UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
5 POST OFFICE SQUARE, SUITE 100
BOSTON, MASSACHUSETTS 02109-3912

January 18, 2018

Mr. Peter Britz, Environmental Planner
City of Portsmouth, Planning Department
1 Junkins Avenue
Portsmouth, NH 03801

Subject: Coakley Landfill Superfund Site
Request for a Bedrock Investigation

Dear Mr. Britz:

Per our previous discussions via telephone, private, and public meetings, EPA in consultation with NHDES has determined that a Bedrock Investigation is needed for the Coakley Landfill Superfund Site. This letter and the attachments serve as the agency's official request for the investigation.

There are numerous reasons that justify the need for this investigation. The following is a non-exhaustive list:

- Previous investigations at the Site have included only the overburden and shallow bedrock aquifers and focused on volatile organic compounds that biodegrade over time. Currently there is a very limited number of deep bedrock monitoring wells (defined as greater than 50 ft. into competent bedrock) at the Site. There are no site-specific investigations relating to the interaction of groundwater between deep overburden and bedrock, or measurements of the fracture network or groundwater quality in deep bedrock. As a result, no definitive statements can be made as to the presence or extent of groundwater impacts in deep bedrock.

- Many of the homes and businesses in the vicinity of the Site rely on deep bedrock wells for potable water. As a result, deep bedrock groundwater is considered a sensitive receptor and bedrock fractures represent a potential contaminant migration pathway that remains uninvestigated.

- New contaminants recently identified in shallow bedrock and overburden groundwater at the Site (perfluoroalkyl substances (PFAS) and 1,4-dioxane) are highly mobile and persistent; with the result being that they have the potential to travel great distances in response to off-site pumping, should a pathway in the bedrock exist. Some PFAS compounds are associated with health impacts and have very low cleanup criteria. For instance, the NHDES Ambient Groundwater Quality Standard (AGQS) for combined levels of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) is 70 parts per trillion (ppt), and the 1,4-dioxane AGQS, currently set at 3 parts per billion (ppb) (3000 ppt) is expected to be reduced to 0.32 ppb (320 ppt) in the near future.

- While the conceptual site model (CSM) presented in the Site's Remedial Investigation is that shallow bedrock and overburden groundwater discharge to surface water and vertical groundwater gradients are upward, recent residential and commercial development in the area has put a greater burden on the deep bedrock groundwater. Storage in deep fractured bedrock is minimal, relative to the shallow bedrock and overburden aquifers where the storage coefficient is substantially higher. It can be presumed that the vast majority of groundwater withdrawn from deep bedrock is influenced by contributions from the shallow bedrock and overburden aquifers. It has been documented on several other Superfund Sites in NH that pumping from residential supply wells can draw in contamination from great distances through fractured bedrock.

In summary, because of the increased use of the deep bedrock groundwater resource in the area of the Site, the lack of any direct measurements from the deep bedrock aquifer at the Site, and the discovery of new contaminants that have different fate and transport characteristics from the original contaminants; EPA and NHDES have determined that an investigation similar in scope to a Remedial Investigation, must be conducted on the bedrock aquifer at the Coakley Landfill Superfund Site. The overall objective of this investigation will be to develop an understanding of hydro-geologic pathways in deep overburden and bedrock, and groundwater conditions in the deep bedrock at the Site and adjacent areas such that the potential for migration of Site related contaminants to local receptors via groundwater flow at the interface between overburden and bedrock, and in deep bedrock fractures can be reasonably assessed.

The following are a number of key questions/issues and recommendations that EPA will expect the investigation will address. EPA anticipates adding a few more questions related to the groundwater/surface water interaction in the near future, and will convey those to you via a separate letter. Further, our experience is that this type of investigation can often be iterative, in that new data generated during the initial phases of the investigation can spawn new questions and/or move the investigation in another direction.

1. *Key Question/Issue*: *General Sufficiency of the Existing Monitoring Network*: Is the existing well network sufficient to draw meaningful conclusions regarding the potential for off-site containment migration in groundwater? What are the strengths and limitations? What steps can be taken, particularly in the short-term, to improve this situation?

