

MEMORANDUM

To: Megan Fortson, Planner, City of Keene, NH
From: Russell Abell, PG
File: 6741.00
Date: August 15, 2025
Re: Summary of Hydrogeologic Review of G2 Holdings Keene Quarry Expansion Application
cc: Mari Brunner, Evan Clements, Emily Duseau

Sanborn Head and Associates, Inc. (Sanborn Head) has been retained by the City of Keene to provide hydrogeologic review of the G2 Holdings Keene Quarry Expansion Application (Application). The site subject to the Application is located at 57 Route 9, Keene, New Hampshire (Site) and is currently an active gravel pit operation. As requested, this review focused on evaluating two conditions at the Site and in the Application:

- 1) Review the need for and evaluate the potential for excavation within six feet or below the water table as this requires a waiver under City of Keene Land Development Code (LDC) Article 25.3.3.B.
- 2) Review the potential for the development of acid mine drainage (AMD) as a result of the planned excavation of bedrock and the need for a waiver under City of Keene LDC Article 25.3.6.

To complete this review, several documents provided as supporting information to the Application were reviewed – these documents are listed in Attachment A. Sanborn Head also prepared Figure 1 (Site Plan) and Figure 2 (Vertical Profile) to assist in the summary of findings. As part of this review, Sanborn Head also needed to review and understand the stormwater management plans for the Site, which is also summarized below, where relevant.

SUMMARY OF CONCERNS

Sanborn Head's review of the Application materials has identified several concerns, which are listed below, and further detail regarding these concerns and our findings are provided later in this summary memorandum. The concerns are as follows:

1. **Excavation Below the Water Table:** The observed water table in newly installed monitoring wells located in proposed excavation area Period 8 represents water table conditions that can be characterized as seasonal low water table conditions. Therefore, the revised Period 8 "Pit Floor" proposed elevation of 860 feet above mean sea level (AMSL) has the potential to be below the water table and/or lower than six feet above the water table during seasonal high water table conditions. This is especially of concern

in the northwest portion of the proposed excavation area. In fact, as shown on Figure 2, under current seasonal low water table conditions, the northwest portion of the Period 8 excavation is projected to be below the water table. Seasonal high water conditions may also be a concern for Period 1 as well, especially in the southeastern portion of the excavation area. Additional data collection from Period 1 would be needed to determine the water table conditions there.

2. **AMD Potential:** The Application supporting documentation has presented a concern for AMD potential as a result of excavation of bedrock in each of the proposed Periods. The recently observed presence of the mineral pyrite (an iron sulfide mineral with chemical formula FeS_2) in drill cuttings generated during the installation of monitoring wells in Period 8 further supports this concern. Although the available information does not allow for a more thorough assessment of AMD development potential, several existing lines of evidence also point to it being a concern. While the Application has provided a monitoring program, best management practice of lining surface water detention and retention ponds with limestone aggregate, and excavation will be terminated if necessary, additional monitoring should be considered and appears warranted.
3. **Period 8 Stormwater Infiltration:** Although not a focus of this review, another concern identified relates to the stormwater management plan for the proposed project. Based on our preliminary review and understanding, an existing infiltration basin (retention basin) and a newly constructed basin in Period 8 will serve to infiltrate all stormwater that emanates at the Site during the implementation of the project. The documentation appears to show the newly constructed Period 8 retention basin will be constructed on the bedrock pit “floor” (or will be excavated into bedrock), and will exist as the only infiltration basin during the late stages of the project (excavation of Period 8), if it is not also active earlier in the project. With the base located on bedrock, even if saprolite or highly weathered (typically clay-rich) materials are present, it seems unlikely that an infiltration rate of 0.3 inches per hour will be achieved as the Application used to determine stormwater management. It is possible that the actual infiltration rate could be close to zero (if competent, unfractured bedrock), or as much as an order of magnitude lower (if weathered bedrock or saprolite). Therefore, it appears unlikely that stormwater will infiltrate in this Period 8 basin, especially at the rate used to model stormwater management.

