REPORT ON
ROCK SLOPE STABILITY EVALUATION
KIPP ACADEMY
LYNN, MASSACHUSETTS

by

Haley & Aldrich, Inc.
Boston, Massachusetts

for

KIPP Academy c/o Skanska USA
Boston, Massachusetts

File No. 36815-003
8 November 2011

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8 November 2011
File No. 36815-003

KIPP Academy
c/o Skanska USA Building, Inc.
253 Summer Street
Boston, Massachusetts 02210

Attention: Mr. Jim Dowd

Subject: Rock Slope Stability Evaluation
and Treatment Recommendations
Athletic Field
KIPP Academy
Lynn, Massachusetts

Ladies and Gentlemen:

At your request, we are providing a summary of our engineering analysis and recommended treatment of the exposed rock slopes associated with the proposed athletic field area at the new KIPP Academy, in Lynn, Massachusetts. Currently, the KIPP school buildings are under active construction, and the athletic field is serving as a staging and processing area for excavated site soils, blasted bedrock, boulder piles, and other construction materials.

This evaluation supplements and refines our previous site preparation memoranda and recommendations (dated 21 and 22 June 2010), rock removal specifications (dated 27 August 2010) and rock cut stabilization approach memorandum (dated 22 April 2011) related to construction geometry and long-term performance expectations of the rock slopes.

PROJECT UNDERSTANDING

The objectives of our engineering evaluation were to examine and analyze the condition of the exposed rock and the overall stability of the rock slopes, and identify areas where potential large rock failures may occur by sliding, toppling or other mechanisms, and recommend a treatment approach to stabilize those areas.

EVALUATION OF ATHLETIC FIELD ROCK SLOPES

The rock slope evaluation focused on the proposed athletic field area, where two linear rock faces were created by controlled rock blasting performed by MD Drilling & Blasting. The objective of the analysis was to evaluate and judge the condition and overall stability of the exposed rock, and identify where potential large rock failures may occur by sliding, toppling or other mechanisms, and recommend treatments to stabilize those areas of the slopes.

For the purpose of our evaluation, we identified and differentiated three segments of the overall rock slopes adjacent to the perimeter of the proposed athletic field (defined as linear "Traverses") for inspection and analysis.

The general configuration of each Traverse is shown on annotated photographs in Appendix A on Figures 1 through Figure 9. The three slopes were differentiated according to physical similarities using the following criteria:

- orientation of the cut slope
- height of the cut slope of the cut slope
- rock mass characteristics
- presence of water
- character/spacing/condition of bedrock discontinuities, and
- overall geology.

We judged that each Traverse, based on the criteria above, was likely to exhibit slightly different potential failure modes or long-term performance behavior, and was therefore evaluated independently. Each Traverse is described in brief detail below.

Although supplemental rock slope improvement measures (such as passive rock dowel installation) were not judged necessary on Traverse 1 and Traverse 2, we recommend additional construction elements to improve the long-term performance of the rock slopes that are common to all three Traverses. These common improvements are specifically the use of:

- angled rock slope drains installed into the rock faces to relieve potential water pressure behind the slopes;
- construction of a sloped catchment area (fall zone) at the base of all rock slopes; and
- use of hydroseeding and rolled erosion control product (RECP) matting to blanket certain sections of the exposed soil slopes above the rock faces.

For the benefit of the project team and construction contractor, we have provided a summary of the anticipated number, type and length of rock dowels, recommended installation procedures, dimensions of the rock fall catchment area, installation of rock slope water drains, and comments on the use of erosion control matting at the top of the slopes in Appendix B. Appendix B is intended to highlight key installation aspects that were previously described in our memoranda or contract specifications.

Traverse 1 - North End of Field

Traverse 1 is defined as the section of the exposed rock face at the northern end of the proposed athletic field that is approximately 45 feet long. The blasted rock face is sloped at an approximate 4V:1H (76 degree) angle and oriented in a general east-west direction (see Appendix A).

The exposed rock height varies between 1 to 2 feet (at the western end) and 12 feet at the eastern end. Soil thickness above the top of rock ranged from 0 feet (bare rock) to approximately 7 feet at the eastern end of Traverse 1. The overall rock slope was judged to be in good condition and stable in terms of large kinematic global failures, although there were numerous small rock blocks and pieces that may become dislodged by long-term water infiltration or frost action over time.

There were no readily visible joint planes or intersecting joint planes that would lead to large planar or rock wedge failures. Accordingly, we do not recommend at this time that additional improvements (such as the installation of passive rock dowels) are necessary on Traverse 1.

Several areas of Traverse 1 slopes were observed to be "wet or moist" where water was seeping from the face or from water flowing over the rock surface from the overlying saturated soil after rain events. These wet areas were noted at the eastern end of the Traverse (near the intersection with Traverse 2) and were located approximately half way up the slope face.

Construction recommendations and treatments for Traverse 1 are provided in Appendix B.

Traverse 2 – Northeast End of Field

Traverse 2 is defined as the section of the exposed rock face at the northeast corner of the proposed athletic field where Traverse 1 and Traverse 3 intersect. Following the rock blasting and excavation, a shallow transverse rock "bench" remained at the base of the slope at the corner, forming the area defined as Traverse 2. Overall, Traverse 2 is about 25 feet wide, and the blasted rock face sloped at an estimated 4V:1H to 2V:1H geometry.

The exposed rock height varies between 12 feet to 18 feet above the base of the slope. Soil thickness above the top of rock was approximately 7 feet and sloped at a 1V:1H angle (45 degree) or steeper, and consisted of mixed topsoil fill and glacial till.

The overall rock slope was judged to be in fair condition and stable in terms of large kinematic global failures, although there were numerous small rock blocks and pieces that may become dislodged by water infiltration or frost action over time. There were no readily visible joint planes or intersecting joint planes that would lead to large planar or rock wedge failures. Accordingly, we do not recommend at this time that additional improvements (such as the installation of passive rock dowels) are necessary within Traverse 2.

Many areas of Traverse 2 were observed as "wet or moist" where water was seeping from the face or from water flowing over the rock surface from the overlying saturated soil after rain events. These wet areas extended up the entire slope face in some areas.

Construction recommendations and treatments for Traverse 2 are provided in Appendix B.

