Chapter 21 Materials Source Investigation and Report

21.1 Overview

A geotechnical site investigation of WSDOT-owned or -leased materials sources is required in order to determine the quality and quantity of materials available for WSDOT construction projects. These materials include gravel base, crushed surfacing materials, mineral and concrete aggregates, riprap, borrow excavation and gravel borrow, and filler. A Material Source Report (MSR) provides geotechnical documentation of the reconnaissance, exploration, sampling, laboratory testing, and development of the mining plan for the pit site or quarry site. This report includes a legal description of the location of the site and indicates the potential aggregate reserves for the material source. The Material Source Report requires the stamp of a licensed Engineering Geologist. The report is valid for the life of the material source.

Amendments to the MSR provide updates of any changes to the original Material Source Report, such as additional phases of exploration drilling, sampling and testing, mining development, extension of existing property boundaries of the material source, or changes with Department of Natural Resources reclamation permits or any other regulatory permits issued, etc. After a material source is used for project construction, a Pit Evaluation Report form is completed by the Project Engineer and submitted to the Regional Materials Engineer for review. The Pit Evaluation Report form is used to identify the quantity of material removed from the source, and includes comments about the production of the aggregate material extracted from the source for the project construction. This form contains valuable information on the use and production of material from the source.

Any new potential materials source sites considered need to be large enough in acreage to meet the quantity and quality requirements of the immediate construction project with adequate work and storage areas, but also the future construction project needs. It is also desirable that the source has sufficient material to support future maintenance needs in the area. When developing materials source sites, reclamation requirements and aesthetic considerations must be evaluated, to preserve or enhance the visual quality of the highway and local surroundings. This is especially important along scenic highways and adjacent to residential developments. Exposed sites, such as hillside borrow that cannot be visually reclaimed, should not be considered for development as a material source.

21.2 Material Source Geotechnical Investigation

It is preferred that existing approved material sources be used when there are suitable sites available within a reasonable haul distance to the project. When there are no approved WSDOT material sources available, the Regional Materials Engineer requests that the HQ Geotechnical Division conduct a materials source investigation. The materials source investigation typically consists of the following elements:

(a) **Evaluation of Existing Material Source Sites** – Any existing material source data within the project area are collected and reviewed. In project areas where materials sites are presently located, data that should be reviewed includes:

- Site Geology, from existing mapping, reports, etc.
- Aerial photographs, LIDAR coverage
- Past quality testing and production history of the materials source sites
- Surface and subsurface drainage in the site area
- Seasonal fluctuations in the water table, including water wells located on adjacent land that might be affected by those fluctuations, or moisture content of the deposit
- Claims made by adjacent landowners
- Contractor claims, including final settlements
- Maintenance use of the site

(b) **Geologic Field Exploration** – The geologic field exploration phase of the site investigation includes a reconnaissance level review of the material source site to begin the process of developing an understanding of the specific geology at the site, and how the site will be mined with consideration for existing adjacent land use (see Chapter 2). The reconnaissance incorporates the detailed review of the published geologic maps for the area or other published geologic or geophysical information in the vicinity, as well as LIDAR and aerial photographs. The reconnaissance phase review includes mapping existing outcrops and developing the strategy for the exploration drilling and sampling program, and the mine development of the site. During the initial reconnaissance to determine whether a site merits detailed exploration, some specific elements considered include:

- Topography
- Geology
- Test pits
- Test probes
- Test holes
- Representative photographs of the site
- Geologic mapping of existing exposures

Typically, a minimum of three test pits or test holes should be advanced during this phase of investigation. The site investigation should be planned and conducted in accordance with Chapters 2 and 3. The logging of the test pits and test holes should be in accordance with Chapter 4. To minimize exploration costs representative samples can be collected from existing cut faces for quality testing that includes Specific Gravity, Los Angeles Abrasion, and Degradation. A reconnaissance geologic report should be completed describing the site geology, preliminary field exploration and testing results. This report should be transmitted to the Regional Materials Engineer.

(c) **Detailed Site Exploration** – At a request by the Regional Materials Engineer, a detailed site exploration is conducted by the WSDOT Geotechnical Division. The Engineering Geologist submits an exploration plan to the Chief Engineering Geologist for review and concurrence prior to exploration. The test pits and test holes are logged in accordance with Chapter 4. The Engineering Geologist selects representative samples for quality testing. Refer to the *Construction Manual* Chapter 9, for additional discussion about sampling of natural deposits. On the basis of geologic considerations, the number, location, depth, and type of test pits or test borings are determined. In the absence of geological examination, the test pits or test borings are spaced roughly every 150 to 200 feet, on a grid, and extend to the base of the deposit, or to the depth required to provide the needed quantities. A significantly greater spacing (up to 500 feet) is used for nonexclusive leased sites or short-term leases that WSDOT has with other agencies.

