reactor Composition	Reactor Amendment	Duration
1	SMP-1	10 g Low-uranium overburden Soil 200 mL Low-uranium overburden groundwater	SMP at 10 mg/L P	At least 24 hours
2	SMP-2		SMP at 50 mg/L P	
3	SMP-3		SMP at 100 mg/L P	
4	SMP-4		SMP at 200 mg/L P	
5	SMP-5		SMP at 300 mg/L P	

Column Test

Column Number	Column Name	Soil	Soil Amendement	Column Influent
1	ISS2-ApA	Low-uranium overburden soil (same as ISS-2 batch reactor study)	Best performing Apatite II dose from ISS-2 batch reactor test	High-uranium overburden groundwater (same as ISS-2 batch reactor study) Weeks 1-6: aerobic (air-sparged) Week 7: highly alkaline (Na_2CO_3 amended)
2	ISS2-ApB			
3	ISS2-SMPA		Best performing SMP dose from ISS-2 batch reactor test	
4	ISS2-SMPB			
5	ISS2-ZVIA		Best performing ZVI dose from ISS-2 batch reactor test	
6	ISS2-ZVIB			
7	ISS2-CtrlA		No amendment (control)	
8	ISS2-CtrlB			
9	ISS2-Leach	High-uranium overburden soil	No amendment	Low-uranium overburden groundwater equilibrated with Apatite II

Table 2
Summary of Batch Reactor and Column Tests
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-3: Reagent Testing for Bedrock Groundwater

Batch Reactor Test

Reactor Number	Reactor Name	Expected Batch Reactor Composition	Treatment Amendment	Duration
1-3	ISS3-Ap-1	1 g Crushed bedrock 200 mL High-uranium bedrock groundwater	0.5 wt% Apatite II	8 weeks
4-6	ISS3-Ap-2		1.5 wt% Apatite II	
7-9	ISS3-Ap-3		3.0 wt% Apatite II	
10-12	ISS3-STPP-1		STPP at 46 mg/L P	
13-15	ISS3-STPP-2		STPP at 138 mg/L P	
16-18	ISS3-STPP-3		STPP at 277 mg/L P	
19-21	ISS3-ZVI-A1		0.5 wt% ZVI - small particle size	
22-24	ISS3-ZVI-A2		1.5 wt% ZVI - small particle size	
25-27	ISS3-ZVI-A3		3.0 wt% ZVI - small particle size	
28-30	ISS3-ZVI-B1		0.5 wt% ZVI - large particle size	
31-33	ISS3-ZVI-B2		1.5 wt% ZVI - large particle size	
34-36	ISS3-ZVI-B3		3.0 wt% ZVI - large particle size	
37-39	ISS3-Ctrl		Unamended control	

Notes:
g = grams
mg/L = milligram per liter
mL = milliliter
P = phosphorus
SMP = sodium monophosphate
STPP = soluble tripolyphosphate
wt % = weight percent

Table 3
Summary of Samples and Analyses

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-1: Reagent Testing for Sequestration of Uranium in Holding Basin Soils				
Baseline Characterization				
Sample Matrix	**Time**		**Sample Preparation**	**Analyses**
High-uranium Holding Basin Soil	Baseline characterization prior to starting column test		Homogenized	- Organic and inorganic carbon (combustion analysis) - Acid digestion for total U, Fe, Al, Ca, Mn, Mo, As (ICP-MS/ICP-OES) - Leachable U (SPLP, ICP-MS) - Fe(II) (colorimetry) - Sulfide (turbidimetry)
Column influent (Low-uranium Holding Basin groundwater)	Baseline characterization at time of sampling		Unfiltered and filtered (0.45 µm)	- Field parameters: pH, ORP, DO, turbidity, specific conductance - pH - ORP - Inorganic carbon (coulometry) - Nitrate (colorimetry) - Total U, Ca, P, As, Mn, Mo, and Fe (ICP-MS/ICP-OES)
	Baseline characterization prior to starting column test		Unfiltered and filtered (0.45 µm)	
Column Test				
Sample Matrix	**Time**		**Sample Preparation**	**Analyses**
Column effluent	Week 1 (aerobic)	Days 2, 4, and 7	Unfiltered	- pH - ORP - Total U, Ca, P, As[1], Mo[1], Mn, and Fe[2] (ICP-MS/ICP-OES) - Nitrate[2] (colorimetry) - Sulfide[2] (turbidimetry) - Inorganic carbon (coulometry)
	Weeks 2-3 (anaerobic)	Days 2, 7, and 14	Unfiltered	
	Week 4 (aerobic)	Days 2, 4, and 7	Unfiltered	

Table 3
Summary of Samples and Analyses
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-2: Reagent Testing for Overburden Groundwater

Baseline Characterization

Sample Matrix	Time	Sample preparation	Analyses
Low-uranium overburden soil (Batch and column treatment tests)	Baseline characterization prior to starting batch and column tests	Homogenized	- Organic and inorganic carbon (combustion analysis) - Acid digestion for total U, Fe, Mn, Mo, As, Al, and Ca (ICP-MS/ICP-OES) - Leachable U (SPLP, ICP-MS) - 4-step sequential extraction for U[3] (high-uranium soil only) - Fe(II) (colorimetry) - Sulfide (turbidimetry)
High-uranium overburden soil (phosphate transport column test)	Baseline characterization prior to starting batch and column tests	Homogenized	
Low-uranium Overburden Groundwater (SMP sorption test, phosphate transport column test)	Baseline characterization at time of sampling	Unfiltered and filtered (0.45 µm)	- Field parameters: pH, ORP, DO, turbidity, specific conductance - pH - ORP - Inorganic carbon (coulometry) - Total U, Ca, P, As, Mo, Mn, and Fe (ICP-MS/ICP-OES) - Nitrate (colorimetry) - Sulfide (turbidimetry)
	Baseline characterization prior to starting batch and column tests		
High-uranium overburden groundwater (Batch and column treatment tests)	Baseline characterization at time of sampling	Unfiltered and filtered (0.45 µm)	
	Baseline characterization prior to starting batch and column tests		

Batch Reactor Test

Sample Matrix	Time	Sample preparation	Analyses
Batch Reactors	Day 3 Day 7 (1 week) Day 56 (8 weeks)	Centrifuge, unfiltered supernatant	- Total U (ICP-MS/ICP-OES)
		Filtered (<0.45 µm)	- pH - ORP - Inorganic carbon (coulometry) - Total U, Ca, P, As[1], Mo[1], Mn, and Fe[2] (ICP-MS/ICP-OES) - Nitrate[2] (colorimetry) - Sulfide[2] (turbidimetry)

SMP Sorption Capacity Test

Sample Matrix	Time	Sample preparation	Analyses
Batch Reactors	After at least 24 hours of equilibration	Filtered (<0.45 µm)	- Total P (ICP-MS/ICP-OES)

Column Test (treatment evaluation)