Traverse 3 – East Side of Field

Traverse 3 is identified as the "longwall" section of exposed rock along the east side of the proposed athletic field that is approximately 165 feet long. The blasted rock face is sloped at an approximate 4V:1H (76 degree) angle and oriented in a general north-south direction.

Several areas of the slopes were wet or moist where water was seeping from the face or from water flowing over the rock surface from the overlying saturated soil after rain events. These wet areas were noted at the northern end of Traverse 3 (near the intersection with Traverse 2) and several other locations along the rock face. Most were located approximately three-fourths of the way up the slope face.

The exposed rock height varies between 18 feet at the north end, rising to approximately 28 feet near Sta. 8+75, and declining to about 1 to 2 feet at the southern slope end. The soil thickness above the top of rock ranged from 3 to 5 feet near Traverse 2 to negligible thicknesses (bare rock) along the remainder of the slope.

The overall rock slope was judged to be in good condition, although the rock mass was crossed by multiple joints and rock discontinuities (fractures) in a wide range of geometric orientations. While many of these discontinuities were also present in the other rock slopes surrounding the athletic field, the length and vertical height of Traverse 3 was judged to require additional stability evaluation and analysis (described below). To proceed with the analysis, a project baseline was established along the base of the Traverse 3 slope to allow referenced structural measurements of the exposed bedrock. The baseline system used a format where Sta. 1+50 represents a location 15 ft along the baseline from the origin.

Rock Slope Stability Analysis – Traverse 3

To assess the overall slope stability, Haley & Aldrich collected and tabulated structural geologic and geotechnical data from field mapping performed on 6, 12 and 24 October 2011, examining and classifying the planar discontinuities (joints and fractures) exposed on the rock face.

During the field mapping, we observed a few areas where potential rock wedge failures were considered possible. Also, large rock blocks were present at the top of the rock in two locations.

Using the field mapping data and results of the geotechnical rock strength testing performed in 2010 for the KIPP project, we analyzed the geometry of the planar discontinuities using RockPack III, a proprietary software tool that examines the potential for discontinuities (e.g. joints) to "daylight" out of the exposed rock slope, and hence indicate the potential for blocks to slide or fall from the rock face. Using a kinematic method of evaluation referred to as Markland's Analysis, the analysis revealed two zones that were potentially unstable on a long-term basis in terms of large wedge failures or block sliding. A wedge failure is where sliding occurs along two discontinuity planes.

The suspect areas were designated "Wedge 1" (located in the vicinity of Sta 4+00) and "Wedge 2" (located near Sta 10+29), and further evaluated using RocScience's SWEDGE program, a limitequilibrium method of analysis that considers the statistical range of variation in characteristics in each discontinuity surface bounding the wedge, as well as variations in shear strength parameters (cohesion and friction angle) affecting the rock's tendency to release and then slide.

The results of the wedge stability analysis indicated that although Wedge 1 and Wedge 2 are stable in their current configuration (with a Factor of Safety equal to or greater than 1), they may become potentially unstable over time due to water infiltration, frost action, "relaxation" of the rock mass after blasting and unloading, and loss of buttressing rock block support below the wedges.

Accordingly, we recommend the installation of passive reinforcement rock dowels in the subject wedges, to prevent or minimize future rock fall from potential wedge failures. By design, passive rock dowels serve to supplement the resistance of the rock wedges from sliding forces, should the rock wedges release and consequently engage the shear capacity and strength of the rock dowels.

In early project documentation, including Section 312316 – Controlled Blasting and Rock Removal, we recommended spacing dowels at 10 foot on-center spacing over the rock faces. We understand the construction allowance based on this recommendation called for approximately 60 dowels. Our recent analysis has reduced the number of rock dowels to twelve (12) to be installed in a targeted, spot-applied manner.

Construction recommendations and treatments for Traverse 3, including details on the rock dowel installations, are provided in Appendix B.

ROCK SLOPE PERFORMANCE AND MONITORING

As discussed with you and the project team, freshly-blasted rock faces can be expected to have many cracks, and develop numerous small broken rock chips, fragments and generally small pieces that will become dislodged by water infiltration, frost action, plant growth and other forces over time.

As the excavated faces adjust to newly-exposed conditions, these comparatively small pieces of rock will spall, drop, and "shed," by falling down as intended into the sloped gravel catchment area (fall zone) at the base of the rock slopes. This is a normal, anticipated part of the blasting process, and while it can be reduced by using good blasting practices, it does not indicate improper blasting procedures or that blasting overbreak of the rock mass has occurred. Should minor rock fall occur into the catchment area, the debris should be cleared from the ditch by school or maintenance personnel.

On a long-term basis, we recommend visual monitoring and inspection of the existing rock slopes be performed on a regular schedule by a qualified geotechnical engineer. We recommend inspecting the slope twice during the first year following construction, and once a year thereafter, preferably during the late winter/early spring period.

The inspections should examine the presence of rock falls into the catchment area, condition of the slope drains and rock dowels, presence of vegetation, erosion of the soil slopes above the rock faces, and overall condition of the rock mass, specifically noting visible movement, dislocation or changes in rock block configurations.

However, should significant changes in the rock slopes be observed by school personnel (such as the movement or sliding of large blocks, the buildup of substantial ice, continuous rock fall, or increased water flows) or should rock fall pieces extend beyond the catchment area and barrier fencing, we recommend contacting and engaging a qualified geotechnical engineer to perform a further evaluation of the condition of the exposed rock slopes, and to develop additional mitigation measures as warranted.

As previously recommended, the planned barrier fencing surrounding the perimeter of the athletic field is intended to keep unauthorized personnel out of the fall zone near the base of the exposed rock slopes, except to perform routine maintenance. Fence signs should warn about not entering or occupying the fall zone beneath the rock faces except by qualified personnel.

CLOSURE

We appreciate the continued opportunity to provide geotechnical engineering services on this project.

Please note that we recommend having a qualified Haley & Aldrich field representative be present at the site during the completion of the work described in this letter. Specifically, we will be needed to layout the locations of the rock slope drains, the rock dowel location and installation procedures, and location of the erosion control products to ensure our recommendations are implemented correctly, and that the installations perform as intended.