Recommendations: A comprehensive well inventory is needed to determine the number, distribution and spatial density of monitoring well control in the greater site area. This should include compiling and presenting existing information as follows:

- Compile/update spreadsheet of existing active and inactive site monitoring points/well data monitoring wells, private and public supply wells, irrigation wells, soil borings, piezometers, staff gages, surface water, sediment, and leachate sampling location, etc., including location information (coordinates), total depth in feet below ground surface or feet above mean sea level (ft bgs / ft amsl), well construction material and diameter, measuring point elevation, screened or open interval (ft bgs/ ft amsl), geologic medium/hydrogeologic unit at screened interval; hydraulic conductivity at screened interval, etc.
- Prepare a map showing the location and depth of all existing monitoring points including all monitoring wells, private and public supply wells, irrigation wells, soil borings, piezometers, staff gages, surface water, sediment, and leachate sampling location, etc. Unique symbols should be used for monitoring wells screened in each particular hydrostratigraphic unit;
- For the greater site area, prepare a series of layer-specific map(s) depicting all existing monitoring wells and supply wells screened within each major hydrostratigraphic unit, i.e.,

Shallow overburden (< 30 ft bgs), deep overburden (> 30 ft bgs), till, shallow bedrock (< 50 ft into rock), deeper bedrock (> 50 ft into rock);

- Perform well integrity analysis/testing of existing well network;
- Evaluate monitoring network in conjunction with hydraulic head data and interpretations of groundwater flow;
- Assess monitoring coverage adequacy in three dimensions for each hydrostratigraphic unit
- identify key data gaps
- Recommend locations and depths for additional analysis and/or monitoring control, if needed

2. *Key Question/Issue; Deep Overburden Pathway;* Is there evidence for potential contaminant migration pathway(s) involving the top-of-bedrock surface (i.e., bedrock/overburden contact)?

Recommendations: This issue can be addressed by further analysis and leveraging of existing data sets, including the following:

- Prepare an updated base map showing location of all bedrock control data points including: surface geophysical survey lines, seismic survey points/lines; locations of soil borings, test pits, geotechnical borings and/or excavations; locations, total depth and depth-of-penetration into bedrock for all bedrock cores, bedrock boreholes, and monitoring wells installed into bedrock including private and public supply wells in bedrock.
- Reevaluate all site boring logs and monitoring well installation records to determine top-of-rock elevations at each location, as well as minimum elevations for top of bedrock (TOR) depths at "refusal" locations where confirmation not established.
- Re-evaluate geotechnical data from landfill construction efforts including rock core/RQD data from geotechnical borings, excavator logs, photographs, daily logs, etc. Determine confirmed bedrock depths/elevations as well as refusal depths/elevations.
- Interpret TOR depths from surface geophysical surveys/records.
- Prepare an updated bedrock surface elevation map for the greater Coakley landfill area using all "hard" bedrock elevation data control.
- Evaluate top-of-bedrock (TOR) surface for potential buried valleys or other features which may facilitate contaminant transport via groundwater.
- An overburden thickness map should be constructed in conjunction with the updated top-of-bedrock (TOR) surface elevation map.
- In conjunction with updated TOR and overburden thickness maps, assess adequacy of monitoring network to monitor potential pathways at the bedrock/ overburden interface.
- Identify key data gaps.
- Recommend locations and depths for additional assessment and/or monitoring control if needed.
- Consideration should be given to performing limited surficial geophysical surveys in key down-gradient locations to augment data density on the top-of-bedrock surface, including but not limited to:
    - Seismic reflection
    - Seismic refraction tomography (SRT)
    - Electrical Resistance tomography (ERT)
    - Multi-channel analysis of Surface waves (MASW)
    - Low-frequency ground penetrating radar (GPR)

3. *Key Question/Issue; Shallow fractured bedrock pathway;* Is there evidence for potential contaminant migration pathway(s) *involving uppermost shallow fractured bedrock (<50 ft bgs)?*

Recommendations:

- Assess monitoring coverage in Shallow weathered bedrock (lateral and vertical resolution).
- Determine whether there is evidence for highly fractured and/or chemically weathered intervals within the shallow uppermost 50 feet of bedrock by evaluating:
  - Bedrock outcrops
  - Rock cores from monitoring well installations and geotechnical borings
  - Borehole geophysical logs
  - Boring logs and well installation diagrams
  - Data from surface geophysical surveys such as seismic velocity of upper bedrock from seismic reflection/refraction data
- Are the highly fractured intervals continuous? If so, do they represent a potential contaminant migration pathway in groundwater?
- If possible, prepare a thickness map of the highly fractured intervals across the site and/or prepare an updated, more highly resolved, map of the site area showing the lateral continuity, variability, and distribution of "tight" and "fractured" bedrock domains in shallow bedrock.
- Are low-angle "sheeting fractures" present in the upper portions of bedrock? And if so, do they have a systematic orientation? Or do they mirror land surface topography?
- Assess adequacy of monitoring network to monitor potential pathways.
- Recommend locations for additional monitoring control if needed.
- Consideration should be given to performing limited surficial geophysical surveys in locations to augment the site data density regarding the nature and physical properties of the upper bedrock interval (< 50 ft into bedrock), including but not limited to:
  - Seismic reflection
  - Seismic refraction tomography
  - Electrical Resistance tomography (ERT)
  - Multi-channel analysis of Surface waves (MASW)
  - Low-frequency ground penetrating radar (GPR)
- Hydraulic testing of the "tightness" of the upper rock within areas of critical interest should be contemplated to augment the site database.

4. *Key Question/Issue; Updated Fracture Trace Analysis;* Is there ***surficial evidence*** for contaminant migration pathway(s) involving deeper fractured bedrock via faults, interconnected fracture networks, and other bedrock structures that may influence groundwater migration pathway(s) in fractured bedrock from the site?

Recommendations: An updated fracture trace analysis is needed as a foundational step in addressing this issue.

- This will first involve compiling, synthesizing, and interpreting the following data sets to produce a high-resolution topographic base map:
  - Site-specific topographic surveys

- Surface topography at a variety of scales available from U.S.G.S.
    - Elevation and topographic mapping from NHDOT
    - Elevation and topographic mapping/GIS data from utilities and local DPW
    - Publically available digital elevation models (USGS, etc.)
    - NHDES GIS data layers
    - Publically available LiDAR data
    - Other
- Review the USGS Lineament Map for NH to identify mapped lineaments within the study area.
- A site-specific fracture trace analysis (FTA) should be constructed by evaluating aerial imagery at a variety of formats and scales in conjunction with the high-resolution land surface topography base map. Identified linear features representing mapped or interpreted fractures, particularly potentially hydraulically-significant fractures should be plotted on updated topographic/base mapping. The locations of mapped or interpreted features, particularly potentially hydraulically-significant fractures, should be plotted in conjunction with existing monitoring points and other features of interest, such as off-site water supply wells, surface water streams and wetlands, etc. so that the adequacy of the existing well network may be evaluated in that context.

5. *Key Question/Issue; Deep Bedrock Pathway; Focus primarily geologic framework;* Is there comprehensive ***geologic evidence*** for contaminant migration pathway(s) involving deeper fractured bedrock via faults, interconnected fracture networks, and other bedrock structures that may influence groundwater migration pathway(s) in fractured bedrock from the site?

   Recommendations: A comprehensive geologic analysis is needed to more fully assess the issue of potential geologic pathways in bedrock which may connect the site to the surrounding areas. An understanding of the regional bedrock fabric must be established, including assessing the spatial variations in the fabric. Such analysis should consider the following:

   - A series of maps, cross sections and models should be compiled to create a true-scale geologic model of the site to update understanding and distribution of "un-fractured" or "tight" bedrock domains versus "fractured" or "permeable" areas, as well as the spatial position of laterally extensive fractures or interconnecting networks of fractures. The following data sets should be compiled and synthesized to create updated maps and models at the site scale by compiling, analyzing and synthesizing the following data sets:
     - High resolution topographic mapping
     - Aerial imagery including identified linear features of interest identified from FTA
     - Evaluation of bedrock outcrops (spatial position, rock type, composition, presence of compositional layering and orientation, degree of weathering, fracturing style, density/spacing/intensity of fracturing; fracture orientations)
     - Evaluation of Bedrock Core (Rock type, composition, presence of compositional layering and orientation, degree of weathering, fracturing style, density/spacing/intensity of fracturing; fracture orientations, RQD)
     - Evaluation of Borehole geophysical logs (Rock type, presence of compositional layering and orientation, degree of weathering, fracturing style,

    density/spacing/intensity of fracturing; fracture orientations, identification of hydraulically significant fractures)
  - Identification of hydraulically significant fractures from hydraulic testing data (packer tests, HPFM logging, slug tests, pumping tests, etc.)
  - Seismic velocity of upper bedrock from seismic reflection/refraction data
  - Identification of fractures of varying orientations (flat-lying to steeply dipping) from surface geophysical surveys
  - Position and extent of significant bedrock valleys and escarpments from DEM, LiDAR, FTA, bedrock surface elevations, and overburden thickness mapping