Sample Matrix	Time		Sample Preparation	Analyses
Primary column effluent	SMP loading period (SMP treatment column only)	Once per day for approximately 7 days	Unfiltered	- Total P (ICP-MS/ICP-OES)
	Unamended groundwater influent period	Once per week for 6 weeks	Unfiltered	- pH - ORP - Total U, Ca, P, As[1], Mo[1], Mn, and Fe[2] (ICP-MS/ICP-OES) - Inorganic carbon (coulometry) - Nitrate[2] (colorimetry) - Sulfide[2] (turbidimetry)
	Alkaline groundwater influent period	Twice per week for 1 week	Unfiltered	
Secondary column soil	After completion of 6-week unamended groundwater influent period		Centrifuge, remove supernatant	- Acid digestion for total U, Ca, P, Fe (ICP-MS/ICP-OES) - Bicarbonate leaching test[3], U (ICP-MS) - 4-step sequential extraction[3], U, Ca, P, and Fe (ICP-MS/ICP-OES) - XRD or QEMSCAN on select samples

Column Test (phosphate transport and uranium leaching evaluation)

Sample Matrix	Time	Sample Preparation	Analyses
Column effluent	Once per week for up to 6 weeks	Unfiltered	- pH - ORP - Total U, Ca, P, As[1], Mn, and Fe[2] (ICP-MS/ICP-OES) - Inorganic carbon (coulometry) - Nitrate[2] (colorimetry) - Sulfide[2] (turbidimetry)

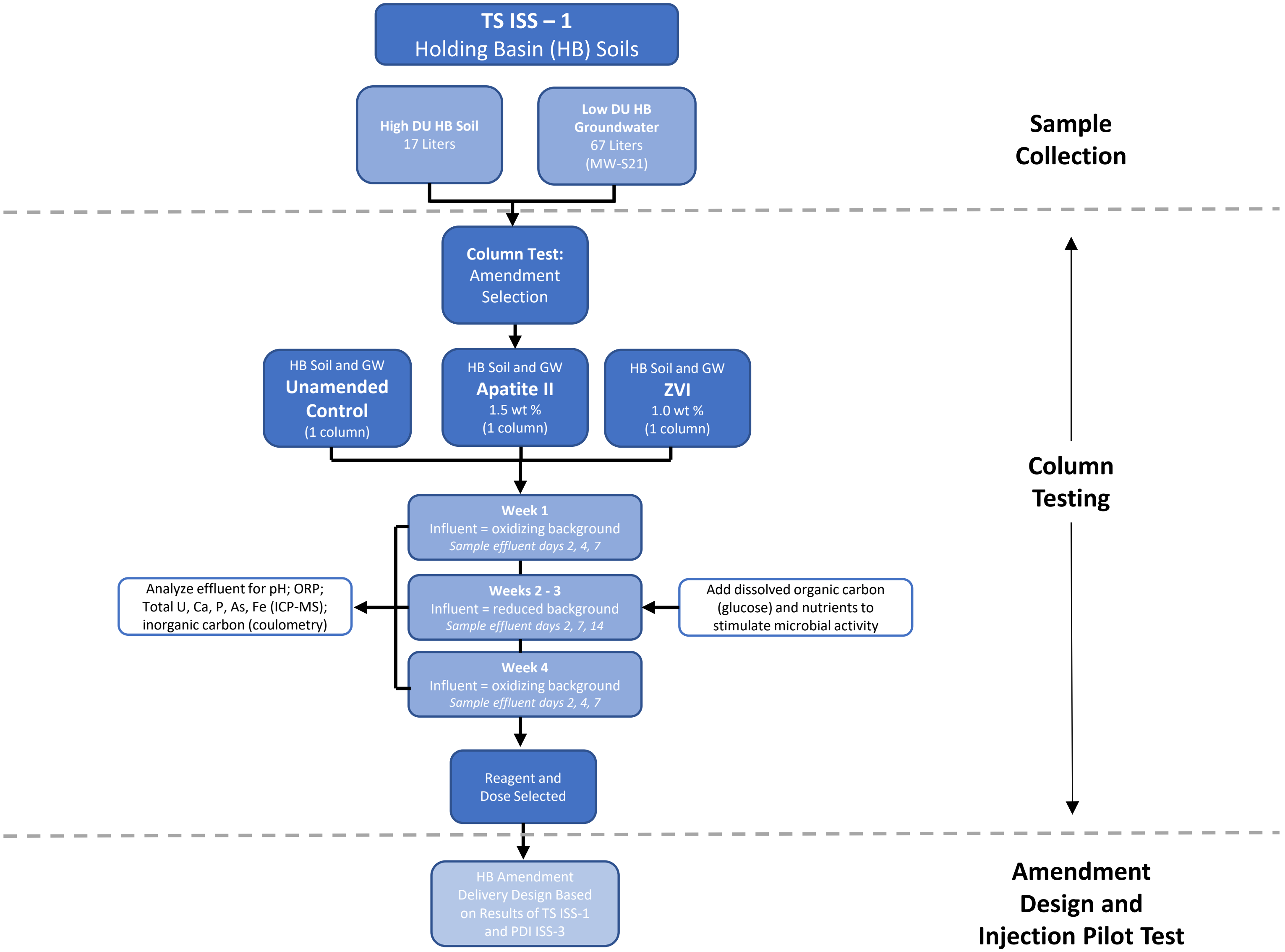
Table 3
Summary of Samples and Analyses
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Treatability Study ISS-3: Reagent Testing for Bedrock Groundwater			
Baseline Characterization			
Sample Matrix	**Time**	**Sample preparation**	**Analyses**
Crushed bedrock	Baseline characterization prior to starting batch reactor test	Homogenized and sieved (target sand fraction)	- Organic and inorganic carbon (combustion analysis) - Acid digestion for total U, Fe, Al, Ca, Mn, Mo, and As (ICP-MS/ICP-OES) - Leachable U (SPLP, ICP-MS) - Fe(II) (colorimetry) - Sulfide (turbidimetry)
Bedrock groundwater	Baseline characterization at time of sampling	Unfiltered and filtered (0.45 µm)	- pH - ORP - Inorganic carbon (coulometry) - Total U, Ca, P, As, Mn, Mo, and Fe (ICP-MS/ICP-OES) - Nitrate (colorimetry) - Sulfide (turbidimetry)
	Baseline characterization prior to starting batch tests		
Batch Reactor Test			
Sample Matrix	**Time**	**Sample preparation**	**Analyses**
Batch reactors (aqueous analyses)	Day 3 Day 7 (1 week) Day 56 (8 weeks)	Centrifuge, unfiltered supernatant	- Total U (ICP-MS/ICP-OES)
		Filtered (<0.45 µm)	- pH - ORP - Inorganic carbon (coulometry) - Total U, Ca, P, As^{1}, Mo^{1}, Mn, and Fe^{2} (ICP-MS/ICP-OES) - Nitrate^{2} (colorimetry) - Sulfide^{2} (turbidimetry)
Batch reactors (solid analyses)	Day 56 (Week 8)	Centrifuge, remove supernatant	- 4-step sequential extraction^{3} on best-performing dose for each treatment, U, Ca, P, and Fe (ICP-MS/ICP-OES)

Notes:
1. Arsenic and molybdenum will be analyzed less frequently than the other analytes.
2. Nitrate, dissolved iron, and sulfide will be analyzed in select samples to monitor the redox conditions of the batch reactors and columns.
3. Details of the bicarbonate leaching test and 4-step sequential extraction are provided in the text.