Please do not hesitate to call if you have any questions or comments, or require further information on this matter.
Sincerely yours,
HALEY & ALDRICH, INC.

Bradford Miller

Bradford A. Miller, PG
Senior Specialist - Geology

Marya E. Gorczyca

for Martin J. Woodard, PhD, PG
Senior Engineering Geologist

Enclosures:

Appendix A – Figure 1 to Figure 9
Appendix B – Rock Slope Treatment Recommendations

cc: Consigli Construction Company; Attn: Brian Fogarty, Site Supervisor
Arrowstreet; Attn: Matthew Rice

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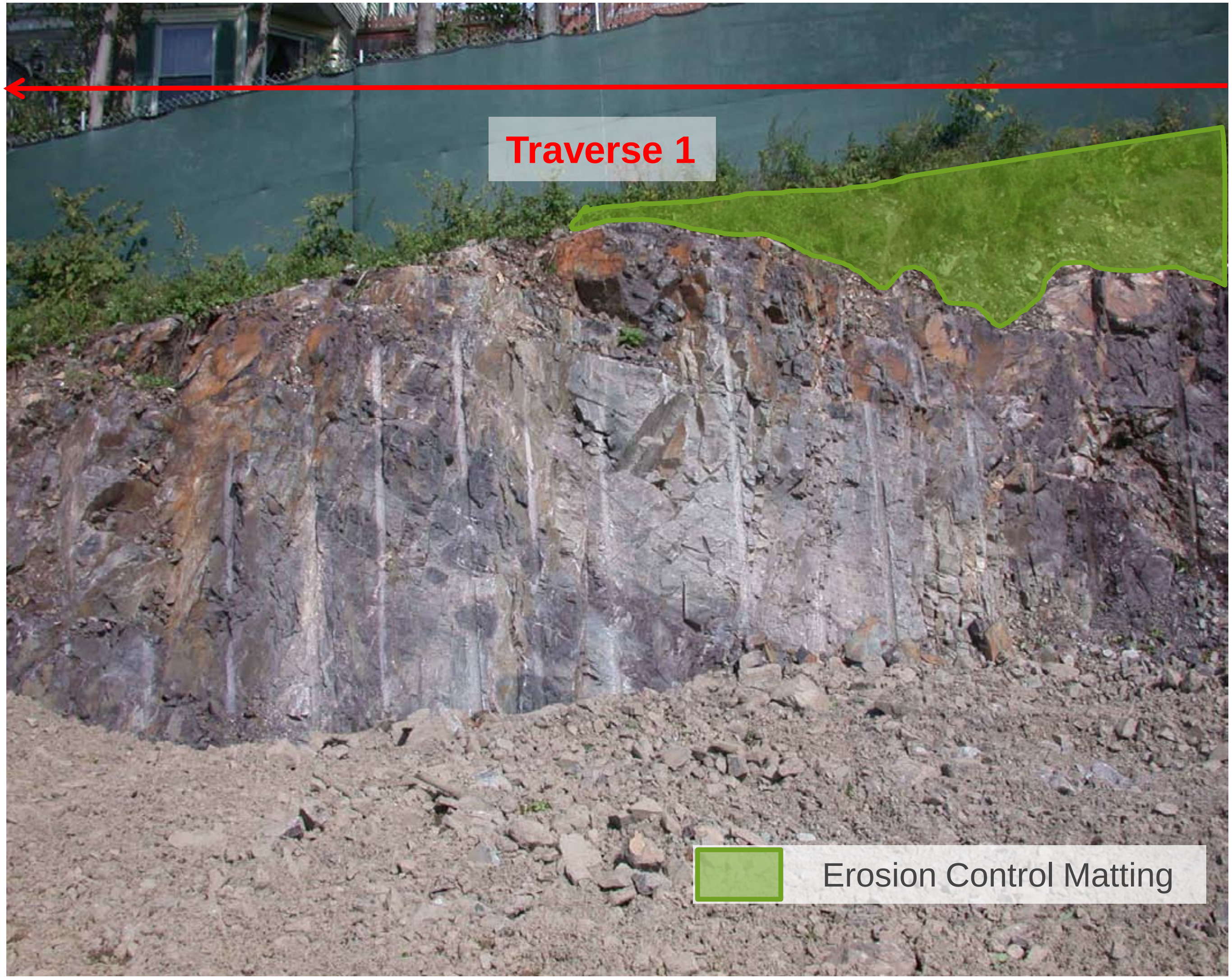
APPENDIX A

