	NEW YORK STATE DEPARTMENT OF TRANSPORTATION MATERIALS BUREAU	ALBANY, NY 12232	Materials Method No.: NY 29
	MATERIALS METHOD		Issue Date: July 2007 Subject Code: 7.42-1
SUBJECT: AGGREGATE SOURCE ACCEPTANCE PROCEDURE			
APPROVED: /s/ John E. Rondinaro John E. Rondinaro, PE, Director, Materials Engineering Bureau			Supersedes: MM 29 Dated: October 2000

PREFACE

The procedures discussed in this Materials Method have been developed by NYSDOT over the course of decades. While some aspects of aggregate acceptance have been well documented, such as test methods and Geological Source Report requirements, others have been promulgated by past practice without being formally codified. This document explains the framework the Department uses to approve, monitor, reject, and evaluate aggregates in situ, in process, and in service.

Aggregate acceptance encompasses two basic requirements: 1) meeting the physical test and petrographic requirements of the Standard Specifications, 2) having a currently accepted Geological Source Report. A letter, showing aggregate source approval status and any limitations on that approval, is issued when a source has met the two basic requirements. This letter shows the limitations to the approval status that are contained in the Approved List of Sources of Fine and Coarse Aggregates. An aggregate source must meet these requirements to have approved status and to be published in the Approved List of Sources of Fine and Coarse Aggregates. Currently, the Approved List is published electronically and can be accessed on the internet (www.DOT.NY.gov) click on "Business Center/ Publications & Guidance". The list is updated regularly but, because change to a source's approval status predates change to the published Approved List, current status should be confirmed with the Materials Bureau or with the Regional Materials Engineer.

The Department began testing aggregates more than a century ago and for many years it was on the basis of these tests that aggregates were accepted. In the early 1930s, the Department was using sulfate soundness testing and abrasion resistance with the Deval machine. In the mid-1950s the freeze - thaw test was added and during the 1960s the Los Angeles Abrasion test gradually replaced the Deval.

The first Geological Source Reports were required of crushed stone operations in 1961 and, between 1972 and 1975, sand and gravel operations were phased in. Specifications for friction

aggregates were developed by the Department in the mid to late 1960s and formally introduced in 1968. Acid insoluble residue content and copper nitrate staining methods were introduced to aid in the evaluation of carbonate aggregates with respect to their frictional qualities.

Since 2000, when MM29 was created, operations plans were added to the geological source report requirements. In 2003, friction coarse aggregate requirements for portland cement concrete were introduced and acid insoluble residue is now used to monitor carbonate crushed stone friction aggregate, including particles of chert.

Throughout, the Department has sought to improve its aggregate procedures to reflect accepted methods and current research.

