February 12, 2024

BCM Environmental and Land Law, PLLC
3 Maple Street
Concord, New Hampshire 03301
Attn: Amy Manzelli, Esq.

SUBJECT: Hydrogeological Comments
Standard Solid Waste Permit Application – October 2023
Granite State Landfill, Dalton and Bethlehem, New Hampshire

Dear Attorney Manzelli,

Calex Environmental, LLC, (Calex), has reviewed the October 16, 2023 Standard Permit for Solid Waste Landfill (Phase I Landfill and Infrastructure Development) submitted by Granite State Landfill (GSL) (the Applicant) to the New Hampshire Department of Environmental Services (NHDES). The Standard Permit application is comprised of:

Standard Permit form – Volume 1 (dated Oct 16, 2023) Identification, Facility Description, Status, Legal Notifications

- Section V Site Report Volume 2 (Part 1) – Attachments V(1) – V(4)
- Section V Site Report Volume 2 (Part 2) - Attachments V(5) - V(6)
- Section VI Volume 3 - Design Plans and Specifications
- Volume 4 - Facility Operating Plan
- Volume 5 - Facility Closure Plan
- Volume 6 - Public Benefit, Signature and Fee Calculation
- Volume 7 – Full Size Plans

Comments provided by Calex on the application documents listed above are focused on the hydrogeological aspects of the proposed site and landfill design/operations. Our comments provided below begin with detailed comments on Section V Site Report Volume 2 Attachment V(4) *Hydrogeologic Report*, *(Hydrogeologic Report*), followed by general comments on selected sections of the remainder of the Permit Application where interpreted hydrogeologic site conditions may impact the particular topic. Finally, we provide three summary points and our conclusion.

Executive Summary

The proposed Granite State Landfill would generate leachate contamination for the better part of 100 years, so it is critical that all potential contaminant pathways be identified in the permitting process and weighed as to potential risks to the water resource receptors in the region when releases occur. The Hydrogeologic Report, meant to serve as the underlying hydrogeological characterization of the site, identifies and quantifies only the shallow (overburden and 20' or less

in bedrock) pathways on site and fails to field locate through drilling and testing, the identified bedrock fracture systems that may provide potential hydrogeological pathways offsite towards Forest Lake or water supply wells. The limited hydrogeological study illustrates variable, and highly transmissive surficial bedrock conditions exhibiting primarily downward hydraulic gradient conditions. These hydraulic conditions are conducive for contamination to flow into deeper bedrock flow systems; systems that are currently unquantified at the site and vicinity. Relying on shallow groundwater studies for regional hydrogeological interpretations is subject to substantial error.

The Solid Waste Permit Application for the proposed Granite State Landfill relies upon the level of investigation and conclusions provided by the hydrogeological study, a study which is limited to the investigation and quantification of only shallow groundwater conditions at the site and vicinity. Therefore, the Solid Waste Permit Application relies upon inadequate data, and the application should accordingly be rejected by the Department. With knowingly creating a 100-year source of contamination at this site, DES should not have to assume anything about pathways or receptors. The hydrogeological study needs to be thorough and quantitative so that risks are known and can be weighed according to law.

Attachment V(4) – Hydrogeologic Report (Sanborn, Head & Associates (SHA))

A comprehensive study of the hydrogeological characteristics of the proposed landfill site and vicinity is crucial to identifying, evaluating, and understanding the hydraulic interconnections which may serve at potential contaminant pathways among the water resources in the vicinity. The potential contaminant pathways include permeable hydrostratigraphic units in both overburden and bedrock deposits located anywhere onsite where waste materials, leachate or contaminated gases are disposed, stored, or handled. The water resources include private and public water supply wells, rivers, lakes, streams, springs, and wetlands located hydraulically downgradient or connected to the potential contaminant pathways.