µm = micrometer
As = arsenic
Ca = calcium
DO = dissolved oxygen
EPA = United States Environmental Protection Agency
Fe = iron
ICP-MS = inductively coupled plasma mass spectrometry
ICP-OES = inductively coupled plasma optical emission spectroscopy
ORP = Oxidation reduction potential
P = phosphorus
QEMSCAN = Quantitative Evaluation of Minerals by SCANing electron microscopy
SMP = sodium monophosphate
SPLP = synthetic precipitation leaching procedure
U = uranium
XRD = X-ray diffraction

FIGURES



TS ISS – 1
Holding Basin (HB) Soils

High DU HB Soil
17 Liters

Low DU HB Groundwater
67 Liters
(MW-S21)

Sample Collection

Column Test:
Amendment Selection

HB Soil and GW
Unamended Control
(1 column)

HB Soil and GW
Apatite II
1.5 wt %
(1 column)

HB Soil and GW
ZVI
1.0 wt %
(1 column)

Week 1
Influent = oxidizing background
Sample effluent days 2, 4, 7

Weeks 2 - 3
Influent = reduced background
Sample effluent days 2, 7, 14

Week 4
Influent = oxidizing background
Sample effluent days 2, 4, 7

Analyze effluent for pH; ORP; Total U, Ca, P, As, Fe (ICP-MS); inorganic carbon (coulometry)

Add dissolved organic carbon (glucose) and nutrients to stimulate microbial activity

Reagent and Dose Selected

Column Testing

HB Amendment Delivery Design Based on Results of TS ISS-1 and PDI ISS-3

Amendment Design and Injection Pilot Test

Notes:
GW = groundwater
ISS = in situ stabilization
mg/L = milligram per liter
P = phosphorus
SMP = sodium monophosphate
STPP = sodium tripolyphosphate
TS = treatability study
U = uranium
Wt % = weight percentage
ZVI = zero valent iron

Flow Chart for Holding Basin Uranium in Soils Treatability Testing (TS ISS-1)

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

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Figure

1A

BR0090

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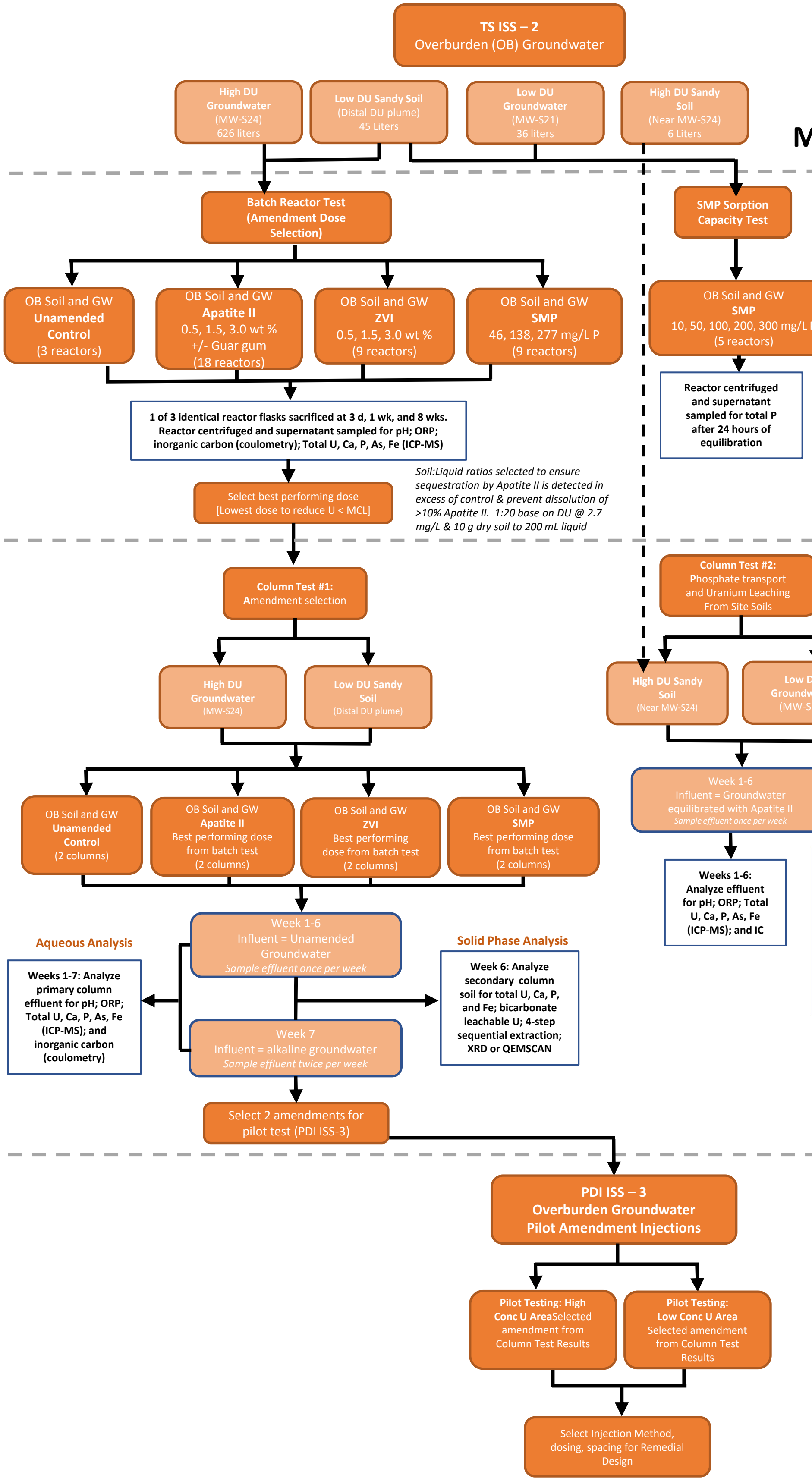

TS ISS – 2
Overburden (OB) Groundwater

High DU Groundwater
(MW-S24)
626 liters

Low DU Sandy Soil
(Distal DU plume)
45 Liters

Low DU Groundwater
(MW-S21)
36 liters

High DU Sandy Soil
(Near MW-S24)
6 Liters

Soil and Groundwater Media Collection

Batch Reactor Test (Amendment Dose Selection)