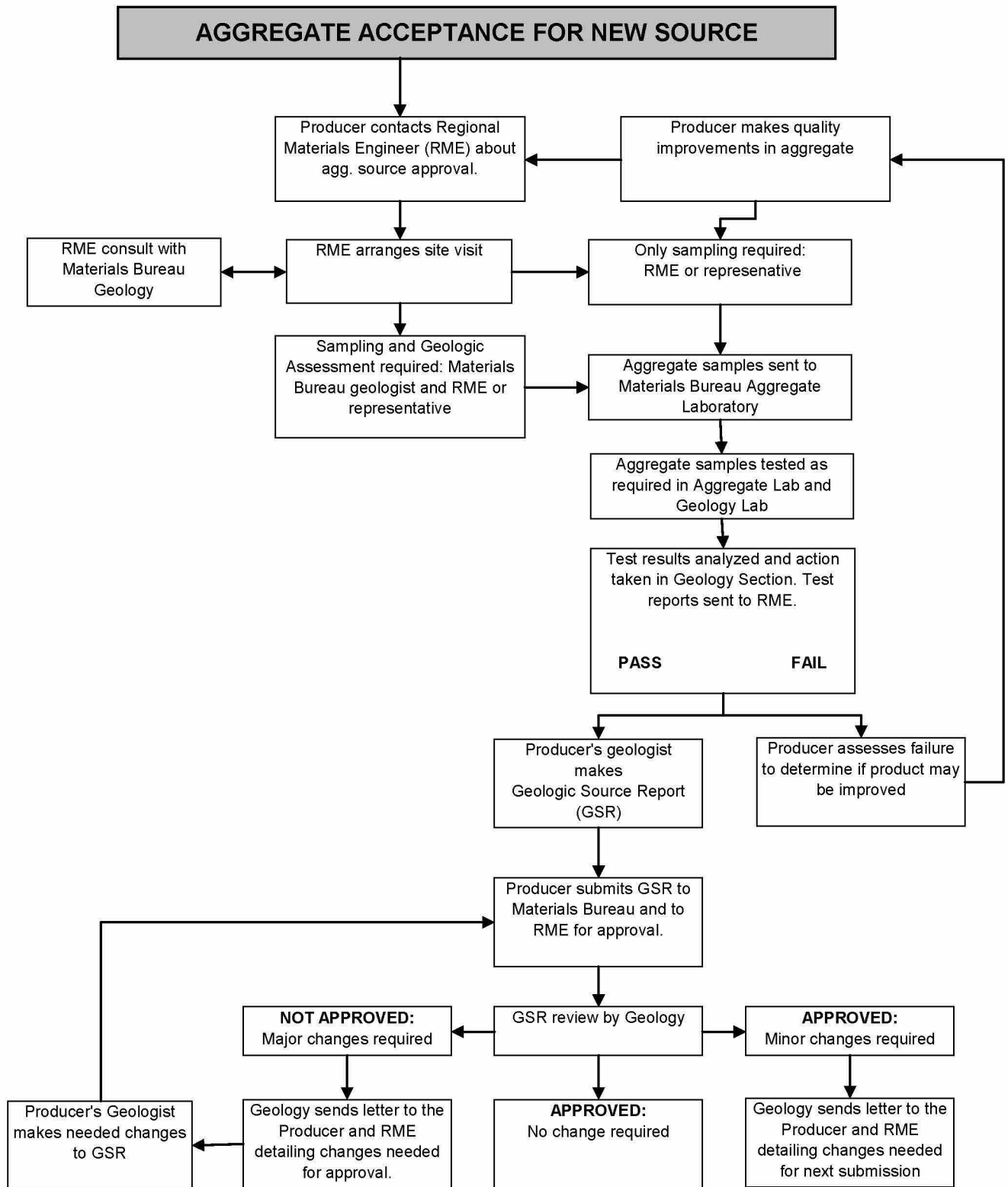


TABLE OF CONTENTS

I. Preface	Error! Bookmark not defined.
II. Table of Contents	4
III. Geological Source Reports.....	5
A. Geological Source Report Requirements.....	5
B. Administrative Protocols	5
IV. Aggregate Tests.....	8
A. Test Methods (see Appendix C for NYSDOT test methods).....	8
B. Administrative protocols	13
V. Performance Evaluation.....	15
A. Durability performance evaluation	16
B. Pavement friction performance evaluation.....	16
C. Alkali-aggregate reactivity evaluation	16
VI. Aggregate Source Monitoring	16
A. Biennial sampling and testing.....	18
B. Plant samples	19
C. Special samples.....	19
D. Field inspection.....	19
VII. Problem Resolution.....	19
A. Protocol for dealing with non-specification aggregate in a project.....	19
B. Protocol for performance problem resolution.....	20
C. Protocol for dealing with variable sources	21
VIII. Change in Aggregate Source Approval Status	22
A. Reasons for change.....	22
B. Review of proposed change	23
C. Determination of the extent of the proposed change	23
D. Procedure for maintaining aggregate source approval.....	24
E. Procedure on reactivating an aggregate source whose approval has lapsed.....	25
 APPENDICES	
APPENDIX A Source Report Requirements	28
APPENDIX B Modified Source Report Requirements for Long Island and Southern New Jersey	58
APPENDIX C - 1 NYSDOT Aggregate Test Methods	69
APPENDIX C - 2 703-06P,G	74
APPENDIX C - 3 703-07P,G	81
APPENDIX C - 4 703-08P,G	87
APPENDIX D Due Dates and Action Times	93
APPENDIX E GSR Cyclic Submissions Schedule.....	95
APPENDIX F Blending Aggregates to meet Friction or quality Requirements.....	97