Figures 1 through 9



Appendix A Figure 1

Traverse 1 – Erosion Control

KIPP Academy, Lynn, MA
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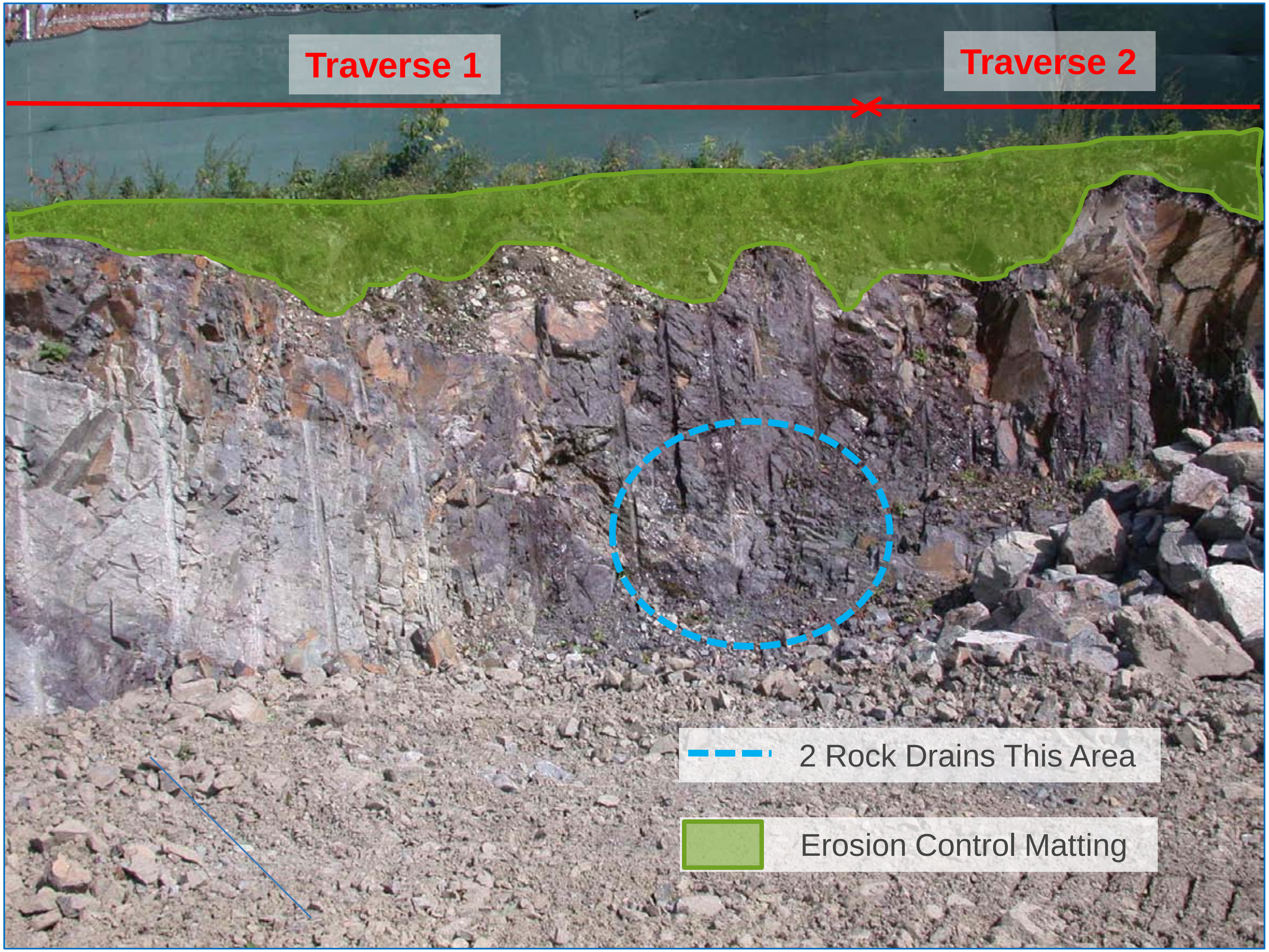

Appendix A Figure 2

Traverse 1 – Drainage

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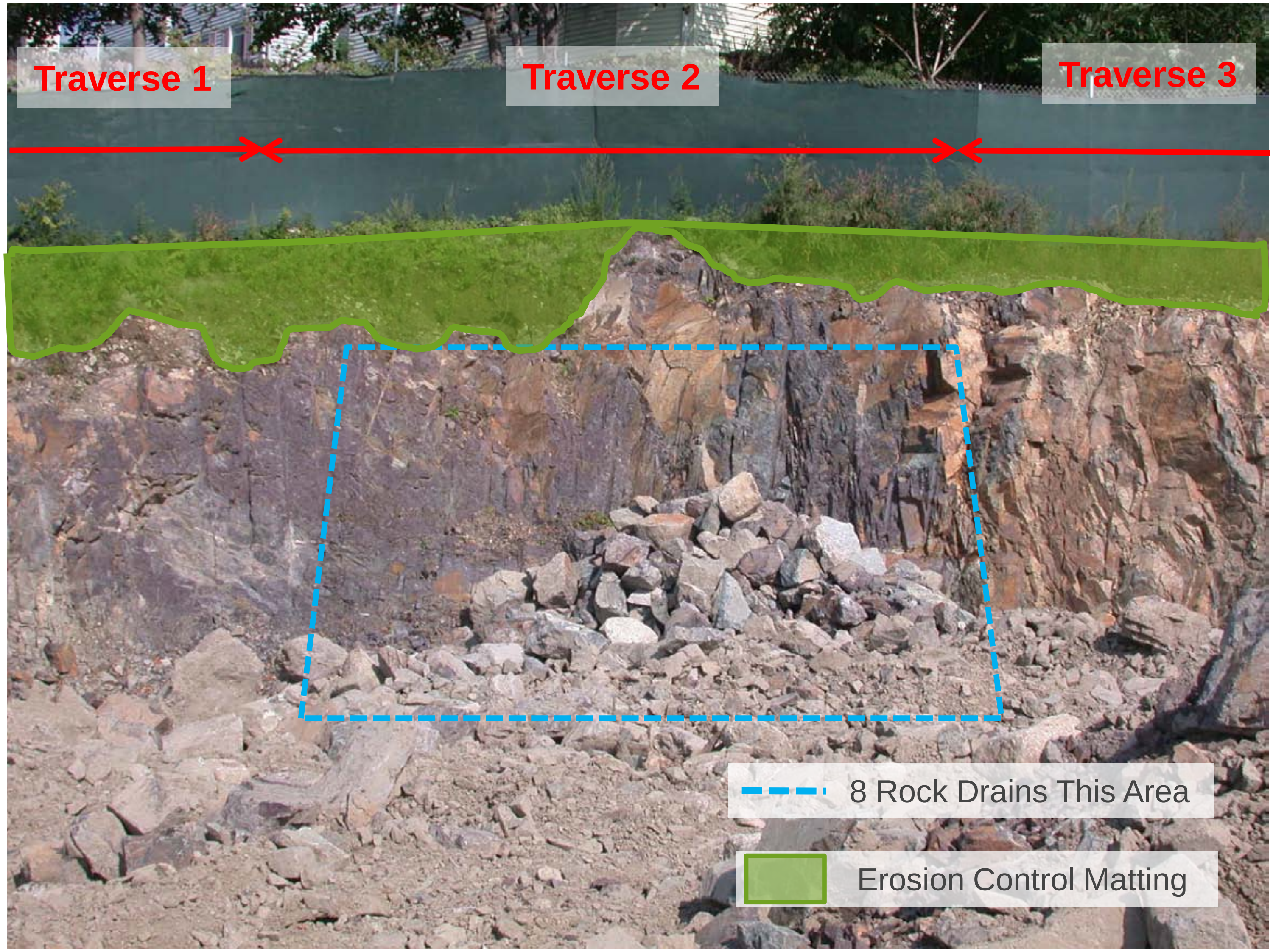