OB Soil and GW
Unamended Control
(3 reactors)

OB Soil and GW
Apatite II
0.5, 1.5, 3.0 wt %
+/- Guar gum
(18 reactors)

OB Soil and GW
ZVI
0.5, 1.5, 3.0 wt %
(9 reactors)

OB Soil and GW
SMP
46, 138, 277 mg/L P
(9 reactors)

1 of 3 identical reactor flasks sacrificed at 3 d, 1 wk, and 8 wks. Reactor centrifuged and supernatant sampled for pH; ORP; inorganic carbon (coulometry); Total U, Ca, P, As, Fe (ICP-MS)

Select best performing dose
[Lowest dose to reduce U < MCL]

Soil:Liquid ratios selected to ensure sequestration by Apatite II is detected in excess of control & prevent dissolution of >10% Apatite II. 1:20 base on DU @ 2.7 mg/L & 10 g dry soil to 200 mL liquid

SMP Sorption Capacity Test

OB Soil and GW
SMP
10, 50, 100, 200, 300 mg/L P
(5 reactors)

Reactor centrifuged and supernatant sampled for total P after 24 hours of equilibration

Batch Testing

Column Test #1:
Amendment selection

High DU Groundwater
(MW-S24)

Low DU Sandy Soil
(Distal DU plume)

OB Soil and GW
Unamended Control
(2 columns)

OB Soil and GW
Apatite II
Best performing dose from batch test
(2 columns)

OB Soil and GW
ZVI
Best performing dose from batch test
(2 columns)

OB Soil and GW
SMP
Best performing dose from batch test
(2 columns)

Week 1-6
Influent = Unamended Groundwater
Sample effluent once per week

Week 7
Influent = alkaline groundwater
Sample effluent twice per week

Aqueous Analysis

Weeks 1-7: Analyze primary column effluent for pH; ORP; Total U, Ca, P, As, Fe (ICP-MS); and inorganic carbon (coulometry)

Solid Phase Analysis

Week 6: Analyze secondary column soil for total U, Ca, P, and Fe; bicarbonate leachable U; 4-step sequential extraction; XRD or QEMSCAN

Select 2 amendments for pilot test (PDI ISS-3)

Column Test #2:
Phosphate transport and Uranium Leaching From Site Soils

High DU Sandy Soil
(Near MW-S24)

Low DU Groundwater
(MW-S21)

Week 1-6
Influent = Groundwater equilibrated with Apatite II
Sample effluent once per week

Weeks 1-6: Analyze effluent for pH; ORP; Total U, Ca, P, As, Fe (ICP-MS); and IC

Column Testing

PDI ISS – 3
Overburden Groundwater
Pilot Amendment Injections

Pilot Testing: High Conc U Area Selected amendment from Column Test Results

Pilot Testing: Low Conc U Area
Selected amendment from Column Test Results

Select Injection Method, dosing, spacing for Remedial Design

Amendment Design and Injection Pilot Test

Notes:
GW = groundwater
ISS = in situ stabilization
mg/L = milligram per liter
P = phosphorus
SMP = sodium monophosphate
STPP = sodium tripolyphosphate
TS = treatability study
U = uranium
Wt % = weight percentage
ZVI = zero valent iron

Flow Chart for Overburden Uranium in Groundwater Treatability Testing (TS ISS-2)

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

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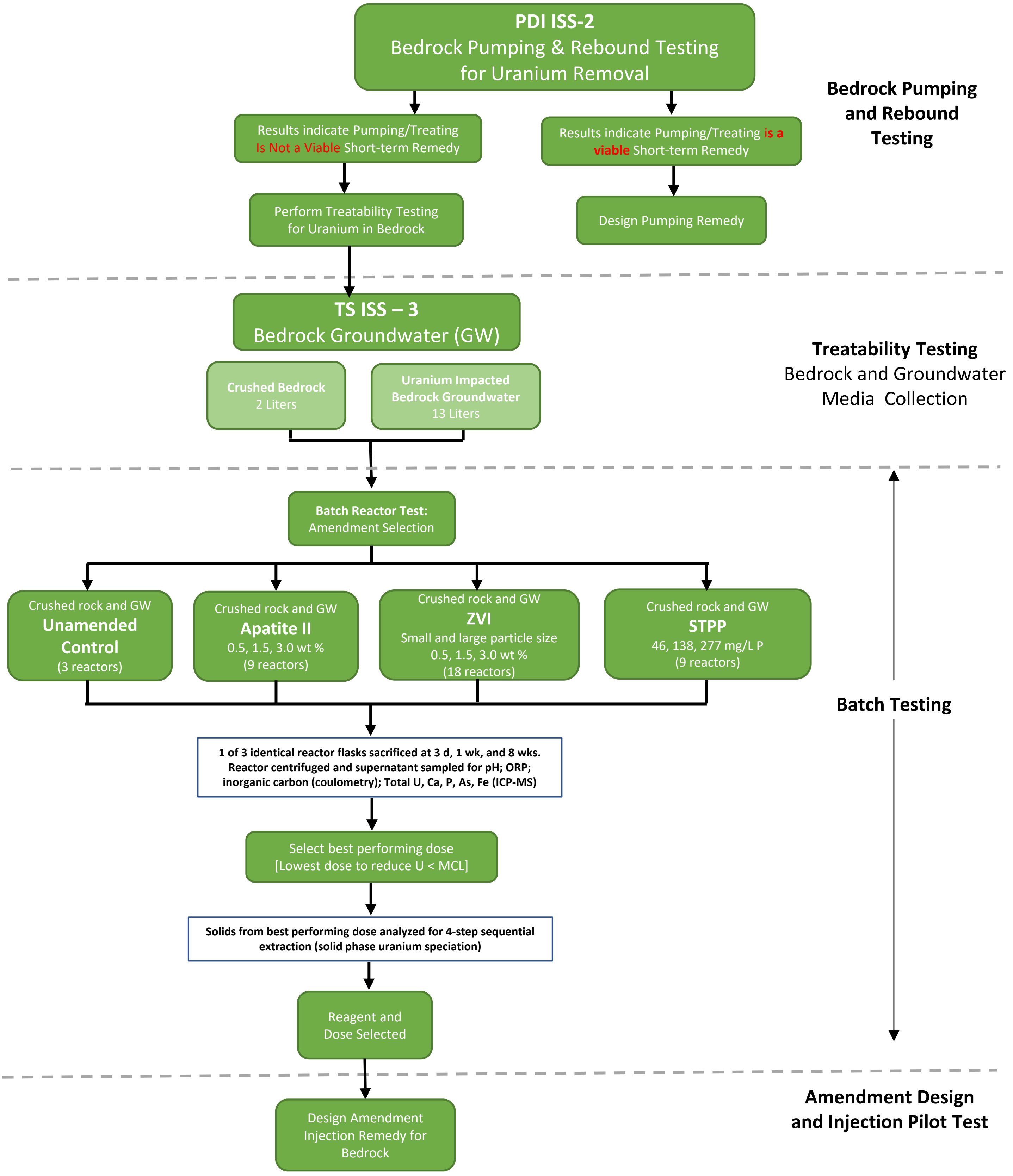
Figure
1B