III. Geological Source Reports

A. Geological Source Report Requirements

Each approved aggregate source must have a currently accepted Geological Source Report. Appendix A contains the Geological Source Report Requirements. The requirements apply to crushed stone aggregates (including lightweight aggregates) and to sand & gravel operations (including slag). Geological Source Reports are modular in layout, containing three levels of report information based on how frequently it requires revision.

1. *Modular Layout*

The Geological Source Report will be submitted in a loose leaf binder so that those components that need updating may be removed and replaced with current information. A single report will be kept on file in the Materials Bureau Geology Section and another with the Regional Materials Engineer.

2. *Three Levels of Report Information*

Active aggregate sources are dynamic and some of the information presented in the Geological Source Report changes from time to time. New information that pertains to the operation of an aggregate source must be provided to keep the report current. The frequency with which various parts of an operation change varies. This fact is acknowledged by dividing the required report updating into three levels: static, cyclic, and annual.

- a. Static - Information that does not change, including the location map, geology, drilling, petrographic information, and information that may not change for the life of the mine.
- b. Cyclic - Information that is continuously changing, including the source map, geologic cross sections, plant flow and photographs.
- c. Annual - The Operations Plan must be submitted annually and includes information that addresses aggregate quality monitoring both in the mine and in the processing plant.

B. Administrative Protocols

1. *Deadline for Submission of Geological Source Reports (GSR)* (see also Appendix D)

Geological Source Report information must be submitted to the Department by February 1st of the year of record. Operations Plans must be submitted annually. Cyclically updated information must be submitted every 4 years for crushed stone

operations and every 2 years for sand & gravel operations (see Appendix E for details). Whenever a significant change to the operation occurs, either operationally or geologically, or additional information is developed (petrographic analyses, core logs, etc.) it must be documented with revisions to the cyclic and annual modules. Reminder letters may or may not be issued by the Regional Materials Engineer, but failure to do so does not alter the deadline. Extensions to the deadline may be granted upon application to the Director, Materials Bureau and such application must be confirmed in writing. If there has been no verbal or written application for extension by February 1st, the source may be removed from the *Approved List of Sources of Fine and Coarse Aggregates*.