Appendix A Figure 3

Traverse 2 – Drainage

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Appendix A Figure 4

Traverse 3 – Drainage

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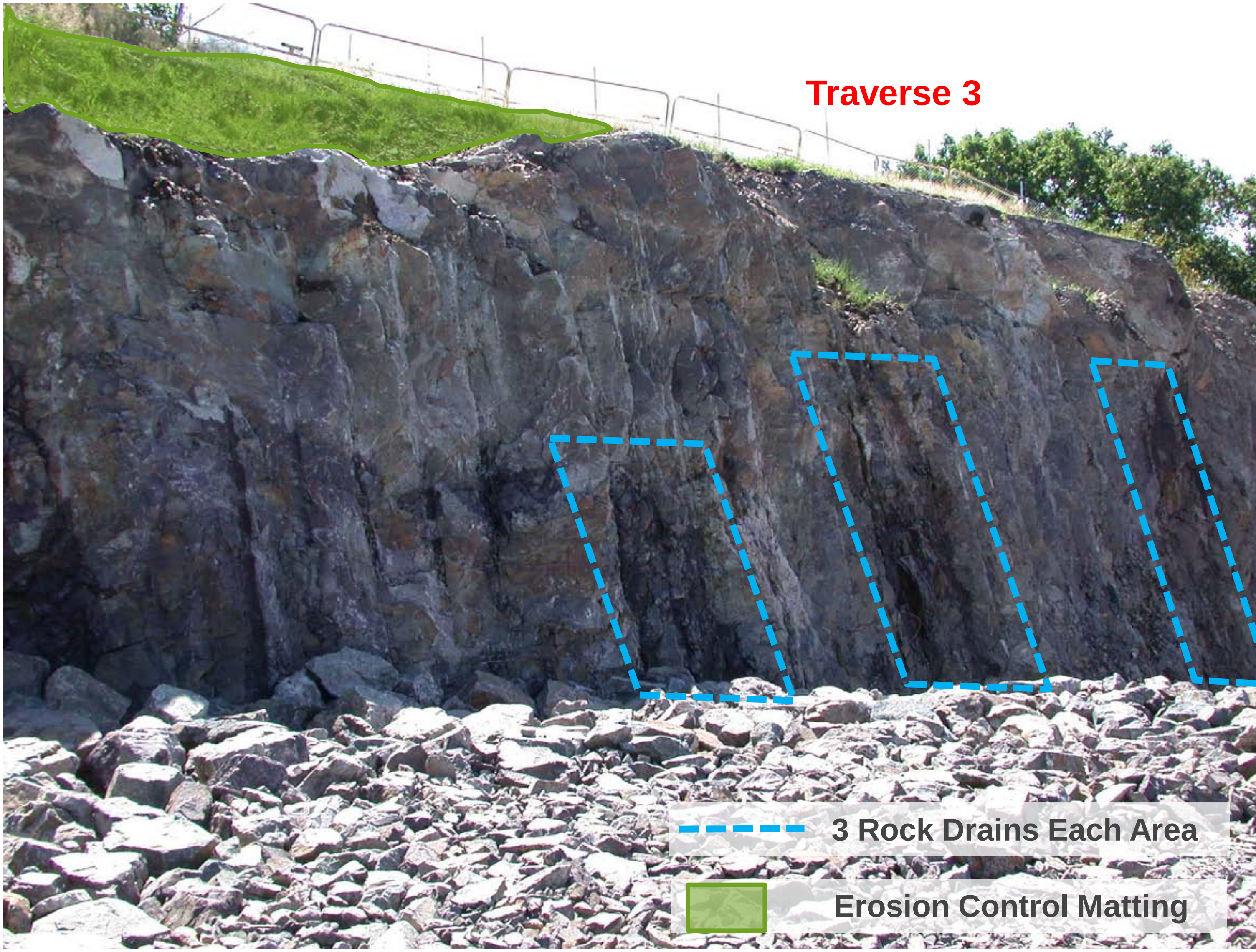

Appendix A Figure 5

Traverse 3 – Drainage

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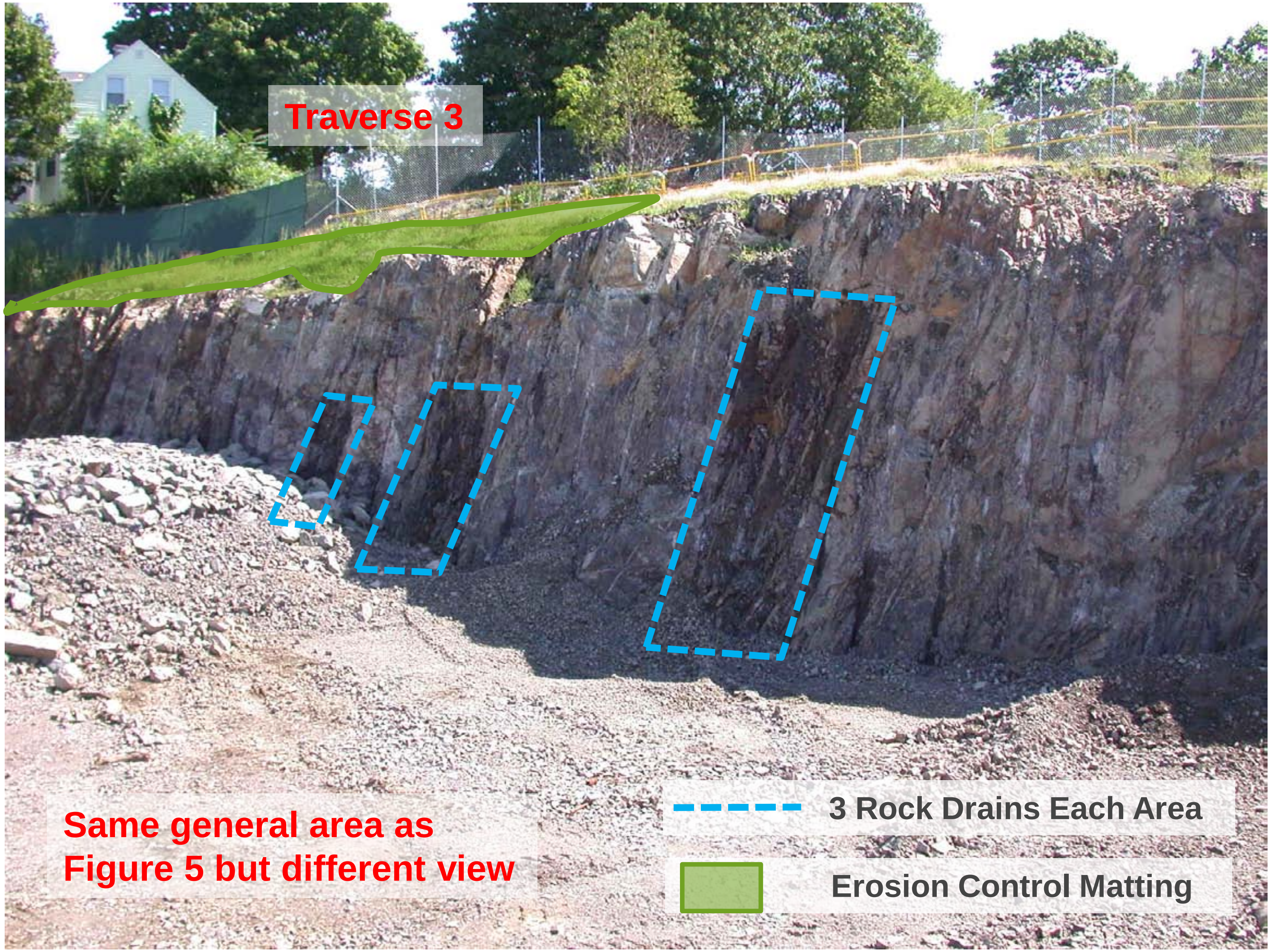