For pit site investigations, exploration equipment that allows direct observation and sampling of the subsurface layers is preferred. The equipment can consist of backhoes, bulldozers, large diameter augers, or the Becker Hammer reverse circulation drilling method. Groundwater levels should be recorded during the site investigation. Where significant seasonal groundwater fluctuation is anticipated, observation wells should be installed to monitor water levels.

For quarry site investigations, wet rotary rock coring methods are used to determine subsurface conditions and to obtain samples for testing. Triple-tube core barrels are commonly needed to maximize core recovery. For riprap sources, fracture mapping includes careful measurement of the spacing of fractures to assess rock block sizes that can be produced by blasting. Also, identification of the type and amount of joint infilling is noted. Core samples are reviewed by the Engineering Geologist for assessment for quality testing for riprap or aggregates. If assessment is made on the basis of an existing quarry site face, it may be necessary to core or use geophysical techniques to verify that the nature of the rock does not change behind the face, or at depth.

Geophysical methods employed for material source exploration include seismic refraction surveys, electrical resistivity surveys, and ground penetrating radar. Downhole techniques can also be utilized to identify fracture orientation and condition; and software is available to interpret the fracture orientation in the core. For electrical resistivity surveys typically poor quality rock is denoted with low resistivity and good quality rock is denoted with high resistivity. Faults and fault splays can also be identified using electrical resistivity. Results from these geophysical methods supplies information that is used in developing the mining plan for a material source.

(d) **Special Considerations** – The Engineering Geologist must determine the appropriate shrink/swell factors (see Table 10-1) to convert the needed cubic yards to yards in place (bank yards) at the proposed source. This does not address or account for losses or wastage on construction.

The Engineering Geologist must assess the “indicated” quantity of material that is available in the potential material source. The Engineering Geologist uses knowledge of the mode of occurrence of the deposit in conjunction with the test pits and test borings to determine the surface plane area of the usable material.

The quantity of material reported as "indicated" is defined to mean that quantity of material estimated as being present at the site, including a safety factor. Extrapolation beneath the depth of test borings will not be made for calculation of "indicated" quantities unless well supported by geologic considerations.

A general formula for calculation of "indicated" quantity is:

$$Q = \frac{(LWD) - Cbs}{SF}$$

Where Q is the quantity in cubic yards, L is length in feet, W is width in feet, D is depth in feet, Cbs is the back slope correction, and SF is a safety factor. The back slope correction (Cbs) depends on the slope specified in the reclamation plan or mining plan. ***[Notes: Cbs = ½ (base × height) + perimeter (ft^2). To convert cubic feet to cubic yards, divide cubic feet by 27.]***

The safety factor (SF) used will vary with the size and type of deposit, the history of other deposits in the area, and the exploration equipment used. In order to determine the SF, calculate the quantity (Q) available without a SF and apply the appropriate SF from the following table.

Bank Yards Available Without Safety Factor	Suggested Safety Factor
0 to 30,000 cubic yards	2.00
30,000 to 60,000 cubic yards	1.70
60,000 to 150,000 cubic yards	1.45
150,000 to 300,000 cubic yards	1.35
300,000 plus cubic yards	1.25

Other considerations are: (1) Determine the surface drainage at the site, noting areas of ponding water, swamps, sloughs, or streams. It is important to determine flooding possibilities or surface flow after periods of heavy rainfall, during spring snow melt, and from artesian conditions. (2) Describe the location of the groundwater table, if known, along with seasonal variations. Identify any springs in the area that will affect the development of the site, or if production operations can impact the water source. (3) For aggregate sources, it is important that the degradation and wear characteristics be determined. The history of use of the aggregate is especially important for aggregates with Los Angeles Wear test values greater than 25 and Degradation test values less than 45. (4) An estimate of oversize material (greater than 10 inches in diameter) determined in percent by volume is necessary. The estimate is given in a percent range, such as, 15 to 25 percent oversize. Also describe the largest size cobble or boulder observed during the site investigation, as well as any glacial erratics.

21.3 Materials Source Report

The Engineering Geologist prepares a Materials Source Report (MSR), following the outline presented below. The MSR provides documentation for the detailed site exploration, sampling and laboratory testing, and subsequent development of a pit or quarry site. The report reviews and discusses the site geology, exploration field data and testing information, slope stability, and groundwater information that has been acquired for the site, and indicates the mining plan for development of the site.

(a) **Introduction** – A brief description of the location of the site including county, state highway, milepost, and haul road access to the site.