The potential impacts to water resources in the vicinity of the landfill operations include disruptions in recharge from changes in the flow systems due to terrain alteration from construction of the landfill and its infrastructure, and impaired water quality due to landfill operations and releases of leachate. While it is understood that the proposed landfill plans and operations are designed to reduce the potential for impacts to local water resources, no operator can guarantee 100% fail safe operations for the decades-long life of the landfill. Therefore, leachate impacts in the vicinity of the landfill are to be expected, as is so clearly demonstrated by operations at the nearby Bethlehem Landfill site operated by Casella.

Therefore, the comprehensive identification and quantification of contaminant pathways and water resources in the vicinity of a proposed landfill site is critical so that NHDES can weigh the impacts to the nearby water resources <u>when</u> leachate releases occur.

1. **Identification of Water Resources**

A. <u>Drinking water resources</u> in the area are comprised of private and public water supply wells, as no surface water reservoirs are identified. The aquifer(s) from which the water

supply wells derive their water are not comprehensively identified or quantitatively evaluated in the *Hydrogeologic Report* for potential recharge interconnections with the proposed landfill property and its flow systems. These deficiencies in the study mean that overly simplistic interpretations are made concerning whether local water supplies will potentially be impacted by landfill operations that release contaminants:

- The Site Report by CMA uses NHDES well inventory data reflected on Figure 12 to identify the locations of private and public water supply wells. The inventory shows more than 100 private wells, but no information is provided about the depth or yield of those wells. One cannot determine the source of drinking water for those wells without more information and hydrogeologic evaluation. There was no tabulation of the identified water supply wells in the *Report* indicating typical pertinent data, such as: type of aquifer (i.e., bedrock or overburden), yield, construction, ownership, age, or depth. In NH, most residential water supplies rely upon drilled wells into bedrock, and according to a 2020 NHDES Fact Sheet (DWGB-1-2, Bedrock (Artesian, Drilled) Well Design), these residential wells are on average 400 feet deep and yield 15 gallons per minute. There should be a field-verified spreadsheet of the associated database provided, which indicates the source of water (i.e., overburden or bedrock) for the well inventory.

- A figure of the proposed landfill property, Figure 13, instead identifies six water wells in the inventory as Chicks Sand & Gravel "test/exploration" wells and one well classified as Ingerson "other". The Applicant does not provide depth data for any of the wells, or information as to their construction or yield.

- Answers provided to Env-Sw 804.02 (a) on page 92/1161 of Vol 1 of the Application notes that Mr. Ingerson has the closest drinking water well located "…2,000 feet from the site's infrastructure area…" an area which is not located on Figure 13, with the report providing no information for this well.

- Page 3/1037 of Volume 3 Design Plans and Specifications notes a "...high-volume supply well..." located nearby the proposed maintenance building, but no information is provided to determine if this "high-volume supply well" derives its water from a deep bedrock fracture system or from a shallow sand and gravel aquifer.

- Page 95/1161 of the Site Report Volume 2 Env-Sw 804.03 Surface Water Protection Standards (f) states "groundwater flow from the landfill is in the opposite direction…" from the community drinking water supply along Forest Lake. This statement has been proven only for shallow groundwater in the overburden and surficial bedrock on site because no wells have probed greater than 20 feet into the bedrock and no explorations were sited in fractured areas identified in the fracture trace analyses and geophysical surveys. With the information provided, one cannot determine if there are any fracture pathways connected to the proposed landfill site that may recharge the community well.

- SHA subcontracted the analysis of bedrock fracture systems to Hager-Richter whose report is included in Appendix F of the *Hydrogeologic Report*. The Hager

Richter report identifies potential locations and likely depths of various fracture systems onsite utilizing the typical three-step bedrock fractures evaluation process of: 1) aerial photographic interpretation, 2) field mapping of bedrock structures, and 3) field reconnaissance with surficial geophysical instruments. What is missing is the KEY fourth step of quantification where test drilling in identified fracture systems is coupled with associated hydraulic testing. In the *Hydrogeologic Report* there appears to be no follow through on the Hager Richter work. There is no table in the Site Report that provides RATIONALE for drilling locations, drilling target depths, or hydraulic testing zones. Instead, the drilling/monitoring well/hydraulic testing program in the overburden/shallow bedrock appears to be entirely independent of the regional bedrock fracture system geophysical interpretations located within the top 500 feet or so of bedrock. The field work is focused on only the overburden and shallow (top 20') bedrock, and thus interpretations are limited to that zone.