Appendix A Figure 6

Traverse 3 – Drainage

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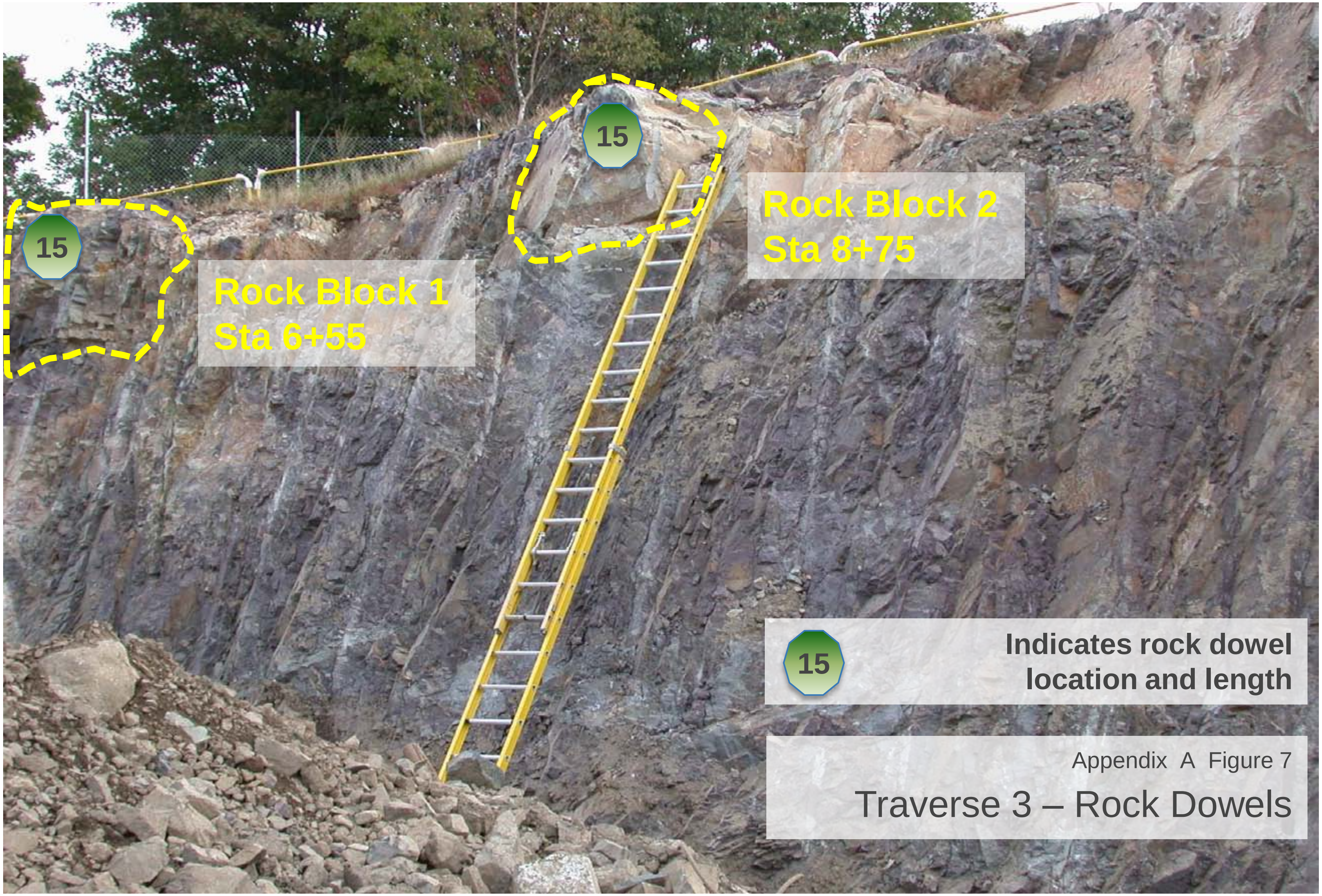
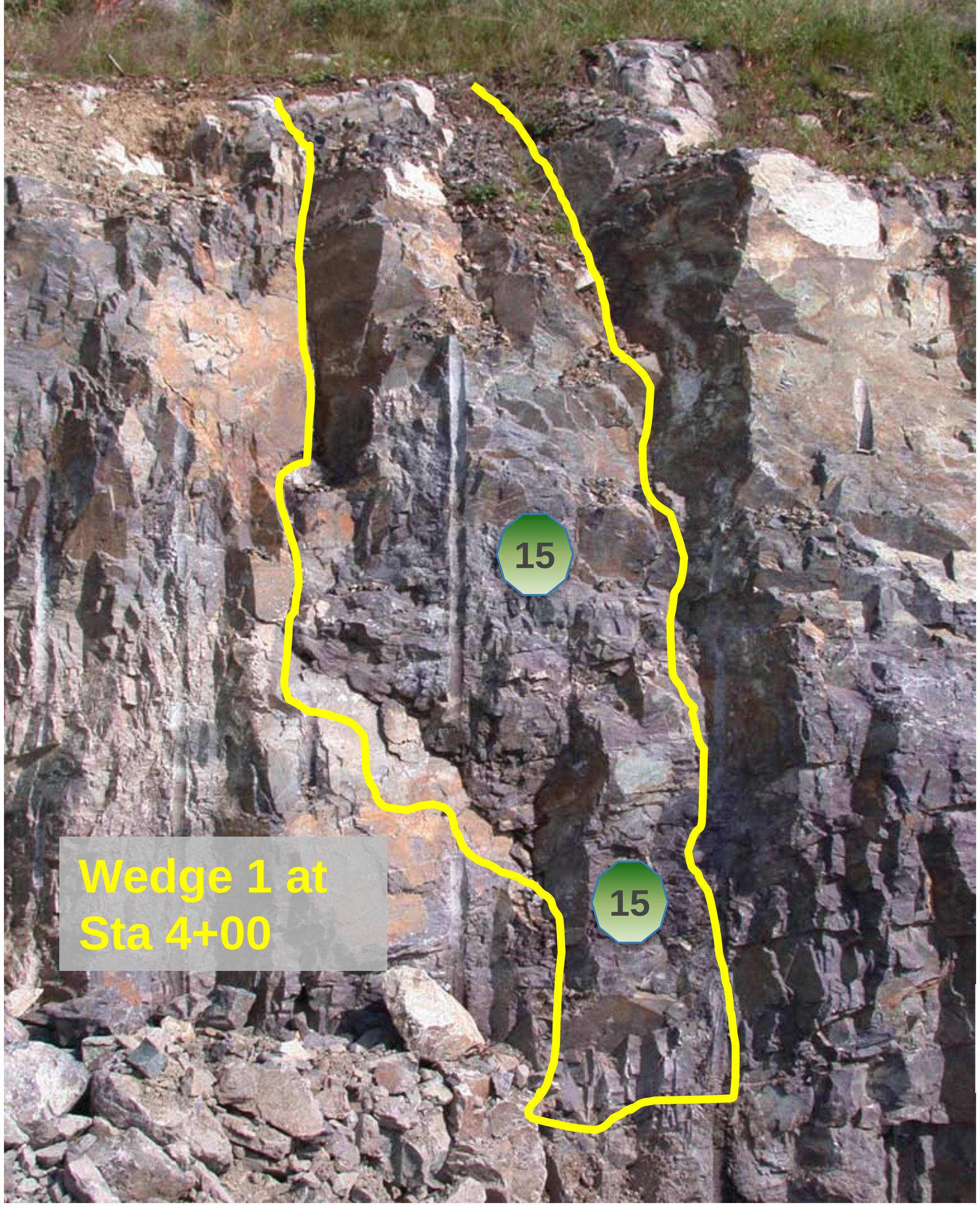