Notes:
GW = groundwater
ISS = in situ stabilization
mg/L = milligram per liter
P = phosphorus
SMP = sodium monophosphate
STPP = sodium tripolyphosphate
TS = treatability study
U = uranium
Wt % = weight percentage
ZVI = zero valent iron

Flow Chart for Bedrock Uranium in Groundwater Treatability Testing (TS ISS-3)

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

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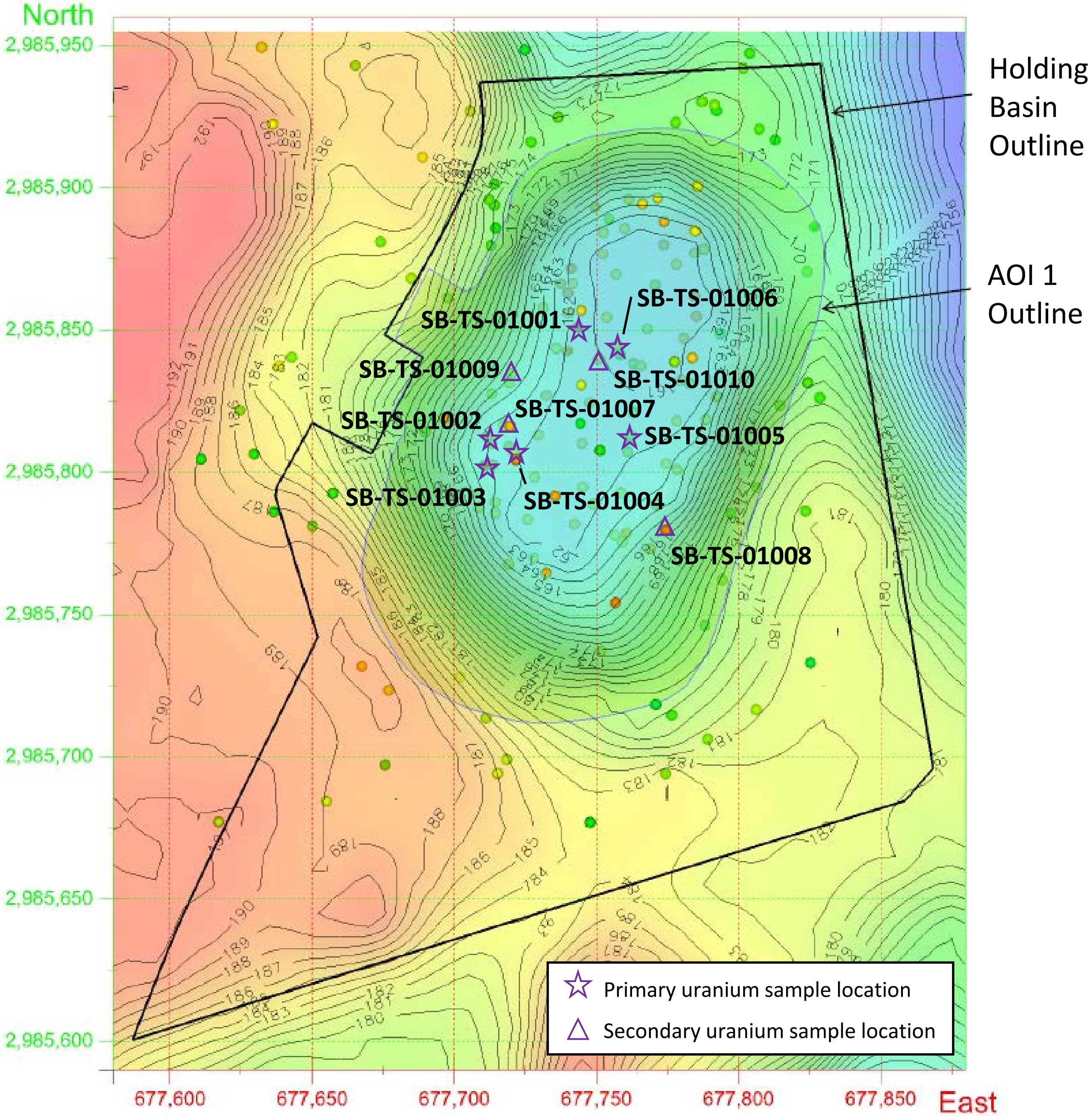
BR0090	September 2020

Figure

1C



Boring ID	Primary Boring	Easting	Northing	Sample Depth Interval (ft bgs)	Closest Historical Sample	
					Sample ID	Uranium Conc. Range (mg/kg)
Unsaturated						
SB-TS-01001	Y	677,743	2,985,851	8 – 18	SB-8	3,868 – 12,023
SB-TS-01002	Y	677,712	2,985,812	7 – 17	HB-308	1,150 – 2,740
SB-TS-01003	Y	677,714	2,985,803	6 – 16	SB-3	939 – 1,977
SB-TS-01007	N	677,717	2,985,817	13 – 23	HB-437	686 – 1,188
SB-TS-01008	N	677,775	2,985,780	4 – 14	SB-5	579 – 1,309
Saturated						
SB-TS-01004	Y	677,720	2,985,808	45 – 55	HB-439	464 – 1,317
SB-TS-01005	Y	677,762	2,985,812	47 – 57	HB-440	462 – 545
SB-TS-01006	Y	677,715	2,985,886	46 – 56	HB-441	106 – 391
SB-TS-01009	N	677,720	2,985,835	50 – 60	HB-503	213 – 388
SB-TS-01010	N	677,751	2,985,840	26 – 36	HB-423	272 – 1,096

1) Abbreviations: AOI = area of investigation; conc. = concentration; ft bgs = feet below ground surface; mg/kg = milligram per kilogram

2) Coordinates are in state plane

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Proposed Holding Basin Soil Boring Locations
ACTON, MASSACHUSETTS

PROJECT: BR0090 | FIGURE 2

MW-S01 (NA)	
3/05	0.71
10/05	0.41
9/08	3.41
7/17	0.43
11/19	0.465

MW-SD01 (0.22%)	
3/05	0.81
10/05	3.81
4/08	5.31
9/08	10.53
11/09	5.65
6/10	6.44
5/11	6.04
10/12	5.48
7/13	6.33/J
7/17	11.5
11/19	7.85