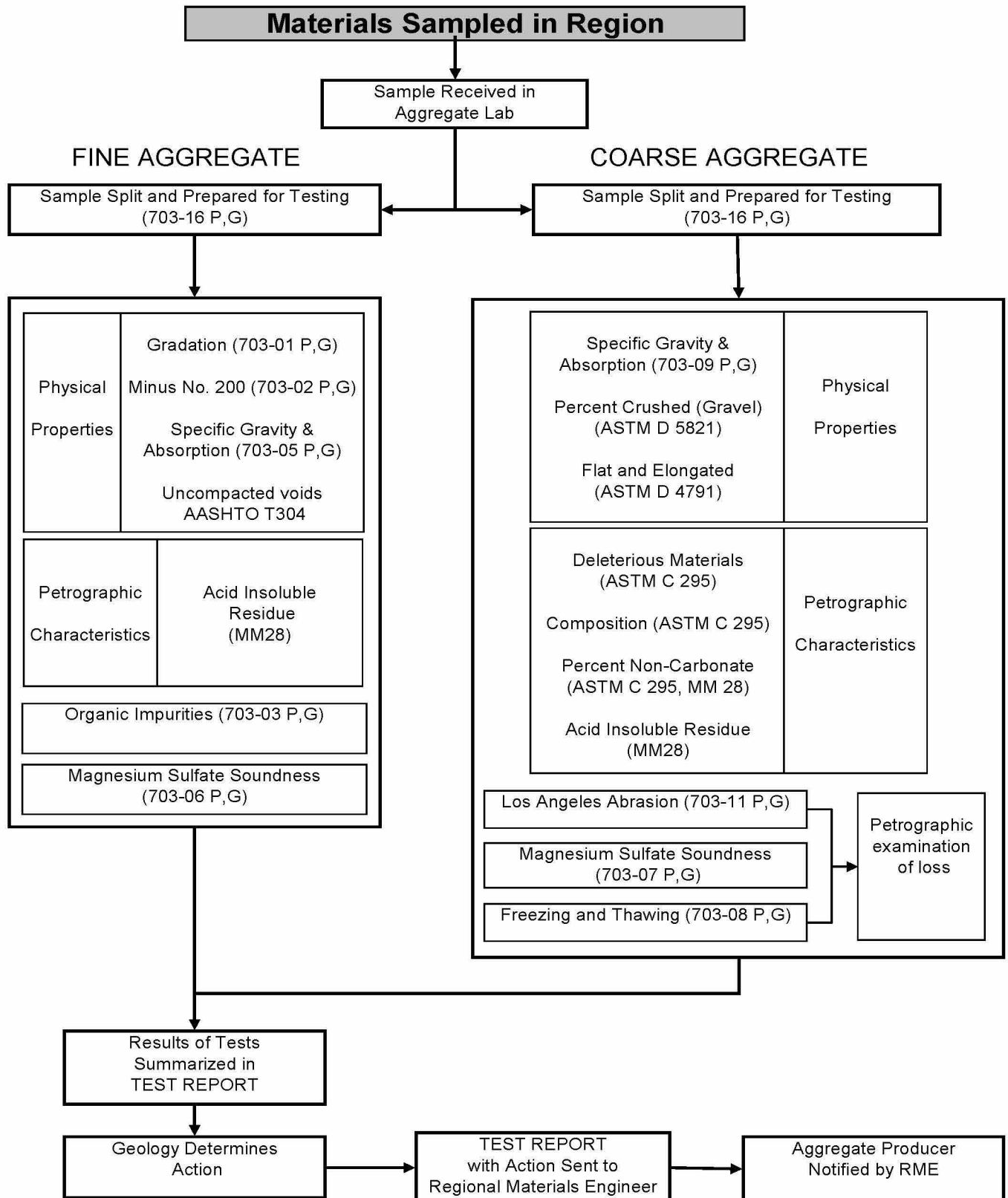
One copy of each submission must be sent to the Materials Bureau Geology Section at 50 Wolf Road, Mail Pod 3-4, Albany, NY 12232. In addition, one copy must be sent to the Regional Materials Engineer in the region governing the source. See the *Approved List of Sources of Fine and Coarse Aggregates* for addresses of each regional office.

2. *Timetable for response by the Materials Bureau Geology Section* (see also Appendix D)

Within 60 days from the date Geological Source Report information is received in Albany, verbal or written notification will be made to the producer and the geologist, with a copy to the Regional Materials Engineer, of the need for revisions to the information submitted. Verbal notification will be followed by written confirmation. If such notification is not made, it may be assumed that any required revisions are to be made to future submissions and will not affect the approval of the information under review. Required revisions will be detailed in a letter and must be submitted to the Regional Materials Engineer and the Director, Materials Bureau, within 60 days of the postmarked letter. Extensions to the deadline may be granted upon application to the Director, Materials Bureau and such application must be confirmed in writing. If there has been no verbal or written response by the deadline, the source may lose its approved status and, as a result, be removed from the *Approved List of Sources of Fine and Coarse Aggregates*. Currently approved aggregate sources will be maintained on the *Approved List of Sources of Fine and Coarse Aggregates* throughout the review process.