- At the site, 61 monitoring wells and 12 geotechnical borings were completed with boring logs contained in Appendix B of the *Hydrogeologic Report*. Of this large number of subsurface penetrations, only 9 (or 12%) penetrated more than 50' below ground surface [B-2 (79.5', 35' into bedrock), MW 21L/U (55', finished as overburden couplet), MW 28/R (51.5', finished as shallow overburden and bedrock couplet), MW 38/R (80', finished as shallow overburden and bedrock couplet), MW 39/R (60', finished as shallow overburden and bedrock couplet)]. As to evaluation of the bedrock aquifer, only 21 wells are completed in the top 15 feet of bedrock, with a maximum depth of 22 feet into bedrock. The hydrogeological study did not locate representative bedrock wells that were advanced deeply enough to penetrate any regional fracture systems that may be interconnected with area water supply wells. Thus, the investigation is not representative of hydrogeological conditions that support surrounding bedrock water supply wells that, in New Hampshire, are finished substantially deeper than 25 feet into bedrock.
- The hydrogeological study evaluated the relative vertical gradients between the overburden and shallow bedrock wells at multiple couplet locations. Fig 9 of the *Hydrogeologic Report* generally shows downward vertical gradients, with just three upward gradients, all located within the waste disposal footprint. This characteristic indicates that contaminants, when released into the surficial groundwater, will likely flow downward into the shallow fractured bedrock. The ultimate fate and transport of contaminants moving downward in bedrock has not been identified in the hydrogeologic study.

- Figures 8B-E of the *Hydrogeologic Report* show only overburden groundwater flow plots. The study is incomplete and cannot represent any interpretations regarding deep bedrock flow.

- Page 225/1161 notes that water supply wells on West Forest Lake Road and along Forest Lake are ¼ to ½ mile from the landfill footprint and even closer to the infrastructure area where leachate would be collected, stored, and handled and portions of the landfill access road which will carry thousands of leachate tanker trucks. The recharge zone(s) to these wells and possible interconnections to the landfill site and associated infrastructure have not been determined or

quantified. In fact, the infrastructure area shows very transmissive shallow hydrogeology. Figure G.1 illustrates high (>10 ft/day) adjacent to infrastructure area (MW-9). Hydraulic testing in the Infrastructure Area revealed exceedingly high seepage velocities (MW-9 at 31 feet/day) which is very concerning for an area that is the focus of collection, storage, and handling of leachate.

- It would be exceedingly helpful if Figures 10 A-E would show the infrastructure area of the landfill operations also (e.g., leachate collection and handling areas) instead of just the area of waste filling, since the leachate handling areas are so prone to releases. Figure B.1 in Appendix B is much more helpful.

In summary, the hydrogeologic study identifies and quantifies the shallow (overburden and 20' or less in bedrock) groundwater systems on site but fails to field locate and quantify any of the identified bedrock fracture systems that may provide potential hydrogeological pathways offsite to Forest Lake or water supply wells. The limited hydrogeological study illustrates variable, and highly transmissive surficial bedrock conditions exhibiting primarily downward hydraulic gradient conditions. These hydraulic conditions are conducive for contamination to flow into deeper bedrock flow systems; systems that are currently unquantified at the site and vicinity. Relying on shallow groundwater studies for regional hydrogeological interpretations is subject to substantial errors. The landfill will generate contamination for the better part of 100 years, so it is critical that all potential contaminant pathways be identified in the permitting process and weighed as to potential risks to the region.