MW-S06 (NA)	
10/05	<0.07
5/06	0.48
8/07	0.64
9/08	4.51/J
5/09	<0.346/UJ
8/13	<0.067/U
7/17	1.63
11/19	0.147J

MW-SD06 (0.67%)	
4/05	0.84
10/05	1.81
11/09	1.2
11/19	1.22

MW-SD02 (NA)	
3/05	<0.009
11/05	<0.03
8/13	0.56
11/19	0.391

MW-SD27 (NA)	
11/05	0.26/J
5/06	0.14/UJ
11/19	<0.067

MW-SD30 (NA)	
11/05	<0.03/UJ
5/06	<0.08/UJ
11/19	<0.067

MW-S27 (NA)	
11/05	0.17/J
5/06	0.1/UJ
9/08	0.17/UJ

MW-S30 (NA)	
11/05	<0.048/UJ
5/06	<0.11/UJ
4/08	0.37
9/08	<0.087/UJ
11/19	<0.0677/J

MW-S17 (NA)	
3/05	0.83
11/05	1.2
11/19	0.46

MW-SD17 (NA)	
3/05	0.27
10/05	<0.11
11/19	0.142/J

MW-8A (0.21%)	
4/05	573
11/05	645/J
5/06	726
8/07	772
4/08	982
9/08	799/J
5/09	797/J
11/09	727
6/10	690/J
5/11	675
10/12	447
8/13	551/N
7/17	148
11/19	251

MW-S07 (NA)	
4/05	1.2
11/05	1/J
11/19	1.2

MW-S16 (0.21%)	
4/05	114
11/05	146/J
5/06	169
8/07	158
4/08	160
9/08	157/J
5/11	125
10/12	105
8/13	120
11/19	100

TW-4 (0.33%)	
4/05	8.7/J

MW-S24 (0.20%)	
4/05	3710
10/05	3840
5/06	2890
8/07	3940
4/08	5360
9/08	4160/J
5/09	5480/J
11/09	3420
6/10	3930/J
5/11	4200
10/12	2730
8/13	2550
7/17	2946
11/19	2675

MW-T24 (0.23%)	
4/05	75.4/J
10/05	120/J
5/09	26.3/J
11/09	87.4
6/10	65.1
5/11	65.4/J
10/12	37.3
8/13	47.9
11/19	59.8

MW-S02 (0.24%)	
3/05	30.9
10/05	26.4
8/07	9.32
4/08	2
9/08	28.7/J
5/09	1.46
11/09	31.6
6/10	<0.332
5/11	0.7
10/12	120/J
8/13	53
7/17	0.912
11/19	4.24

MW-S05 (NA)	
3/05	26.6
11/05	5.31/J
5/06	2.1
11/09	0.53
5/11	0.36
10/12	0.25
8/13	0.34/N

HBPZ-2R (0.20%)	
4/05	2390
11/05	1800/J
5/06	1570
8/07	1670
4/08	1160
9/08	1350/J
5/09	931/J
11/09	1380
6/10	825/J
5/11	1180
10/12	1810/J
8/13	1370
7/17	1964
11/19	1132

HB-07 (0.20%)	
4/05	77.2
11/05	63.9/J

GZW-7-1 (0.20%)	
4/05	129/J
10/05	124
9/08	151
11/09	132
6/10	94.2/J
5/11	111/J
10/12	103
8/13	105
11/19	69.3

GZW-7S (0.22%)	
4/05	122
10/05	117
8/07	122
11/19	67.1

MW-S20 (NA)	
4/05	2.52
10/05	2.21
11/19	0.483

MW-S18 (NA)	
4/05	2.82
10/05	4.52
5/06	3.2
11/19	0.849

HB-12 (0.20%)	
4/05	2490
11/05	1460
5/06	1160
8/07	1580
4/08	695
9/08	837/J
5/09	560/J
11/09	821
6/10	270/J
5/11	372
10/12	681
8/13	634/N
7/17	571
11/19	441

Legend

- ⌖ Monitoring Well
- ✦ Piezometer
- ɸ Staff Gauge
- ⊕ Groundwater Profiling Location
- ▣ Proposed Soil Sample Location
- ▨ Holding Basin Source Control Area
- ☐ Septic Fields
- ▒ Wetlands
- 🟦 Surface Water
- ━ Uranium Contour in Overburden Groundwater, November 2019 (µg/L)
- ━ Cross Section A-A"

Most Recent Total Uranium

- ● < 1 µg/L
- ● 1.01 - 10 µg/L
- ● 10.01 - 20 µg/L
- ● 20.01 - 30 µg/L
- ● > 30.01 µg/L MCL Exceedance in Overburden

Historical Total Uranium (µg/L)

HBPZ-2R (0.20%)	
Date	Total Uranium (µg/L)
8/13	1370
7/17	1964
11/19	1132

(0.21%) Represents the U-235% in the most recent sample data through November 2019

Notes:

1. Although concentrations shown are for total uranium, results shown are primarily depleted uranium (U-235% <0.6%).
2. Tabular summaries at wells downgradient of elevated total uranium are displayed for illustrative purposes only.
3. µg/L = micrograms per liter.
4. U = Not detected at or above the method detection limit shown.
5. J = Estimated value.
6. N = Indicates presumptive evidence of a compound. This flag is usually used for a tentatively identified compound, where the identification is based on a mass spectral library search.
7. Most Recent concentration text color within tabular summaries on figure coded by concentration ranges listed above.