REVIEW FINDINGS

The following portion of this summary memorandum will provide an overview of Sanborn Head’s findings and supporting information that has led to the concerns summarized above. This portion is separated into two subsections to focus on the two areas of focus: 1) excavation below the water table; and 2) the potential for AMD development with a final section further describing the stormwater management findings.

Excavation Below the Water Table

The Applicant has provided data regarding hydrogeology at the Site based on installation of 12 bedrock monitoring wells, 12 overburden monitoring wells, and review of several pre-existing

monitoring wells. Sanborn Head has reviewed the information and data provided in the hydrogeological investigation reports listed in Attachment A and has also reviewed publicly available information regarding geology and hydrogeology of the Site and vicinity (references also listed in Attachment A). Based on review of available information, Sanborn Head's findings are summarized below:

- Stratigraphy at the Site appears to be a thin layer of till on bedrock with the potential for alluvium or similar at the lowest elevations on Site (i.e., in the vicinity of Period 8).
- Underlying bedrock is mapped as the Rangeley Formation, a highly weathered low-grade schist. However, based on rock cuttings during advancement of borings BRW-1 through BRW-8, the underlying bedrock was characterized as granitic. An outcrop of a highly weathered, orange-stained schist was observed near Period 8 during Sanborn Head's Site visit on July 31, 2025 and drill cutting descriptions during the advancement of borings BRW-09 through BRW-12 also indicate the presence of a highly weathered schist below the observed overburden.
- Groundwater has only been observed in the bedrock monitoring wells and there does not appear to be consistent water table conditions within the overburden materials.
- Groundwater was not observed in monitoring wells installed within or adjacent to Periods 2 through 7, which are the same borings that identified granitic bedrock underlying a thin (<10 feet thick primarily) overburden unit. Refer to Figure 1 for the location of each of the proposed excavation areas (Periods 1-8).
- Groundwater was observed in each of the bedrock monitoring wells located adjacent to/in Periods 1 and 8 and ranged from approximately 1.5 feet below ground surface to approximately 55 feet below ground surface. Sanborn Head prepared a vertical profile across the Site to better visualize and evaluate the water table or groundwater elevations, which is provided as Figure 2. Figure 2 shows that, consistent with the topography of the Site, the water table is shallower adjacent to Period 1 and the water table elevation decreases across Period 8 towards Otter Creek (located east – northeast of the Site).
- As shown on Figure 2, the revised proposed excavation floor elevation (860 feet AMSL) in Period 8 is interpreted to be above the seasonal low water table elevation in the northwestern portion of this area. In addition, during seasonal high water table elevation conditions, it is possible that the revised excavation pit floor elevation (900 feet AMSL) in the southeastern portion of Period 1 may also be below the water table elevation. However, the groundwater elevation observed in monitoring well SLR-12 in March 2022 was approximately 888.5 feet AMSL, which is more than 6 feet below the proposed pit floor elevation of 900 feet AMSL. This monitoring well is located near the southeastern boundary of Period 1 and there is not additional data within Period 1 to evaluate the groundwater elevation in this area.

Based on the above groundwater elevation data, and assuming the groundwater elevation measurements in the Application materials are representative of overall site conditions, Sanborn Head concludes that significant groundwater is not anticipated to be encountered in the planned excavations in Periods 2 through 7. Monitoring wells located in these areas have been gauged for water levels with no groundwater observed in October 2024, December 2024,

July 2025, and August 2025. The absence of groundwater in the monitoring wells is inferred to be due to the granitic rock observed in the drill cuttings for borings advanced in these areas. Granitic bedrock can be less fractured and more massive and may not transmit groundwater except via fractures. Further, geologic mapping in the areas indicates there is a granite bedrock formation (identified as the Concord Granite) that outcrops west of the Site and appears to dip under the Site. Based on the resolution of typical bedrock geology mapping for New Hampshire, it is reasonable that the Concord Granite could be located on Site directly underlying overburden consistent with the rock cutting descriptions in borings advanced in Periods 2 through 7.