3. *Protocol of Review of Geological Source Report Information*

GSR information may be reviewed in the office or may involve field inspection. Field inspection is generally indicated for a source that has never been approved, has been inactive for a period of time and was previously approved, or appears to have changed in some significant way. Field inspection may be made at the discretion of the Director, Materials Bureau.



IV. Aggregate Tests

The Department employs various tests to characterize and evaluate aggregates. Most of these tests follow methods prescribed by AASHTO or ASTM and two are methods developed by NYSDOT.

A. Test Methods (see Appendix C for NYSDOT test methods)

1. *Destructive tests*

Destructive tests are designed to indicate an aggregate's ability to physically withstand the highway environment. The results are also used to demonstrate an aggregate's uniformity over time.

- a. Magnesium sulfate soundness test (703-06 P,G and 703-07 P,G: Appendix C) - NYSDOT began using sulfate testing in the early 1930s and for nearly 35 years used both sodium and magnesium sulfate test solutions. In 1965 it was decided to eliminate sodium sulfate testing due to its greater variability. This finding has been confirmed by ASTM.

Traditionally, coarse aggregate was tested using a ten-cycle test and fine aggregate was tested using a five-cycle test. During 1966 and part of 1967, nearly all biennial test samples of coarse aggregate were tested using both five and ten cycles. It was found that, overall, there was poor correlation between the results after five cycles and the results after ten cycles. It was decided to continue using the ten-cycle test because there was a useful historical database and because the ten-cycle test is harsher. The advantage of a harsh test is that the range of probable test results is wider, facilitating the discrimination between aggregates of different quality.

Research conducted by the Department on the magnesium sulfate soundness test resulted in a test method that is more stringent in its particulars than those adopted by either AASHTO or ASTM. NYSDOT requires stainless steel sample containers of very specific construction, uses standard test sample gradations, larger sample size (coarse aggregate), and has a tighter tolerance on the specific gravity range for the magnesium sulfate solution.

- b. Freeze - thaw test (703-08 P,G: Appendix C) - NYSDOT has been using a freeze - thaw test since 1953. Since then, research has guided its evolution into a test method that differs significantly from AASHTO and ASTM test methods. Research specifically addressed issues of rapid cycling (more than one cycle per day), brine (yes or no) and brine concentration (10% vs 3%), sample immersion

during freezing (yes or no), and sample container construction (rigid vs flexible). The current NYSDOT test method was adopted in 1992 and requires one cycle per day of freezing of the sample immersed in 3% NaCl brine, all contained within a semi-flexible 6" cylinder mold.

- c. Los Angeles Abrasion test (703-11 P,G: follows AASHTO T 96 and ASTM C 131) - This test has the advantages of ease and repeatability and is generally used as supporting data. NYSDOT railroad ballast designations (NY 1, 2, 3 and 4) are based on Los Angeles Abrasion test results as well as on rock type and absorption and excludes gravel. The classifications align with requirements issued by CSX Transportation, American Railway Engineering and Maintenance-of-Way Association (AREMA), and other rail systems operating within New York.

2. *Particle shape determinations*

Aggregate particle shape characteristics are tested for their relationship to systems properties. Asphalt rut resistance and portland cement concrete workability are among the systems properties strongly associated with particle shape. In hot mix asphalt, particle shape requirements are linked to the pavement's traffic level (see MM 5.16).

- a. Percent crushed - NYSDOT uses ASTM D 5821. This replaces the determination based on the definition of a crushed particle that was in the Standard Specifications.
- b. Flat and elongate determination - NYSDOT uses ASTM D 4791. This replaces the determination of flat plus the determination of elongate, as described in ASTM D 4791.
- c. Uncompacted voids content - NYSDOT uses AASHTO T 304, Method A, often referred to as Fine Aggregate Angularity (FAA).