Depleted Uranium in Overburden Groundwater - Data Through November 2019

Nuclear Metals Inc. Superfund Site
Concord, Massachusetts

0 20 40 80 120 160 Feet

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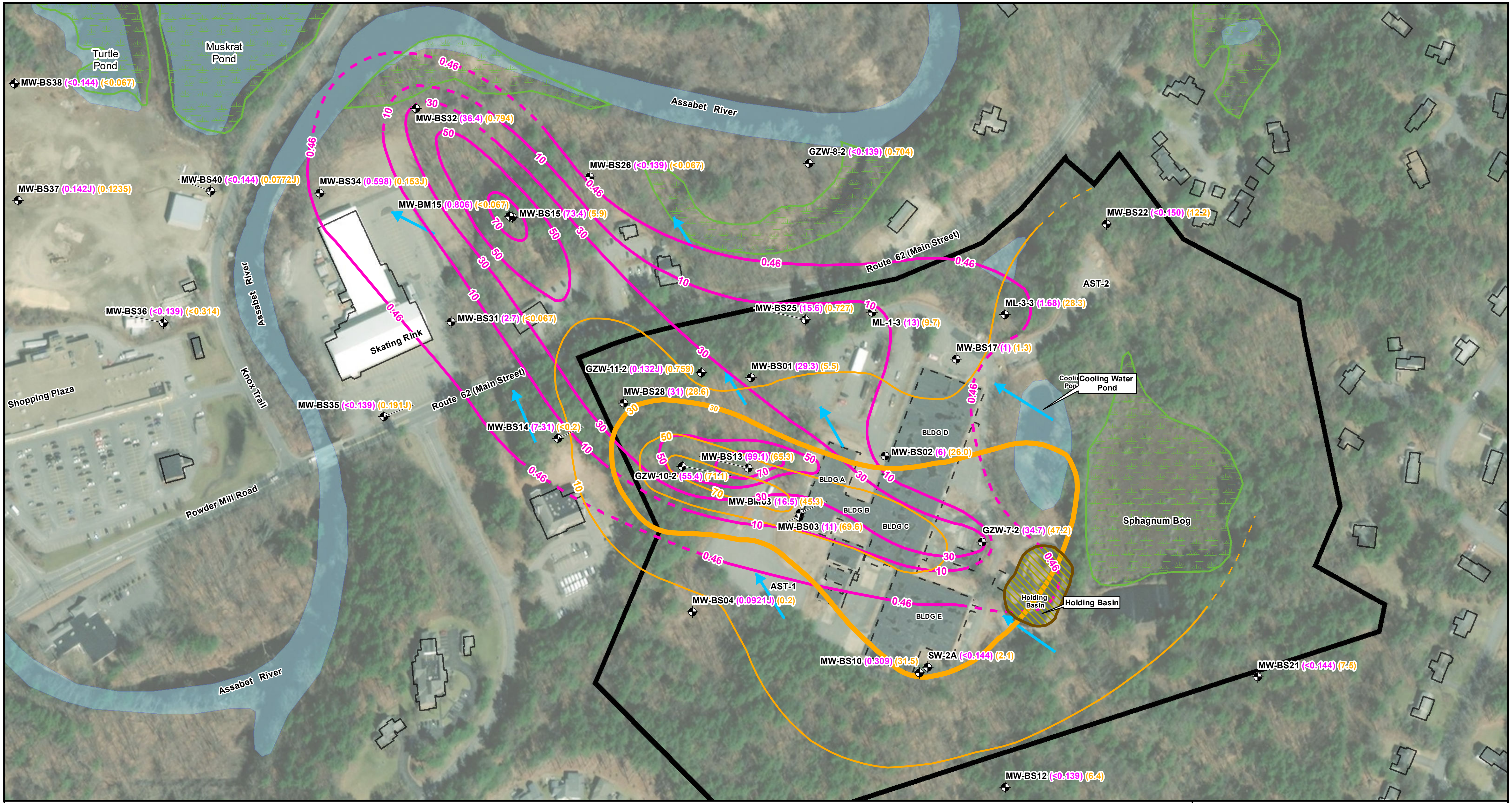
de maximis, inc.

Acton, Massachusetts

September 2020

Figure 3

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 2-5 Depleted Uranium in OB GW_v2.mxd



Legend

- Bedrock Monitoring Well
- Site Boundary
- Building Outline
- Former Building Concrete Foundation
- Bedrock Groundwater Flow Direction Inferred from November 2019 Groundwater Elevations
- Surface Water
- Wetlands
- Uranium ISO Contour in Bedrock November 2019 (µg/L)
- Estimated Uranium ISO Concentration Contour in Bedrock November 2019 ug/L
- 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)
- Estimated 1,4-Dioxane ISO Concentration Contour in Bedrock November 2019 (µg/L)

0.57 1,4-Dioxane Concentrations November 2019 (µg/L)

76.9 Uranium Concentrations November 2019 (µg/L)

Note:

1. The uranium concentrations shown represent total uranium. Uranium in bedrock groundwater is characterized as isotopically natural (U-235% > 0.6%).
2. < = less than laboratory method detection limit.
3. J = estimated detection below method quantitation limit.

DRAFT

N

0 220 Feet

Uranium and 1,4-Dioxane Concentrations in Bedrock Groundwater - November 2019

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants

de maximis, inc.

Figure 4

Acton, Massachusetts

July 2020

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ATTACHMENT A

THE HUFFMAN HAZEN LABORATORIES' QA/QC PLAN

TITLE: THE HUFFMAN HAZEN LABORATORIES' QA/QC PLAN

I. PURPOSE:

This describes Huffman Hazen Laboratories' Quality Assurance/Quality Control (QA/QC) plan.

II. SCOPE:

This procedure applies to analyses performed at Huffman Hazen Laboratories, Inc., 4630 Indiana St., Golden, CO 80403 (Huffman Hazen Labs). Special analytical requirements, client's special needs, or client-supplied procedures may be considered in view of this procedure -- in the case of conflicts, an agreement between the parties may be reached, as deemed appropriate by a suitable representative of each party.

III. PROCEDURE:

A. Quality Control Data

At a minimum, the following Quality Control (QC) analyses shall be performed for all samples, unless otherwise deemed appropriate by a suitable representative of Huffman Labs. It is acceptable to exceed the minimum QC requirements outlined herein. Deviations shall be noted and/or reported appropriately (Refer to Appendices I and II for definitions).

1. Daily:
    a) Initial Calibration Standard(s) (ICS)
    b) Instrument Blanks (IB)
2. At least one per sample batch:
    a) Method Blank (MB)
    b) Laboratory Control Sample (LCS)
3. For every ten samples, at least one per batch:
    a) Duplicate samples (DUP)
    b) Continuing Calibration Standard (CCS) - may also be run at the end of the batch.
4. At least once every 12 months
    a) Instrument detection limits (IDL) shall be confirmed (if applicable).
5. Raw data sufficient to recalculate results shall be maintained for an appropriate period of time, but for at least 30 days. This data shall be appropriately identified.
6. Acceptable values for standards and duplicates shall be as specified in the Standard Operating Procedure (SOP) for individual analytical procedures and/or methods. If not otherwise specified, standards shall be within 10% of predicted values (e.g. calculated values, theoretical values, etc.). Duplicates shall be within 10% of their mean values if quantifiable.
7. Blanks shall be as specified in the SOP for the specific analysis -- if not otherwise specified, variation in the blanks shall be less than half of the reporting limit for the subject analysis.
8. In any case deemed appropriate by a suitable representative of Huffman Hazen Labs, additional measures (e.g. spikes, duplicates, dilutions, etc.) may be added.

B. Corrective Action

1. Samples analyzed while QC values are out of the specified range shall be reanalyzed after the system is brought back into control.

2. In cases where client data has been reported, and wherein it is subsequently determined by a suitable representative of Huffman Hazen Labs that there is a discrepancy in the reported data, the client shall be notified of the discrepancy.

C. Exceptions

1. Additional and/or modified QC requirements may be specified in analytical method SOP's, and/or may be specified by clients.
2. If results are used for an analysis in which QC data is not within designated control limits (for any reason), the QC data shall be summarized and included in the raw data assocated with the samples. Based upon client requests and/or requirements, a suitable representative of Huffman Hazen Labs shall determine if the QC data and/or an appropriate disclaimer shall be reported to the client.
3. In some cases, calibration blanks and instrument blanks may be the same.
4. In some cases (e.g. BTU determinations) blanks may not be required. In these cases, a note shall be included in the individual SOP for the relevant analysis.
5. In the cases where a standard reference material cannot be obtained, this shall be noted in the raw data package. A suitable representative of Huffman Hazen Labs may approve the use of a single reference material, if he/she deems it appropriate.