Based on the above information, Sanborn Head also concludes that at the revised excavation pit floor elevations in Periods 1 (900 feet AMSL) and 8 (860 feet AMSL), groundwater is likely to be encountered during seasonal high water conditions in Period 1 and potentially throughout the year in Period 8. Therefore, it is recommended that the planned excavation area/depth in Period 8 be modified or the Applicant would need to seek a waiver of LDC Article 25.3.3.B. If a waiver is sought, additional requirements would be necessary due to the presence of domestic drinking water wells within ½ mile of the Site including, but not limited to, additional monitoring well installations, a pumping test, and other requirements. It is recommended that the Application install one or more bedrock monitoring wells within Period 1 to better understand the water table conditions in this area.

1. Acid Mine Drainage (AMD) Potential

The Applicant provided an analysis of the potential for AMD development at the Site using the Acid Based Accounting (ABA) approach.¹ The results of the Applicant's ABA analysis indicate that there is potential for AMD development during bedrock excavation in each of the proposed Period excavation areas. However, the ABA approach does not provide information that indicate the magnitude of potential future impacts under the proposed site development scenario. In response to the ABA results, the Applicant has proposed a monitoring program for AMD constituents during development, lining the infiltration basins with limestone aggregate as a best management practice, and other response actions if a concern is observed.

To further evaluate the potential magnitude of AMD impacts, Sanborn Head reviewed the ABA analysis data provided in Appendix C of the Applicant's 2024 Acid Mine Drainage Potential Report (see Attachment A for citation). Based on this review, it appears that rock cuttings samples from borings BRW-01 through BRW-08 were placed in de-ionized water and the de-ionized water was then analyzed for geochemical parameters and dissolved metals. Based on these results, acidic pH was identified in samples from BRW-07 and BRW-08 (pH of 4.8 and 5.0 standard units), and metals were detected in the decantate solution at concentrations above New Hampshire Ambient Groundwater Quality Standards (AGQS) as promulgated in Env-Or 600 in one or more samples. The metals exceeding AGQS in the decantate included:

¹ diPretoro, R.S. and H.W. Rauch, 1988, Use Of Acid - Base Accounts In Premining Prediction Of Acid Drainage Potential : A New Approach From Northern West Virginia, p. 1-10. In: Proceedings: Mine Drainage and Surface Mine Reclamation, Vol. 1, U.S. Bureau of Mines IC9183, Pittsburgh, PA

- Manganese at 771 and 309 micrograms per liter (ug/L) (BRW-07 and BRW-08), compared to its AGQS of 300 ug/L.
- Nickel at 106, 110, 1,800, and 627 ug/L (BRW-02, BRW-03, BRW-07, and BRW-08), compared to its AGQS of 100 ug/L.

In addition, although not regulated by New Hampshire groundwater standards, dissolved iron was also elevated in the sample results, with four concentrations greater than 1,000 ug/L with a maximum of 13,200 ug/L, compared to the U.S. EPA secondary maximum contaminant level (SMCL) of 300 ug/L.² For context, groundwater discharge to surface water should also be considered. The NHDES Freshwater Chronic Criteria for iron in surface water is 1,000 ug/L (Env-Wq 1703.21³).

Further, pyrite was observed in drill cuttings for borings BRW-10 through BRW-12, whereas pyrite or other sulfide minerals were not observed in the borings where samples for the ABA analysis were collected. Given that pyrite is the primary sulfide mineral anticipated to be responsible for AMD potential within the site geology, its observed presence in bedrock cuttings from Period 8 indicate there may be a higher potential for AMD development in Period 8. ABA analysis was not completed in the borings where pyrite was observed.