- Final product should be a series of map(s), cross sections, and/or 3-D models including the following:
  - Position and mapped extent of interpreted laterally-extensive significant bedrock fractures, particularly hydraulically-significant fractures, interpreted from all combined data sets: geologic mapping, outcrop outlines, fracture trace analysis, seismic surveys, core evaluation, borehole geophysics, bedrock surface topography, etc.
  - The location of existing control points with respect to mapped or interpreted fractures at the site scale.

6. *Key Question/Issue: Overlay hydraulic head and COC concentration data onto hydrogeologic model;* In view of a revised hydrogeologic model which includes a realization of potential fracture pathways in bedrock, do hydraulic head and concentration gradients for COCs of interest in on- and off-site wells still suggest the possibility of a contamination migration pathway to offsite areas within or involving bedrock?

Recommendations:
Overlay/combine hydraulic head data sets with hydrogeologic model and identify current points or regions of groundwater extraction or input.

- Evaluate head gradients in context of fracture network and locations of significant hydraulic inputs or withdrawals
  - Prepared flow-netted cross section and/or
  - Numerical flow modeling
  - Particle tracking

- Overlay/combine chemical concentration data for COCs of interest with flow models
  - Are there discernable "plumes" of contaminants?
  - Does the evidence suggest concentration gradients of COCs from landfill to downgradient areas?
  - Do the concentration gradients follow fracture networks?
- Is the hypothesis of an off-site pathway in fractured bedrock strengthened?

7. *Key Question/Issue: Near-term data collection;* After existing information has been sufficiently analyzed and interpreted, what additional near-term data collection efforts should be considered?

Recommendations:

- Borehole geophysical logging should be considered for all site related wells where no such information currently exists.
- The locations and orientations of key fractures and geologic features of interest may help to select locations and alignments for potential surface geophysical surveys and/or locations for drilling and testing of additional bedrock monitoring wells.
- The peripheral areas to the site to the north and west are most critical to address potential contaminant transport in bedrock off site in those directions (i.e., to the north, northwest, and west).
- Surficial geophysical surveys using seismic refraction tomography (SRT), ERT, and MASW methods should be conducted in the areas just west of the landfill in a north to south configuration. Potential locations include along the access trail adjacent to the railroad right of way (ROW), and along the power lines on the west side of the Breakfast Hill Golf Club.
- East-to-west oriented surficial geophysical surveys should be collected at a variety of distances downgradient from the landfill, particularly to the north. The power line ROW north of the landfill may be a good location for this.
- Recommend locations and depths for additional assessment and/or monitoring control if needed.
- Recommendations for additional hydraulic testing (as driven by the data).
- Recommendations for additional water quality testing (as driven by the data).
- Recommendations for additional PFAS testing in all media of interest (as driven by the data).
- Assessment of Groundwater/Surface water interactions in downgradient streams and wetlands. The deployment of seepage meters at selected surface water locations would provide surface water/groundwater flux, direction, and water quality data. These are low-cost devices that provide key data for evaluating groundwater/surface water interactions.

EPA requests that the Coakley Landfill Group submit a work plan for this investigation as soon as possible but no later than one month after receipt of this communication. Such a work plan shall detail investigations that will be implemented in order to address each one of these questions, and an estimated time-frame for each task. In order to ensure a common understanding of these issues and expectations, EPA suggests that the agencies and their hydrogeologists meet with you and your consultant for a technical discussion, as soon as possible. Please let me know your availability for such a meeting and I will make the necessary arrangements. Also, feel free to contact me with any questions on the above.

Sincerely,

Gerardo Millán-Ramos
Remedial Project Manager
Office of Site Remediation and Restoration
EPA – New England, Region 1

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