3. *Petrographic determinations*

Petrographic analysis, based on ASTM C 295 and the definitions in ASTM C 294, is used by the Materials Bureau Engineering Geology Section to make several determinations that affect the acceptance and use of an aggregate. Petrographic examination plays a supportive role when applied to the interpretation of the results of other aggregate tests. Petrographic analysis is also used to verify that the sample is from the correct source or strata and changes have not occurred at the source that may impact the quality of the aggregate.

- a. Deleterious Materials determination - Aggregate samples are routinely examined

for the presence of various materials known to cause distress. Table 703-3 of the Standard Specification pertains to deleterious materials and their maximum allowable limits.

- b. Friction aggregate determination - Aggregate samples are routinely examined for compliance with friction aggregate requirements. ***Friction Aggregate Control and Test Procedures*** (MM 28) provides the details of the tests used to determine compliance. The requirements depend on the rock type and the specification requirements of the contract. Carbonate aggregates and fine aggregates are digested for their insoluble residue content or may be examined for their noncarbonate particle content.
 1. Rock type determination (ASTM C 295) - In terms of friction aggregate, this is very basic. Non-carbonate rock types are accepted as friction aggregates on that basis alone. Carbonate aggregates and blends of carbonate and noncarbonate aggregates require more testing.
 2. Percent noncarbonate determination - In blends of carbonate and noncarbonate particles, friction aggregate specifications require a minimum percentage of noncarbonate particles. The identification of noncarbonate materials is included in ASTM C 295. In addition, test methods that may be used to help make this determination are in MM28.
 3. Acid insoluble residue (AIR) content (in MM28) - This test applies only to carbonate rocks and fine aggregates, and is used to determine the amount of sand-sized residue (plus No. 200 sieve) that it contains. The test method is in MM28.
- c. Alkali-Silica Reactivity (ASR) potential is important for aggregate used in portland cement concrete. Silica reacts chemically with the alkalis in the cement to produce silica gel. The gel may have a deleterious affect on concrete by filling the protective void system or by causing expansion. NYSDOT addresses ASR potential by identifying aggregate constituents known to have ASR potential. These include chert, certain carbonate rocks with high AIR, crypto-crystalline quartz, opal, and certain strained quartz. Potentially reactive aggregates are identified as such in the ***Approved List of Sources of Fine & Coarse Aggregates***. They shall not be used with cement having an alkali content in excess of 0.70% unless there has been partial replacement of the high alkali cement with an approved pozzolin.

Potential reactivity is determined by the Department in two ways: petrographic analysis (ASTM C 295) and mortar bar testing (ASTM C227). Petrographic analysis is used routinely to screen aggregates based on the presence of

components known to be reactive. Mortar bar testing is time-consuming (1 year) and is rarely done. The following table indicates the petrographic limits used by the Department:

	Carbonate Rocks	Chert
Crushed Stone & Manufactured Stone Sand	% AIR ¹ >20%	≥5%
Gravel	N/A	≥5%
Sand	N/A	≥5% in the +No. 30

1. Limestones and dolomites with %AIR >20% (acid insoluble residue content, MM28) are tested using ASTM C 227 (Mortar Bar). Thereafter, strata determined to have ASR potential are flagged as having ASR potential (X-rated) based on %AIR tests.

The limit of 20% AIR is based on the results of Department mortar bar testing. The 5% chert limit is also based on Department mortar bar testing as well as on a report by Bryant Mather (1975).

The 5% chert limit is applied to petrographic analyses in the following manner.

Fine aggregate:

Processed sand petrographic analyses supplied to the Department in the Geological Source Report are evaluated by weighting the chert percentages reported on the + No. 30 sizes. If that weighted average is greater than or equal to 5%, the restriction is applied.