Based on the ABA results and the additional detail presented above, Sanborn Head concludes that there is a moderate to high potential for AMD development at the Site during project implementation. Therefore, the Applicant should consider enhancing the currently proposed monitoring plan as presented in the 2025 AMD Detection Initial Response Action Plan (the "Plan"; see Attachment A for citation) to include additional monitoring wells and increasing the monitoring frequency. Additionally, surface water monitoring locations should also be performed at the same frequency as monitoring wells once the surface water features (stormwater basins) are constructed during project implementation and after baseline monitoring described in the Plan is completed. However, the proposed response actions in Section 5 of the current Plan appear to be a reasonable approach to addressing criteria exceedances in either groundwater or surface water monitoring locations, if observed. The Planning Board could include revisions to the monitoring plan as a condition of approval. Recommended changes to the monitoring program include the following:

- Increase monitoring well sampling frequency to quarterly.
- Include additional monitoring wells in the monitoring program including two of the newly installed monitoring wells in Period 8 and an additional monitoring well located between Period 8 and NH Route 9.
- Include stormwater pond monitoring locations in the monitoring program during operation (quarterly as above).
- Add monthly field screening for pH in stormwater monitoring locations.

² U.S. Environmental Protection Agency (EPA), National Secondary Drinking Water Standards at 40 CFR Part 143.

³ <https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/env-wq-1700.pdf>

PERIOD 8 STORMWATER INFILTRATION

During this review, Sanborn Head also preliminarily reviewed the proposed stormwater management approach at the Site as it directly applies to the potential for AMD to impact groundwater underlying the Site through the planned use of infiltration basins. We understand that stormwater is designed to be only infiltrated and therefore there is no planned discharge to area surface water features including Otter Brook located east of the Site, which is currently impaired for several constituents. As part of this review, a concern regarding the Period 8 infiltration basin was identified. We understand that at the end of the planned project implementation, a newly constructed infiltration/retention basin will be constructed in Period 8 with a bottom elevation of 842 feet AMSL (and “plunge pool” elevation of 840 feet AMSL), which will receive stormwater from the entire Site. Based on boring logs for BRW-09 through BRW-12, which are located within Period 8, it appears that competent bedrock is approximately 860 feet AMSL, equivalent to an elevation approximately 20 feet higher than the proposed base of the infiltration pond.

A preliminary review of the 2025 Stormwater Drainage Report (see Attachment A for citation) indicates that an infiltration rate of 0.3 inches per hour was used to estimate management of stormwater for a 50-year and 100-year rain event. However, since it appears that the infiltration pond base will be located on competent bedrock with limited infiltration potential, it is unlikely that infiltration at the rate used in the HydroCAD modeling is representative of what the actual conditions could be following site development. In fact, if the basin base is located on competent bedrock, there may be very little to no infiltration potential. Although boring logs for this area indicate the bedrock is highly weathered in this area, even if the infiltration basin base is on weathered bedrock, the subsurface material may be clay-rich and the infiltration rate could be substantially lower than 0.3 inches per hour. Therefore, Sanborn Head recommends that the Applicant provide additional information to support the infiltration estimates for the Period 8 infiltration/retention basin. Given the anticipated subsurface conditions, the stormwater management plan may need to be modified to address this concern.

We trust this information meets your needs at this time. Please contact me should you have questions regarding this information. We appreciate the opportunity to support the Town’s review of the Application.

RHA/TMW: rha

Encl. Attachment A – Documents Reviewed and References

ATTACHMENT A – Documents Reviewed and References

Fieldstone Land Consultants, PLLC, 2025, Letter RE: G2 Holdings LLC - Excavation Permit Package Review Tax Map 215 Lots 7 & 8 – 57 Route 9 – Keene, NH, May 30.

Granite Engineering, LLC, 2025, Waivers, Received by the City of Keene on May 8, 2025.

Granite Engineering, LLC, 2025, Gravel And Earth Removal Plan G2 Holdings LLC, Keene Tax Map 215 Lots 7 & 8, Sullivan Tax Map 5 Lots 46 & 46-1, 57 Route 9, Keene New Hampshire, Cheshire County, Revised August 11.

