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Subject: Rock Selection Procedures, Revision 3
Reading Slag Pile Site
STEP Project Number 90C057

Dear Mr. Smith,

This letter serves as a follow-up to recent telephone conversations and a quarry visit with Ted Johnson and Robert Johnson and, on behalf of Cabot Corporation (Cabot), presents the procedures for the selection of rock to construct the proposed rip-rap cover at the Reading Slag Pile Site (Site). These rock selection procedures will ensure that the rock used is homogeneous and generally absent of characteristics that would adversely affect the durability of the overall cover system.

The specifications for the testing and placement of the rock will follow under separate cover.

## I. Background/Supporting Information for Procedures and Specifications

The rock selection procedures and specifications for the testing and placement of the rip rap were developed based on information presented in the Decommissioning Plan and information more recently obtained from the selected quarry regarding its operations.

### A. Summary of Rock Characteristics (Durability)

The rock for the rip-rap cover will be the diabase (diorite) from the Dyer Quarry located approximately 7 miles from the Site. Section 3.0 of Addendum 1 to the Reading Slag Pile Site Decommissioning Plan (Revision 4, August 2006, prepared by ST Environmental Professionals) provides a detailed description of the physical and chemical characteristics and testing of this rock, as well as a general description of the quarrying operations. Based on this information, Addendum 1 concludes that the diabase rock can be used to construct the cover over the slag because it is sufficiently durable to resist weathering and remain stable throughout the 1,000 year period of interest (NUREG-1623, p. 14) without reliance upon active ongoing maintenance.

The following observations from quarry visits and conclusions from Addendum 1 (reference pages cited in parentheses) were considered in developing the rock selection procedures:

- The diabase rock has been well characterized by physical testing, inspection and current uses. This includes testing recently performed by Cabot and over 10 years of testing performed by the quarry and by its purchasers (such as the MD SHA, PennDOT ). Based on the properties reported by the quarry and independent laboratory tests the diabase easily exceeds the criteria in NUREG-1623 of 85% (pg. 3-8);
- Potential adverse heterogeneities in the diabase include joints, fractures, flow zones, chilled margins, alteration zones, zones of higher porosity and xenoliths. However, these features comprise only an insignificant fraction of the overall rock mass are easily recognizable and not all will actually be detrimental. For example, only joints that remain within individual pieces after the quarrying operations will have a potential impact on the durability of the rip rap (pg. 3-9)

    - Other than in the upper bench, nearly all joints and fractures appeared to be unweathered (pg 3-9)
    - It did not appear that joints remained in individual pieces of rock after being quarried. (pg. 3-9).
    - No carbonate minerals or veins were reported by the quarry analyses, the independent Cabot analyses, or noted during the site visit (pg 3-9);
    - Xenoliths were not observed during the site visit and are not believed to be common (pg. 3-10).
    - Alteration zones occur only in the surrounding country rock that is not to be quarried for the rip rap (pg. 3-10).
    - The diabase has essentially no primary porosity and a very low secondary porosity due to widely spaced joints and fractures. It is homogeneous, lacking bedding planes or foliation (pg. 3-10).

**B. General Quarrying Operations**

The diabase at the Dyer quarry consists of a nearly vertical massive dike approximately 800 feet thick. The quarry consists of a pit elongated along the axis of the diabase dike. The quarry operates in 50-foot high benches. The uppermost benches have been largely removed and the current deepest bench is approximately 400 feet below the original ground surface. The contact with the country rock (red shale and tan/brown sandstone) is clearly seen in the perimeter portions of the uppermost benches and is laterally and vertically distant from the current diabase quarrying areas. The lateral distance to the contact is approximately 300 feet from the sides of the lowermost bench (level 1) and the uppermost benches (level 7 and level 8) intersect the contact. Current quarrying is occurring at the head ward end of level 3 through level 5. Therefore, rock currently being quarried and to be used for this project is at least 100 feet laterally distant from the contact with the country rock.

There is some variability in the degree of fracturing in the diabase. The material near the north contact is more highly fractured than the central portion and southern contact. Observations during several visits to the quarry indicated that weathering tends to proceed from an exposed rock face (along a fracture) into the rock as a thin (less than 1 mm) rind separating hard unweathered rock from a soil-like material. Rocks exhibiting weathering of the interior were only observed in a few

specimens from the uppermost benches (level 7 and level 8) near the original ground surface. Therefore, weathering of the diabase is not considered to be a significant concern relative to durability. For the most part, the size of rock fragments produced from a blast is representative of the joint spacing and planes of weakness in the original rock mass. Only a small percentage of rocks displayed evidence of unexpressed joints. Following further processing, nearly all the incipient planes of weakness are expressed and, therefore, will not impact the performance of the rip-rap cover. The maximum size of the final product is controlled by the original joint spacing and essentially precludes the possibility of undesirable rocks.