B. Surface Water Resources Wetlands, streams, the Ammonoosuc River located to the west/southwest of the proposed waste fill zone, and infrastructure area are hydraulically downgradient of the shallow groundwater flow system identified and quantified in the *Hydrogeologic Report*. Contamination that escapes from landfill operations, such as from leachate generation, collection, transmission, storage, handling, or transportation activities, or from any equipment maintenance or fueling activities, or from any contaminated landfill gas residues would initially enter the shallow groundwater system within the Alder Brook watershed. Contaminant migration in the groundwater would be rapid, as determined by the hydraulic testing reported for shallow site monitoring wells in the *Hydrogeologic Report*, Appendix G, and Tables 3 - 5:

- Extensive hydraulic testing was performed in the onsite monitoring wells, (summarized in Table 3 of the *Hydrogeologic Report*). Some wells were located along the anchor trench footprint of the landfill, while many others were outside of the landfill footprint. Hydraulic conductivities in overburden ranged from a high of 60 ft/day to a low of 0.02 feet/day, with a geometric mean of 1.8 feet/day. Shallow fractured bedrock tested at a maximum hydraulic conductivity of 14 feet/day to a minimum of 0.007 feet/day, with a geometric mean of 0.1 feet/day.

- Table 5 of the *Hydrogeologic Report* presents calculated seepage velocities using a representative onsite gradient, ranges of measured hydraulic conductivities in overburden, and a literature value for effective porosity. Groundwater seepage velocities were calculated using high and low hydraulic conductivities. The overburden seepage velocities for the site ranged between 40 and 0.01 feet per day, with the geometric mean at 1.2 feet/day.

- With such high seepage rates in the shallow overburden groundwater, released contaminants will rapidly impact downgradient surface water and wetlands fed by groundwater. Distance to various receptors is dependent on where contaminants are released (all distances in the Application appear to measure from the edge of waste), though releases that occur associated with landfill infrastructure areas where leachate is managed are typically closer to receptors.

- The answer provided on Pg 94/1161 Env-Sw 804.03 Surface Water Protection Standards (c) (3) assumes that the double liner for the waste disposal area and other containment features will "…prevent the release of contaminants to surface water…". This is an overstatement as engineering design can reduce the likelihood of releases, but it cannot *prevent* them. Thus, groundwater, wetlands, and surface water bodies located downgradient of the site will be threatened with degradation.

- The travel time to Alder Brook, located approximately 2,700 from the landfill or 1,200 feet from the infrastructure area (Figure 1 – Locus Plan *Hydrogeologic Report*) using the geometric mean of the seepage velocity is approximately 6 to 2.7 years, respectively. Using maximum seepage calculations, about a year travel time.

- The approximate time it would take for contamination in the overburden to reach the protected area abutting the Ammonoosuc River from either the landfill (approximately 5,000 feet) or the infrastructure area (approximately 3,200 feet) is 7 to 11 years, using the geometric mean of the seepage velocity. At a maximum calculated overburden seepage velocity of 14 feet/day, the travel time shortens to significantly less than 3 years.

- Contaminant pathways controlled by fractured bedrock may intersect Forest Lake or some number of water supply wells completed in the bedrock aquifer. Groundwater flow in the deeper fracture systems was not determined in the hydrogeological study as no wells were drilled to predicted fracture depths and/or into identified fractures, nor was field testing done. The *Hydrogeologic Report* does not present a shallow bedrock seepage velocity, though using the same approach as for the overburden and substituting in the shallow bedrock data yielded 10 ft/day seepage velocity (using the geometric mean of hydraulic conductivity (1.0E-1) and an effective porosity for crystalline bedrock of 0.1% (Freeze and Cherry, 1979)). This seepage rate of 10 ft/day is not unusual because groundwater flow in crystalline rock with low effective porosities is controlled by fracture systems with typically high groundwater velocities.

- If 10 ft/day is representative of seepage velocities in bedrock pathways offsite, landfill-derived contamination migrating downward and entering these pathways could reach Forest Lake (2.400 feet) or some number of water supply wells (1,500 feet to 3,000 feet) in 1 to 2 years. This travel time, or even half that time, provides no margin of error for this site.