D. Quality Assurance

1. Analysts shall monitor QC data and, if possible, make appropriate corrections to any out of control situation.
2. Managers and/or supervisors (i.e. suitable representatives of Huffman Hazen Labs) are responsible for checking to see that QC data has been obtained for all analyses, and that values are acceptable as outlined in SOP DOC-04.
3. The QA/QC Officer or designee shall on an annual basis:
    a) Review a random report for each method to confirm that proper procedures outlined in the SOPs have been followed.
    b) Report non-conforming QA/QC data to the Lab Director of Huffman Hazen Labs, or his/her designee using the CAR/CUC form.
4. The Lab Director of Huffman Hazen Labs, or his/her designee shall make the final decision as to whether QA/QC data are acceptable.
    a) If the data are deemed unacceptable, a representative of Huffman Hazen Labs or his/her designee shall further determine whether analyses and/or QA/QC shall be rerun.
5. Blind samples shall be inserted into routine analyses periodically, as deemed necessary by a suitable representative of Huffman Hazen Labs.
    a) Lab Coordinator and/or Analysts shall not be made aware that these blind samples are standards.
    b) Results of these blind samples shall be reported to a suitable representative of Huffman Hazen Labs, who may then make results available to the supervisors, as he/she deems appropriate.
6. Any individual failing to follow this QA/QC plan shall be subject to disciplinary action, up to and including termination.

E. **Labeling**

1. All sample containers, including client samples and laboratory QC samples such as blanks, standards, etc., from point of preparation to point-of-use, shall be clearly labeled with appropriate information to provide unambiguous traceability to the source of the contents of the container.

APPENDIX I

GLOSSARY

BATCH:

A "batch" shall mean a group of similar samples that are run together for a particular test/analysis. In the case where a client submits a single sample, it may be considered a batch by itself, or may alternatively be combined with similar samples to comprise a batch. A batch does not indicate or imply any particular number of samples, as the term is utilized, herein.

BLANKS:

IB	(Instrument Blank) - Blank for instrument calibration reagents.
MB	(Method Blank) - Blank carried through entire analytical method.

CALIBRATION STANDARDS:

CCS	(Calibration Check Standard) - May be same as ICS or LCS. Run periodically during run to ensure continuing calibration.
ICS	(Initial Calibration Standards) – Calibration standards that are traceable to NIST, when possible.
IDLS	(Instrument Detection Limit Standard) - Calibration standard at 3 to 5 times the detection limit to ensure that the instrument performs at the specified detection limit. The IDL shall be set to three times the standard deviation of 10 non-consecutive runs. Blanks may be used to determine IDL, where appropriate.
LCS	(Laboratory Control Sample) A standard reference material carried through an entire analysis. The LCS matrix shall be as similar to the sample matrix as possible. The LCS shall not be the same as the ICS.

LIMITS:

MDL	(Method Detection Limit) – the minimum amount of a given analyte that can be detected with a sufficient level of confidence.
PQL	(Practical Quantitation Limit) – the minimum amount of a given analyte that can accurately be quantified.
MRL	(Reporting Limit) – the minimum level of a given analyte that can be reported (e.g. to a client).

NOTE: Standards used for calibration are typically NIST traceable, they are purchased from third parties, and they are typically provided with an expiration date. While it is understood that these expiration dates are somewhat arbitrary, they shall be acknowledged and dealt with in the following manner:

Standards that are beyond their expiration date may be revalidated on an as-needed basis, in order to keep them in service. Expired standards shall be analyzed alongside current (i.e. valid, unexpired) standards for comparison. If their values are within acceptable levels, based on analytical precision and/or instrumentation limits, a "revalidation sticker" may be placed on the expired standard. The revalidation sticker shall indicate the new expiration date, which shall be the same duration as that indicated by the original expiration date. This revalidation process may be repeated for any chemical standard, as needed.

SAMPLE CONTROLS

DUP	(Duplicate Sample) - Carried through the entire analytical procedure.
SPIKE	(Spike) - A known quantity of calibration standard (e.g. an ICS) added to a known quantity of sample.

SUITABLE REPRESENTATIVE OF HUFFMAN LABS:

A “suitable representative of Huffman Hazen Labs”, as used in this document and in other related Standard Operating Procedures of Huffman Hazen Labs, shall be any employee (full-time, part-time, or semi-retired) who, in a given situation or circumstance, has the background, training, wherewithal, and/or understanding of a situation to render a well-reasoned decision that produces a viable and sound outcome in the situation at hand. Examples of a “suitable representative of Huffman Hazen Labs” include, but are not limited to the Lab Director, a staff member with an advanced degree in chemistry or related field, the Lab Coordinator, and/or a lab supervisor.

APPENDIX II

QA EXAMPLES

Carbonate Carbon - Although this is an absolute method, coulometer calibration is checked daily by running standards. An acceptable initial instrument blank (IB) shall be obtained followed by an ICS. An LCS shall be run, then every 10 samples a duplicate and a CCS shall be run. Note: The CCS may be the same as the ICS and/or the LCS.

Exemplary analytical sequence:
Calibration: IB, ICS
Calibration Check: LCS
Analysis: 10 samples , DUP, IB, CCS, 10 samples, DUP, IB, CCS...
End of run: CCS

Metals in Solid Material by ICP - A method blank (MB) and a standard reference material (LCS) shall be carried through the entire procedure. The ICP shall be calibrated using the instrument blank (IB) and one or more calibration standards (ICS) and shall be checked with intial calibration check standard (LPC - laboratory performance check) that has all the elements of interest present but made from a second source traceable to NIST (if possible).

Next, the MB and LCS shall be analyzed. If values are satisfactory then 10 samples and 1 duplicate (DUP) shall be analyzed. Next, a continuing calibration standard (CCS or LPC(laboratory performance check)) shall be run. The CCS may be one or more standards similar to the concentrations observed in the samples.

Suggested analytical sequence:
Calibration: IB, ICS
Calibration Check: LPC
Analysis: MB, LPC, 10 samples , DUP, IB, LPC, 10 samples, DUP, IB, LPC...
End of run: LPC

Oxygen - The instrument blank (IB) is analyzed until a low reproducible value is obtained (very close to zero). Then a method blank (MB) that is an empty tin capsule or indium capillary is determined (this depends on the sample matrix being analyzed). After a satisfactory IB is obtained and a MB calibration is performed then an initial calibration standard (ICS) will be run. This will be followed by a laboratory control standard (LCS – this is a second source standard that is different than the calibration standard). If values are satisfactory then 10 samples and 1 duplicate (DUP) are analyzed. Next a CCS would be run. Note: The CCS could be the same as the ICS the LCS.

Typical analytical sequence:
Calibration: IB, ICS
Calibration Check: LCS
Analysis: 10 samples (usually 5 samples in duplicate if sufficient provided), CCS, IB, 10 samples, DUP, CCS, IB...
End of run: CCS