15
15
Rock Block 1
Sta 6+55
Rock Block 2
Sta 8+75
15
Indicates rock dowel location and length
Appendix A Figure 7
Traverse 3 – Rock Dowels



15 Indicates rock dowel location and length

Appendix A Figure 8

Traverse 3 – Rock Dowel Location

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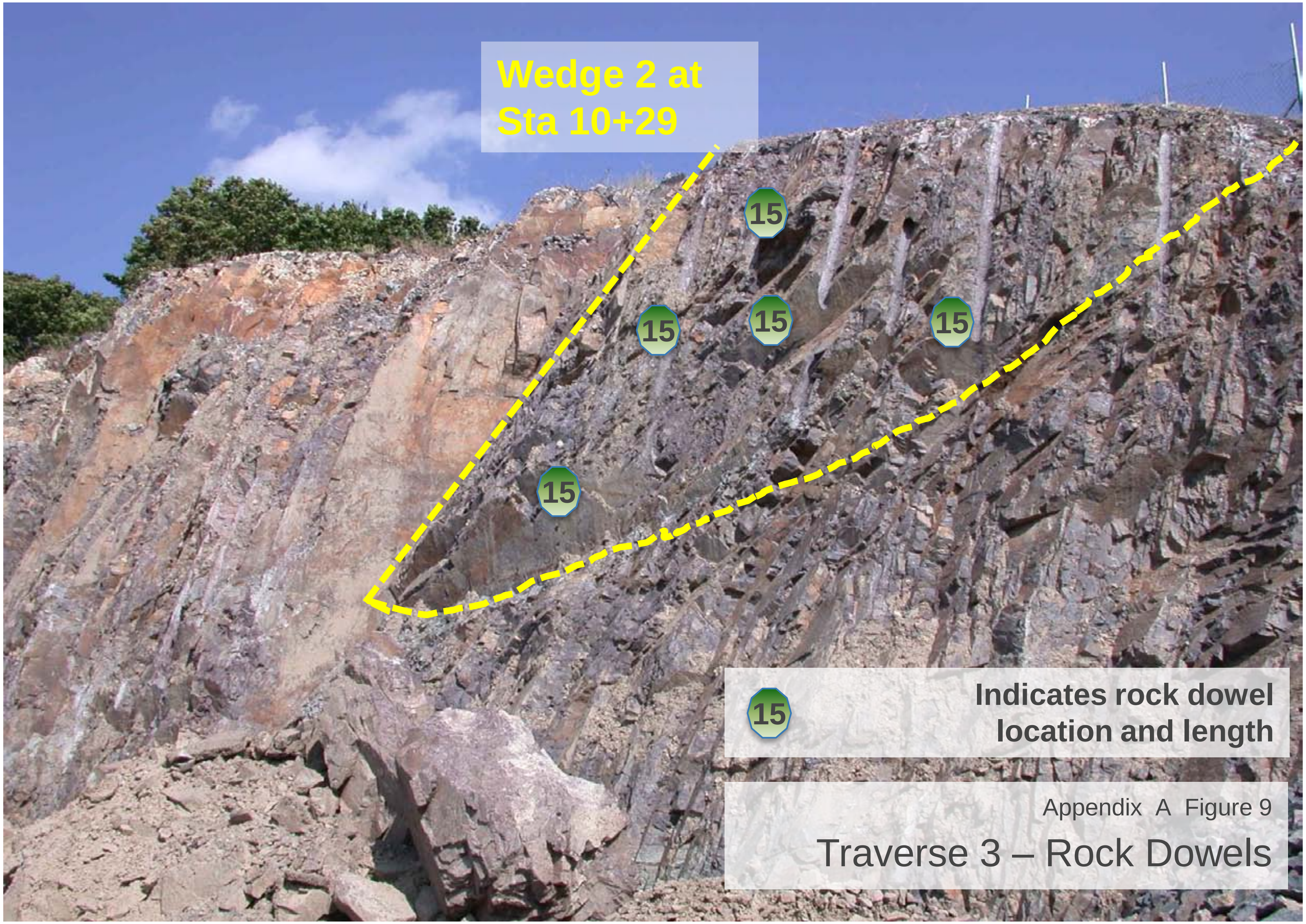