(b) **Source Description** – The source description includes the legal description of the property location (e.g., Township, Range, Section, ¼ ¼ sections). The description also includes the size of the material source in acres. Ownership is identified and any pertinent lease information (e.g., leased to WSDOT for exclusive use, or nonexclusive use). Also, any zoning restriction, or other restrictions or constraints are identified. Stockpiles and waste piles are identified on the site plan map with estimated cubic yards (volume).

(c) **Topography, Vegetation and Climate** – The general geomorphology and topography of the area are described, including drainage features. Vegetation and climate should also be discussed.

(d) **Geotechnical Field Exploration** – For quarry site investigations, the number and location of exploratory borings advanced, and drilling methodology should be described (e.g., core drilling with a CME 850 with auto hammer using an HQ core barrel; retrieving a 1/2 inch diameter core sample). The total footage of core retrieved should be identified. For pit site investigations, the number and location of test pits, or Becker Hammer borings advanced should be identified. The test pits and test borehole locations are presented on a site map included in an Appendix. Copies of the boring logs and test pit logs are contained in an Appendix. Color photographs of the rock core or pit samples are included in an Appendix.

(e) **Laboratory Testing** – Representative samples are selected by the engineering geologist from the subsurface exploration drilling for laboratory testing for quality and to verify field visual identification. The preliminary laboratory quality tests include T-85 for Specific Gravity, T-96 for Los Angeles Wear, and WSDOT test method T-113 for degradation. The test results are used to interpret the distribution of the good quality and the poor quality material at the site. The test results are depicted on the geologic cross-sections and included in a table in the Appendix. Other tests may be performed according to the Standard Specifications Manual for specific products to be used in the construction project.

(f) **Regional Geology** – The regional geologic setting includes a description of the processes that occurred for the existing regional geology.

(g) **Site Geology** – Based on the regional geologic setting, the specific geology at the material source site should be described. Surface drainage should be identified and described, including the identification of springs or drainages that are natural or manmade. The depth to ground water and any seasonal changes should be described and discussed. This information should be included as a table in the Appendix. Natural or designed slope stability at the site should be described and discussed.

A stratigraphy for the material source is developed from the site geology, and from the test borings and test pits logs. Geologic cross-sections are developed to demonstrate the distribution and quality of material available at the site. Overburden and waste material encountered in the borings, quality test results, and groundwater should be identified on the geologic cross-sections. Included in the discussion of the stratigraphy should be a description of good and poor quality rock, as identified on each cross-section, and a summary paragraph for each cross-section.

(h) **Groundwater** – Ground water levels encountered during the subsurface investigation are recorded. Where significant seasonal groundwater fluctuation is anticipated, open standpipe piezometers are installed to monitor ground water levels. If appropriate, dataloggers may be installed in the open standpipe piezometers to monitor groundwater fluctuation. Rainfall gauges, or local weather stations can be utilized to gain information about local rainfall events and their effect on groundwater at the source.

(i) **Quality of Material** – The quality of the material at the site is based on the representative samples selected for laboratory testing for quality. The quality tests are typically Los Angeles Wear, Specific Gravity and Degradation, but can include other tests depending on the product to be produced from the material source site. The test results should be presented on the geologic cross-sections as well as in a table in the Appendix.

(j) **Quantity of Material** – The quantity of useable material present at the site is based on the occurrence of the deposit in conjunction with the test pits or borings to the determined depth to a surface plane over a certain area. The quantity of material reported as “indicated” is defined to mean the quantity of material estimated as being present including a safety factor.

(k) **Slope Stability** – Slope stability analyses should be completed to indicate the stability of the slopes of the material source during mining development, and for reclamation.

(l) **Mining Considerations** – The mining plan indicates how the resource will be developed and demonstrates the logic for the excavation and development of the site. The mining plan for the site should indicate which part of the site is to be mined first, second, third, etc. A discussion of any special problems associated with the material present at the site, such as a description of oversize material, including large rock encountered, or excessive overburden. The waste areas for overburden and stripping material should be identified on the mining plan map. The location of haul roads, gates, fences, and the elevation of the mining floor should be included in the mining plan map. Slope angles, based on slope stability analyses, should be designated for interim and final reclamation. For quarry sites, slopes should be designed, based on the rock parameters mapped, and identified specifically at the quarry. Locations of haul road, stockpile storage, waste, overburden and elevation of the pit or quarry floor should be identified on the reclamation plan map.

(j) **Appendices**

- Figures:

  Location MapSite Plan map, with topography, boring and cross section locations Geologic Cross Sections, with boring locations and quality test results Mining Plan Reclamation Plan
- Tables:

  Boreholes identified with depths and laboratory quality testing results

  Boreholes with Groundwater elevations
- Logs of Test Borings (edited for consistency with lab data)
- Laboratory Test Reports
- Calculations of Quantity Determinations
- Photographs of the site, photos of rock core samples, pit samples