- Section 3.4 in the *Hydrogeologic Report* briefly discusses the surrounding water supplies and dismisses all supplies located "…on the other side of the groundwater flow divide..." despite having no site-specific quantified data on what the actual groundwater flow is in bedrock below 20 feet depth.

- Design of Groundwater Monitoring Systems – the *Hydrogeological Report* is insufficient to design an adequate Groundwater Management and Release Detection Permit because the hydrogeological study literally barely "scratches the surface" (i.e., wells only penetrate the shallow overburden and top 20' of weathered bedrock). There must be sentinel wells located within deep bedrock fracture system(s) that feed nearby water supply wells.

- The Conceptual Site Model presented in Exhibit 5-1 of the *Hydrogeological Report* has a significant data gap related to "inter catchment" area flow. The preponderance of data presented in the *Hydrogeological Study* is representative only of shallow groundwater flow conditions. The structural bedrock work of Hager Richter was not field verified with drilling and hydraulic testing despite the data which point to potential bedrock pathways capable of transporting contaminants. The defined "side gradient" area located between the landfill footprint and the infrastructure area is characterized by very few shallow wells (MW-29R, -30R, -31R, -34/R, -33R, -32R, MW-8, -9), shallow bedrock surfaces described as varying between "highly broken" to "fresh", and very high seepage velocity in MW-9 of 31 ft/day. Identifying bedrock fracture zones means looking for outliers, drilling into them and quantifying the zone to determine its extensiveness.

Summary: The hydrogeological study has failed to demonstrate that Forest Lake or nearby bedrock water supply wells are not hydrogeologically interconnected with pathways which can carry potential future landfill contamination. With knowingly creating a 100-year source of contamination at this site, DES should not have to assume anything about pathways or receptors. The hydrogeological study needs to be thorough and quantitative so that risks are known and can be weighed according to law.

Comments on Landfill Design/Compliance with Solid Waste Rules

The following are comments on various design elements related to hydrogeological site conditions.

- Figure 4 of the Site Report by CMA shows separation between seasonal high groundwater and the lower/secondary liner is generally 7 feet as compared to the required 6 feet minimum (Env-Sw 804.02(d)). With acknowledgement of climate impacts in Section 3.5 of the *Hydrogeologic Report* where precipitation will be increasing by approximately 15% over the life of this landfill, it would seem prudent to require a higher elevation for the bottom liner to ensure that the separation distance is not violated over the life of the landfill.

- Pg 34/1161 depicts Figure 16, the Wetlands Setback Plan for the landfilled waste. The Application does not address the required wetlands setback from the Infrastructure Area which is not double lined.

- Page 211/1161 the stormwater management system is only accommodating the 25 year/24 hour storm, yet the proposed regulations Env Sw 805.09 (f) states the 50 year/24 hour storm. Since this landfill life will be the better part of 100 years, it would be prudent for DES to require all design and operations to comply with updated Rules.

- Attachment V(2) – Compliance with Solid Waste Rules, Env-Sw 804.02 Groundwater Protection Standards (a) – the last sentence is only correct if the word SHALLOW is added in front of "groundwater flow…".

- Attachment V(2) – Compliance with Solid Waste Rules, Env-Sw 804.02 Groundwater Protection Standards (b and c) – the current hydrogeological study is inadequate for siting and design of a groundwater monitoring network to identify potential leachate pathways and protect bedrock water supply wells surrounding the landfill.

- Attachment V(2) – Compliance with Solid Waste Rules, Env-Sw 804.03 Surface Water Protection Standards (c)(1) and (3) – the hydrogeological study described in Attachment V(4) does not meet the standard of a "…thorough hydrogeological investigation…" and should be supplemented.