The quarry operators and managers report that the "country rock" around the diabase (which consists of baked sandstone and shale) is not quarried (except for removal) and that the quarry takes great care to preclude country rock from becoming mixed with the diabase. Inclusions of country rock in the diabase being quarried and stockpiled were not observed or noted during subsequent and current quarry inspections (Addendum 1; pg 3-3). A recent topographic map of the quarry is attached as Figure 1. The approximate location of the contact with country rock is shown on that figure.

The quarry processes approximately 60,000 tons of rock each week. After each blast, large impact hammers mounted on hydraulic excavators are used to break the larger pieces such that the material can be loaded into trucks. The operator takes advantage of any remaining planes of weakness. Larger rocks that cannot be broken with an impact hammer must be reduced by additional blasting. Large rocks are selectively removed from the blast material and transported to a stockpile area. The remaining rock is then transported to the hydraulic rock crusher by large dump trucks. The rock first passes through a primary crusher. Rock which passes through the screens in the primary crusher is then moved by conveyor to be further processed, screened and placed in stockpiles via conveyors. The FS-2, FS-3, and R-4 material is being constantly produced and shipped precluding the ability to select and track material-specific rock source location or characteristics to this material. During the quarry visit(s), stockpiles of R-4, FS-2 and FS-3 were observed to be 30-50 feet tall. No undesirable pieces of rock were observed in the stockpiles.

Several years of test results from the quarry and recent tests performed by Cabot indicate that the rock quality is uniformly high and consistently well above the design requirements of the rip-rap cover. A summary of available historical test results are provided in Table 1. Those results demonstrate the uniformity of the material produced at the quarry. The statistical mean and standard deviation of the test results were calculated and are provided in Table 1. Calculations are provided in Table 1 for less desirable test results two standard deviations different from the mean. Even those results, with a score of 92%, would easily pass the acceptance criteria of 85% .

**II. Personnel Involved in Rock Selection and Testing**

The selection and testing of the rock will be performed by a geologist and an engineer contracted to Cabot. Primarily, but not exclusively, the geologist will be responsible for inspection of the quarry blast face; training of the quarry operator in the selection and/or processing (by hydraulic hammer) of the R-6 and R-7 rock; selection of the R-6 and R-7 material; and visual inspection of the stockpiled R-4, FS-3 and FS-2 during loading. The engineer will be responsible for the selection of rock samples for laboratory testing and inspection of the rip-rap placement at the project site. Cabot's Site Manager will have overall responsibility for the rock selection and placement operations.

## III. Rock Selection Procedure

Five gradations of material for the cover construction will be obtained from the Dyer quarry; FS-2, FS-3, R-4, R-6, and R-7. The procedures for rock selection incorporate the processing methods used at the quarry and the use of the materials in constructing the cover. The overall goal of the rock selection process is to minimize the potential that the diabase for the project contains deleterious material, primarily the country rock or chill zone material.

### *A. Blast Face Inspection*

The quantity of rock required for this project does not allow Cabot to be directly involved in the quarrying operations, such as selecting a blast face for the project material. At initiation of the project, the geologist will meet with representatives of the quarry to understand the locations of recent blasts and schedule for future blasts. If the schedule allows, rock selection will follow blast areas which are as far away from the country rock as possible. However the selected blast areas will be no closer than 100 feet from the contact. If accessible, the geologist will inspect the recent blasts and the next 3-4 scheduled blast faces and review Figure 1 to ensure the country rock will remain at least 100 feet from the expected blast face.

### *B. Selection of R-6 and R-7 Material*

As mentioned above, large rock is stockpiled at the quarry. The geologist will work with the quarry operator to select and generate sample piles of rocks consisting of the desired size and characteristics. If possible, a pile of material with undesirable characteristics will also be created to guide the operator. The geologist will be onsite for at least the first two days of work for every operator used to ensure that the operator is able to recognize and select the desired materials. The geologist will be on site at least one day per week thereafter to inspect the material as it is stockpiled. The interval between the inspections will be adjusted so that all the rock selected can be adequately assessed. This will be accomplished by having the operator produce low-height stockpiles over a large area and not adding more height between inspections than the maximum size of each gradation class (i.e. no more than 24-inch lifts for the R-6 material and no more than 30-inch lifts for the R-7 material.

Due to the limited available space and schedule of quarry operations it may not be logistically possible to spread the material out in low-height lifts. If this situation occurs, the quarry will produce and stockpile the material in piles approximately 10 to 15 feet high and the geologist will inspect the material during the loading process. The geologist will inspect the entire visible face of the R-6 and R-7 stockpiles prior to initiation of loading. The operator will be instructed to remove no more from the face of the stockpile than approximately the maximum size of the material. The operator will move along the face from one end to the other. The geologist will inspect the newly exposed face as work progresses.

As described above and stated in Addendum 1 to the Decommissioning Plan, specific undesirable characteristics include highly weathered pieces (a weathering rind greater than 1 cm), internal carbonate veins, or obvious unexpressed planes of weakness such as joints and seams.

The selection process is designed to preclude rock with undesirable characteristics. To ensure that the material meets the selection criteria, the R-6 and R-7 source material will be evaluated by the geologist. The geologist will inspect the rocks and mark, on at least three faces with an orange "X" using permanent spray paint, any rocks that contain one or more of the undesirable features of country rock inclusions, internal fractures or carbonate veins, or weathering rinds thicker than 1 cm. The marked rocks will be excluded from shipment to the Reading Slag Pile Site.