Granite Engineering, LLC, 2025, Letter RE: G2 Holdings, LLC, Tax Map 215 Lots 7 & 8, 21 & 57 Route 9, Keene, NH, GE Project No. 2302011, August 11.

Granite Engineering, LLC, 2024, Existing Conditions Photographs, Received by the City of Keene on December 19, 2024.

Frontier Geoservices, 2024, Gordon Services - Keene Pit 2024 Acid Mine Drainage Potential Report, 57 Route 9, Keene, New Hampshire, December 18.

Frontier Geoservices, 2024, Gordon Services - Keene Pit 2024 Hydrogeologic Investigation Report, 57 Route 9, Keene, New Hampshire, December 18.

Frontier Geoservices, 2025, Gordon Services – Keene Pit Acid Mine Drainage Detection Initial Response Action Plan, 57 Route 9, Keene, NH, April 6.

Frontier Geoservices, 2025, Addendum To: Gordon Services - Keene Pit 2024 Hydrogeologic Investigation Report, 57 Route 9, Keene, New Hampshire, August 8.

United States Geological Survey (USGS), R. Moore, C. D. Johnson, E.M. Douglas, 1994, Geohydrology and water quality of stratified-drift aquifers in the lower Connecticut River basin, southwestern New Hampshire. Water Resources Investigations Report 92-4013.DOI: [10.3133/wri924013](https://doi.org/10.3133/wri924013) .

University of New Hampshire, 2025, NH GRANIT GIS Clearinghouse, GRANITview, accessed at: https://granitview.unh.edu/html5viewer/index.html?viewer=granit_view , and accessed between July 29 and August 13, 2025.

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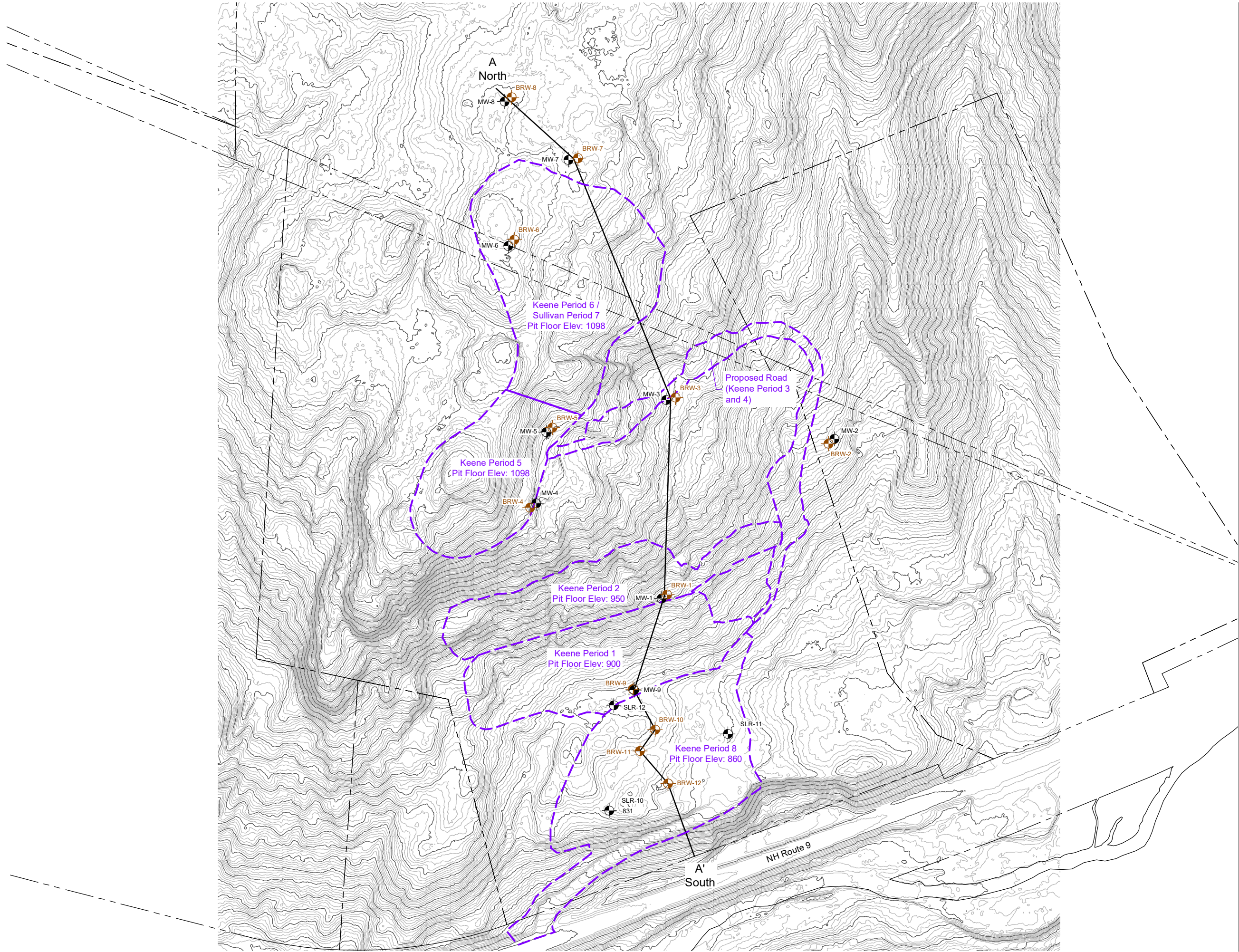