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APPENDIX B

Rock Slope Treatment Recommendations

APPENDIX B

ROCK SLOPE TREATMENT RECOMMENDATIONS

Rock Slope Stability Evaluation Report
KIPP Academy
Lynn, MA

Haley & Aldrich, Inc.
36815-003
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I. GENERAL RECOMMENDATIONS, TREATMENTS AND QUANTITIES

A. Passive Rock Dowels

- The rock dowels shall consist of #4 (1/2” diameter) galvanized steel, Grade 60 Allthread Rebar manufactured by Williams Form Engineering, part number R50-04, or approved equivalent. Install up to twelve (12) passive rock dowels at general locations indicated in Appendix A.

- Minimum dowel length shall be 15 feet long, installed at 5 degree angle below horizontal in minimum two (2) inch diameter drill holes, and equipped with appropriate centralizers, steel bearing plates, angled or beveled washers, and hexagonal nuts. The use of couplers shall be minimized.

- After drilling but before dowel and grout installation, the drill hole shall be “blown out” and cleared of rock dust and cuttings using a high-pressure compressed air jet.

- The full length of the rock dowel drill hole shall be grouted with cement grout.

- Following installation of each rock dowel, a “seating load” shall be applied to the hexagonal nut to ensure the base plate and beveled washers are snug and flush with the rock surface.

B. Rock Slope Drains

- Install 10 foot long rock slope drains to relieve potential water pressure behind the rock faces.

- Install the rock slope drains at heights ranging from 2 feet above the final toe-of-slope grade to approximately half way of the slope face.

- Angle the drilled drains upward (to slope down to the face) at an approximately 15 degree angle above horizontal and sleeve with perforated 2 inch diameter Sch 40 gray PVC, constructed with 0.010 inch slotted screen and solid pipe.

- Construct each drain using a minimum of 5 foot slotted section length, 5 foot solid section length, centralizers, and appropriate end cap. Drilled drain hole diameters shall be sufficient to accommodate the 2 inch PVC sleeves without binding, kinking or splitting. A minimum 2 foot thick cement grout plug shall be installed in the drain annulus at the rock face, and the drain shall project from the face approximately 2 inches.

- Alternatively, a 10 ft slotted PVC drain section may be installed, providing the grout plug does not interfere with the drain operability and function.

C. Sloped Catchment Area (Fall Zone)

- Configure the catchment area (fall zone) at the base of all rock slopes to be a minimum of 6 feet wide, sloped at 1V:4H where the athletic field is higher than the toe of rock slope, and blanket with a minimum 12 inch thick layer of ¾ inch crushed stone.

- Configure the catchment zone below all subject rock slopes.

D. Rolled Erosion Control Product (RECP) Landscape Matting

- Install RECP on the soil slopes above the rock faces. The RECP matting is intended to reduce erosion of the exposed soil slopes due to water flow and seepage, and encourage the growth of permanent grass or other vegetation that will lead to a stabilized soil condition above the exposed rock.

- We recommend North American Green SC150BN double-net blanket with an 18 month durability period, or approved equivalent.

- Hydroseed the exposed, fine-graded and prepared soil slopes prior to placement of the RECP.

- Layout, unroll, overlap, anchor and pin the RECP in accordance with manufacturer's recommendations.

II. SPECIFIC TRAVERSE RECOMMENDATIONS

A. Traverse 1

Traverse 1 was defined as the section of the exposed rock face at the northern end of the proposed athletic field that is approximately 45 feet long. The blasted rock face is sloped at an approximate 4V:1H (76 degree) angle and oriented in a general east-west direction.

- Install rock slope drains in two (2) locations in the general location shown in Appendix A (see Figure 2).

- Extend the RECP from the intersection of Traverse 1 with Traverse 2 approximately 25 feet west and away from the rock slope towards the property line (see Appendix A, Figure 1 and Figure 2).

B. Traverse 2

Traverse 2 was defined as the section of the exposed rock face at the northeast corner of the proposed athletic field where Traverse 1 and Traverse 3 intersect. Overall, Traverse 2 was about 25 feet wide, and the blasted rock face sloped at an estimated 4V:1H to 2V:1H geometry.

- Install rock drains in approximately eight (8) locations as shown in Appendix A (see Figure 3).

- Extend the RECP the entire width of Traverse 2 and away from the rock slope towards the property line (Appendix A, Figure 3).

C. Traverse 3

Traverse 3 was identified as the "longwall" section of exposed rock along the east side of the proposed athletic field that is approximately 165 feet long. The blasted rock face is sloped at an approximate 4V:1H (76 degree) angle and oriented in a general north-south direction.

- Install up to twelve (12) passive rock dowels at general locations indicated in Appendix A (see Figures 6 through Figure 9).

- Install rock slope drains in approximately seventeen (17) locations at heights ranging from 2 feet above the final toe-of-slope grade to approximately three-fourths of the way of the slope face (see Appendix A, Figures 4, 5 and 6).

- Extend RECP from Traverse 2 approximately 35 feet down Traverse 3 (see Appendix A, Figure 5 and Figure 6).

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