Coarse aggregate:

Unprocessed gravel petrographic analyses supplied to the Department in the Geological Source Report are evaluated by determining the chert percentages reported on each size analyzed. If any one size has greater than 5% chert, the gravel is considered to have ASR potential and is restricted. If there is a history of plant samples having an average percent chert greater than or equal to 5%, the restriction is applied.

- d. Alkali-Carbonate Reactivity (ACR) potential - As with ASR, ACR is important for aggregates used in portland cement concrete. Cement alkalis react chemically with some carbonate rocks (typically that have textures in which large dolomite rhombs exist within a micritic matrix). The reaction results in expansion and cracking. Aggregate producing strata having ACR potential are usually identified through performance. Confirmation of alkali-carbonate reactivity potential in an aggregate is done using concrete prism testing according to CSA A23.2-14A, a Canadian Standards Association test method.

Aggregates identified as having ACR potential are restricted from use in portland

cement concrete. Alkali-carbonate reaction proceeds with even small amounts of cement alkali and there is no accepted protocol for mitigating ACR. This restriction appears in the *Approved List of Sources of Fine & Coarse Aggregates*.

- e. Examination of non-traditional aggregates - These include altered rock materials (lightweight aggregate, slag) and recycled materials (recycled asphalt pavement (RAP), incinerator ash, glass, pelletized municipal waste, and natural aggregates recovered from landfills). In general, the examination is done according to ASTM C 295, with due consideration given to possible chemical reactions and incompatibilities as well as particle shape characteristics and deleterious substances.
4. *Special Tests for traditional and non-traditional aggregates*

Atypical applications of traditional aggregates and the compositional and physical peculiarities of non-traditional aggregates pose special evaluation problems. Potential hazards associated with handling some materials must be considered before testing begins. It is also important to learn as much as possible about atypical applications and about non-traditional materials, so that a testing program may be designed that will properly address potential usage. A thorough evaluation may involve the Geotechnical Engineering Bureau, the Environmental Analysis Bureau, and the Transportation Research & Development Bureau, as well as others.

B. Administrative protocols

1. *Procedures for sampling and testing new aggregate sources*

Potential sources that have never been accepted by NYSDOT for aggregates may be either existing mines or deposits (including bedrock ledges) that have never been developed. The Materials Bureau will test only processed (finished product) aggregates sampled by representatives of the Department who have observed the aggregate being processed.

- a. Producer's actions - The producer must arrange for the excavation of material representative of the potential source, as it is intended to be operated. A minimum of 30 tons of raw material must then be transported to a plant for processing into aggregate for sampling and testing. Prior to the initiation of this process, the producer must contact the Regional Materials Engineer. If the producer is uncertain of which NYSDOT region has jurisdiction, that information may be obtained from the Geology Section at (518) 457-1038.
- b. NYSDOT's actions - Representatives of the Department must be present for the

excavation, transportation, and processing of material from the potential source. In addition, these representatives will take samples of the processed aggregate for testing in the Materials Bureau Aggregate Laboratory in Albany.

- c. Test results - The producer may obtain the results of all physical and petrographic tests on a Test Report marked “meets specifications” or “does not meet specifications”. The producer may also wish to consult with the Geology Section at (518) 457-1038. Aggregates that meet specification requirements may be approved upon receipt of, and acceptance of, a Geological Source Report and Operations Plan (see section III, Geological Source Reports). At that time, a Source Approval Letter will be sent to the aggregate producer and to the Regional Materials Engineer and the source will be placed on the ***Approved List of Sources of Fine & Coarse Aggregates***. The listing will include the number on the Test Report and any limitations on use. This ***Approved List*** is published electronically and updated frequently and appears on the Department web site (www.nysdot.gov, click on “Publications”).