Figure 1

Site Plan

Support of Planning Board Permit Review

City of Keene
Keene, New Hampshire

Drawn By: E. Wright
Designed By: R. Abell
Reviewed By: R. Abell
Project No: 6741.000
Date: August 2025

Figure Narrative

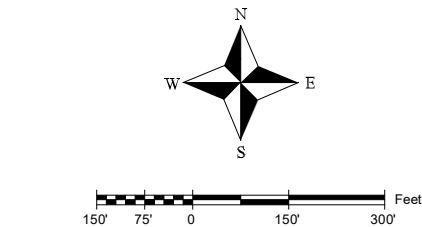
This figure shows the site and profile A-A' alignment.

Notes

1. Ground surface topography developed from Connecticut River Watershed LiDAR data downloaded from GRANIT and dated 2015.
2. Site features and well locations are based on information provided in the Gordon Services - Keene Pit, 2024 Hydrogeologic Investigation Report, 57 Route 9, Keene, New Hampshire, December 2024 and Addendum to: G2 Holdings - Keene Quarry Expansion - Hydrogeologic Investigation Report, 57 Route 9, Keene, NH, August 2025.

Legend

- Approximate parcel line
- MW-2 Monitoring well
- BRW-2 Bedrock monitoring well



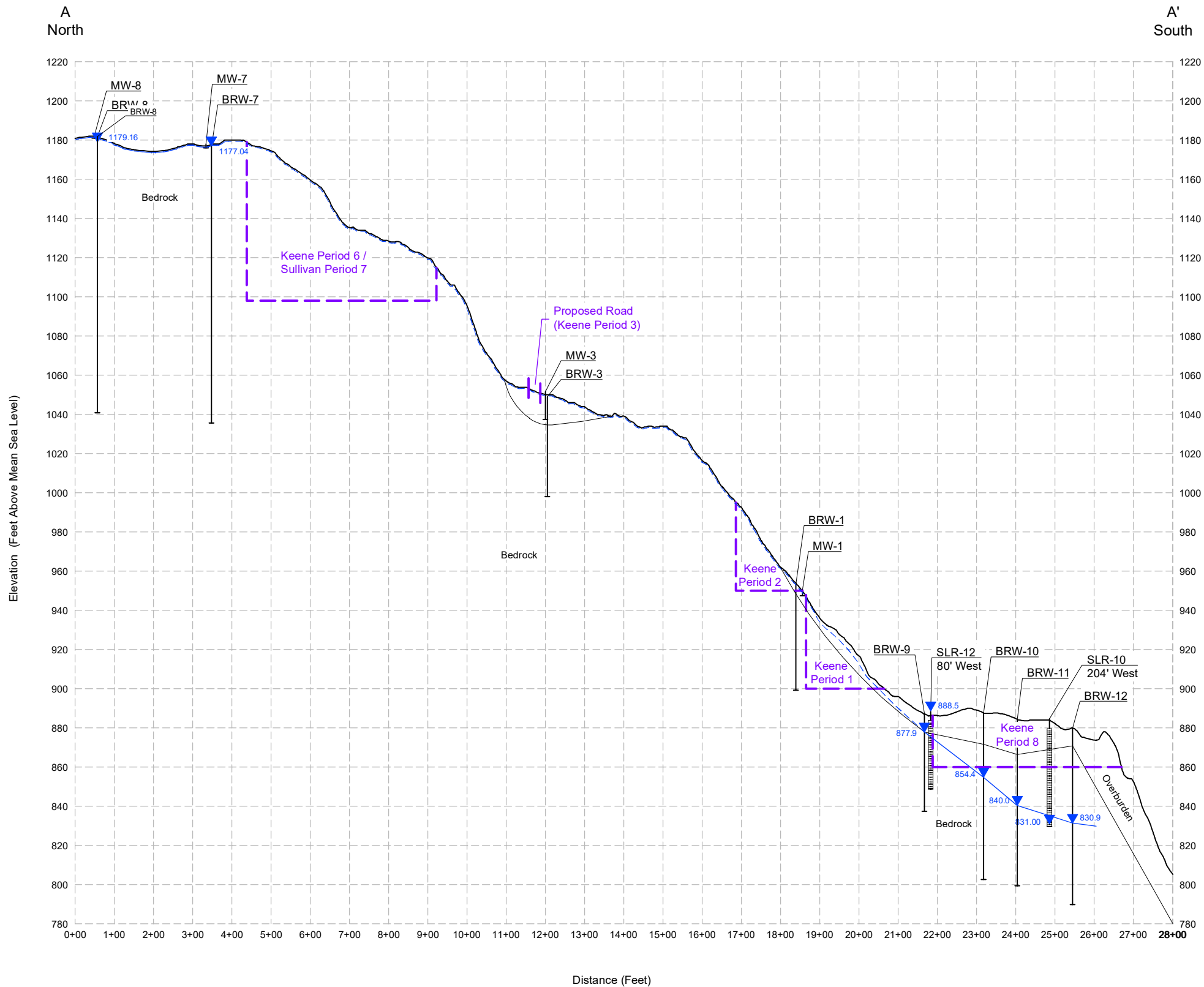


Figure 2

Groundwater Elevation Profile

Support of Planning Board Permit Review

City of Keene
Keene, New Hampshire

Drawn By: E. Wright
Designed By: R. Abell
Reviewed By: R. Abell
Project No: 6741.000
Date: August 2025

Notes

- Ground surface topography developed from Connecticut River Watershed LiDAR data downloaded from GRANIT and dated 2015.
- Well locations and groundwater elevations are based on data and information provided in the Gordon Services - Keene Pit, 2024 Hydrogeologic Investigation Report, 57 Route 9, Keene, New Hampshire, December 2024 and Addendum to: G2 Holdings - Keene Quarry Expansion - Hydrogeologic Investigation Report, 57 Route 9, Keene, NH, August 2025.
- Water level elevations except BRW-9 through BRW-12 are from the December 2024 Hydrogeologic Investigation Report. Water level elevations for BRW-9 through BRW-12 provided on a figure entitled, "Monitoring Plan" prepared by Granite Engineering, of Manchester, New Hampshire. Dated May 2025, last revised August 11, 2025.

Legend

- Monitoring Well
- Ground Surface
- Water Table
- Groundwater Elevation (March 2024)
- Screen Interval
- Bottom of Boring