- Attachment V(2) – Compliance with Solid Waste Rules, Env-Sw 804.03 Surface Water Protection Standards (d and f) – It is true that the landfill is in a separate watershed from Forest Lake but that surficial topography does not necessarily govern deep groundwater flow in the fractured bedrock which may be feeding public or private water supply wells and potentially discharging to Forest Lake or other surface water bodies. These deeper, more regional hydrogeological conditions have not been field verified in the current hydrogeological study reported on in Attachment V(4) of this Solid Waste Permit Application.

- Attachment V(2) Env-Sw 805.02 General Landfill Design Requirements (a) (4) – the Groundwater Release Detection system cannot be adequately designed or installed until a more thorough understanding of the hydrogeological conditions is known, as the current site study is inadequate.

- Attachment V(2) Env-Sw 805.08 Groundwater and Surface Water Monitoring System Design Standards (a and b) – The existing hydrogeological study is surficially focused and inadequate for the location and design of a robust monitoring system for protection of area water resources and groundwater supplies. Site specific *data*, and not *theories*, are needed to identify and quantify the bedrock pathways to determine protections for surrounding water supplies and water resources that derive water from the deeper bedrock system.

- Attachment V(2) Env–Sw 806.04 Operating Standards for Groundwater and Surface Water Monitoring – same comment as for Env-Sw 805.08 above.

- Attachment V(2) Env-Sw 806.08 (f) – same comment as for Env-Sw 805.08 above.

- Attachment V(2) Env-Sw 807.03 (8) Constructing, operating, and maintaining the facility's groundwater and surface water monitoring system and implementing the facility's approved post-closure groundwater monitoring program in accordance with RSA 485-C – same comment as for Env-Sw 805.08 above.

- Attachment V(2) Env-Sw 1002.02 Discharge of Pollutants Prohibited (a) – the assurance provided in paragraph 2 is not currently supported by the data presented in the hydrogeological study.

- Attachment V(2) Env-Sw 1002.02 Discharge of Pollutants Prohibited (c and d) – same comment as for Env-Sw 805.08.

Summary

1) The hydrogeological study has an expanded analysis of the shallow bedrock/overburden system and its interactions with topographically downgradient wetlands/streams, but ignores the deeper, regional bedrock fracture system study it commissioned from Hager Richter. The study needs to be expanded to field verify the Hager Richter results so that bedrock fracture pathways are quantified as to their hydraulic conductivities and seepage velocities.

2) Many hydraulic tests in the overburden/shallow bedrock confirm very high groundwater seepage velocities adjacent to and downgradient of landfill operations, such that travel times for released contaminants to wetlands/surface water can be expected in less than 3 years.

3) A landfill provides a source of contamination to the site and vicinity for the better part of 100 years. Contaminants will be released, and the nearby resources need to be protected from offsite migration of these contaminants. The current study provides no quantitative field data regarding these potential offsite pathways. In fact, the onsite data point to a high potential for these regional pathways to pick up contaminants due to the prevalence of downward vertical gradients in groundwater and generally weathered, fractured, and highly transmissive shallow bedrock surfaces.

Conclusions

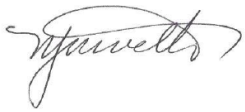
The Solid Waste Permit Application illustrates that in many areas it relies upon the level of investigation and conclusions provided by the hydrogeological study, a study which is limited to the investigation and quantification of only shallow groundwater conditions at the site and vicinity. The hydrogeological study needs to be expanded, similar to a typical bedrock water supply investigation study, to include field verification and hydraulic testing of the structural geology study performed by Hager Richter that identified and field evaluated bedrock fracture responses. Targeted drilling and hydraulic testing would determine the locations and the rate of ground water

transport below the top 20-foot zone of the bedrock hydrogeological system. Until the regional bedrock fracture system(s) are located and quantified, the conceptual hydrogeological model for the site is incomplete. Therefore, the Solid Waste Permit Application relies upon inadequate data, and the application should accordingly be rejected by the Department.

Please do not hesitate to call if you have any questions. Thank you.

Sincerely,

CALEX ENVIRONMENTAL, LLC



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