*C. Selection of R-4, FS-3 and FS-2 Material*

The FS-2 and FS-3 material will be used only for the drainage layer beneath the rip-rap cover. The cover design is relatively insensitive to variations in the characteristics of this material other than the initial size gradation. The R-4 material will be used to construct the rip-rap cover on the upper portions of the slope.

Large stockpiles of R-4, FS-3 and FS-2 exist at the quarry and this material is routinely sold and replenished as part of quarrying operations. To the extent practical and as the quarry schedule and project schedule allow, selection of this material will be based (in part) on knowing that the material in the stock pile came from one of the blast faces inspected by the geologist. However, it is understood that this may not be possible.

The numerous crushing and sorting processes used to produce this material ensures that the piles will be fairly homogenous and the visual portions will be representative of the entire pile. The processing also ensures that unexpressed planes of weakness will be rare or absent in this material.

The geologist will inspect the stockpiles of this material prior to loading for transport to the project site. The inspection will focus on ensuring that there is not a significant amount of country rock in that portion of the stockpile to be used. Because the quarry is careful to not include country rock in the diabase quarrying and the stockpiles consist of material that comes from multiple blasts, the likelihood of there being significant country rock in the stockpiles is low.

The geologist will also observe the loading of the rock into the trucks from a safe distance. If the geologist observes significant country rock to be present, he will notify the loading operator to stop. The geologist will inspect the stockpile and, if unacceptable, have the truck emptied and reloaded. If appropriate, the geologist may instruct the operator to load from a different area of the stockpile.

We trust that these procedures will meet with the NRC's concurrence.

Yours truly,

Steffan R. Helbig

Steffan R. Helbig, P.G.

Attachments

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# TABLE 1
# SUMMARY OF DYER QUARRY DIABASE TEST RESULTS
# and NUREG-1623 ROCK QUALITY SCORE

## HISTORICAL TEST RESULTS

| DATE | TESTED BY | L/A ABRASION % | SODIUM SULFATE % | SPECIFIC GRAVITY | ABSORPTION % |
|---|---|---|---|---|---|
| 6/28/1996 | Maryland SHA | 15 | 0.3 | 2.92 | 1 |
| 6/25/1998 | Maryland SHA | 15 | 0.3 | 2.93 | 0.8 |
| 8/20/2004 | Penn DOT | 13.71 | 0.25 | 2.95 | 0.58 |
| 4/27/2005 | Maryland SHA | 17 | 0.2 | 2.99 | 0.9 |
| 4/7/2006 | Maryland SHA | 16 | 0.2 | 2.95 | 0.06 |
| 6/9/2006 | Penn DOT | 16.35 | | 2.97 | 0.56 |
| 5/1/2007 | Agg. Soils and Testing | 17.7 | | | |
| 5/1/2007 | Agg. Soils and Testing | 17.7 | | | |
| 5/1/2007 | Agg. Soils and Testing | 15.8 | | | |
| 5/3/2007 | Agg. Soils and Testing | | 0.7 | | |
| 5/3/2007 | Agg. Soils and Testing | | 0.5 | | |
| 5/7/2007 | Agg. Soils and Testing | | 0.5 | | |
| 2005 | Cabot | 17 | 1.95 | 2.97 | 0.4 |
| 2005 | Cabot | 12.8 | 0.18 | 3 | 0.22 |
| | MEAN | 15.82 | 0.51 | 2.96 | 0.57 |
| | STANDARD DEVIATION | 1.51 | 0.51 | 0.03 | 0.31 |
| | MEAN + or - 2 Std. Dev. | 18.84 | 1.52 | 2.91 | 1.18 |

## ROCK QUALITY SCORE FOR RESULTS TWO STANDARD DEVIATIONS FROM MEAN

| Laboratory Test | Weighting Factor Igneous | Mean Test Result + or - Two Standard Deviations | NUREG 1623 Table F-2 Score | NUREG 1623 Table F-2 Maximum | Weighted Score Total | Weighted Score Maximum |
|---|---|---|---|---|---|---|
| Sp. Gravity | 9.0 | 2.9 | 10.0 | 10.0 | 90.0 | 90 |
| Absorption (%) | 2.0 | 1.2 | 4.5 | 10.0 | 9.0 | 20 |
| Sodium Sulfate (%) | 11.0 | 1.5 | 10.0 | 10.0 | 110.0 | 110 |
| L/A Abrasion (%) | 1.0 | 18.8 | 2.5 | 10.0 | 2.5 | 10 |
| TOTAL | | | | | 211.5 | 230.0 |
| Percentage | | | | | | **92.0%** |


SCALE FEET

0 600 1,200

NORTH

SOURCE: Dyer Quarry Existing Conditions, August 2007
McCarthy Engineering

# FIGURE 1
## DYER QUARRY TOPOGRAPHIC MAP

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