2. Timetable for sampling, testing, review of results, and action

- a. Sampling - A sampling date can generally be scheduled with Department representatives within two weeks of initial contact for in-state sources; out-of-state sources may take longer.
- b. Testing - Sample testing is normally completed within 90 days, although samples from potential new sources are placed ahead of routine testing and may be completed before 90 days.
- c. Review of test results - The review process may take up to two weeks.
- d. Action - A decision on action is made at the end of the review process.

3. Procedures for dealing with out-of-specification or abnormal results

- a. When a test result is at variance with test history but still within specification limits, any or all of the following actions will be initiated.
 1. Retest using excess material from the original sample.
 2. Review the petrographic analysis of the tested sample.
 3. Review of petrographic history for the source, including petrographic information provided in GSRs.

4. Resample for additional testing.

If the above review yields a benign explanation of the variance, the circumstance may or may not be discussed with regional Materials personnel. If the review yields an explanation that suggests a trend away from acceptability or that there has been a fundamental change in the aggregate, the circumstance will be discussed with regional Materials personnel and a field inspection may be scheduled.

- b. When a test result on an approved aggregate exceeds the specification limit, specific actions are initiated. Special consideration will be given if the test result is close to the norm for the source. In that case, it will be treated as a variance in the preceding protocol. In addition to the actions outlined in the previous procedure, these actions may include:
 1. Immediate notification and discussion with regional Materials personnel concerning options that may include one or more actions. In determining action, the Department will consider whether or not the test results indicate the aggregate will potentially compromise public safety (friction) or that the aggregate has the clear potential to cause failure (deleterious materials, alkali-aggregate reactivity). Possible immediate actions are as follows:
 - a. Stockpile rejection
 - b. Stockpile resampling
 - c. Field inspection and evaluation
 - d. Meeting with the producer or representative and/or the producer's geologist to discuss a plan of corrective actions.
 2. If efforts to resolve aggregate quality issues fail, the source may be removed from the *Approved List of Sources of Fine and Coarse Aggregates*.

V. Performance Evaluation

The Standard Specifications allow for the consideration of performance in approval of aggregates. Historically, performance has been used as a basis for both approval and rejection. Such evaluation must narrowly consider only distresses generally associated with aggregate performance.

A. Durability performance evaluation

1. *Aggregate performance in asphalt pavements*

Pavement distresses generally associated with aggregates include pocking, raveling, and potholes. These all stem from particle degradation or disintegration. Although there are distresses associated with aggregate cleanliness, gradation, and shape characteristics, such problems may be addressed in processing.

2. *Aggregate performance in portland cement concrete*

Pavement D-cracking and popouts, scaling, map-cracking, and expansion are all expressions of aggregate problems in portland cement concrete. These distresses must be investigated to substantiate the linkage to aggregate characteristics.

B. Pavement friction performance evaluation

Pavement friction is monitored by the Pavement Friction Inventory program that tests selected sites representing the various aggregate/traffic volume combinations in both open road and intersection environments. In addition, pavement friction is monitored through the Skid Accident Reduction Program (SKARP), and tests-by-request (TBRs).

C. Alkali-aggregate reactivity evaluation

This is a general term covering alkali-silica reactivity (ASR) and alkali-carbonate reactivity (ACR).

1. *Alkali-silica reactivity (ASR) evaluation*

ASR is associated with map cracking, expansion, spalling, and breakdown of the concrete mass. Some D-cracking has also been linked to ASR. To show that ASR is a destructive factor in the distress it must be shown that the silica gel generated by the reaction effectively fills available voids and is directly associated with cracking. Petrographic examination of concrete samples is used to make this determination.

2. *Alkali-carbonate reactivity (ACR) evaluation*

ACR is also associated with map cracking, expansion, spalling, and breakdown of the concrete mass. It must be demonstrated that ACR is a destructive factor in the distress. Petrographic examination of concrete samples is used to make this determination.

VI. Aggregate Source Monitoring

After the initial acceptance of an aggregate source there are various methods by which quality is monitored. These include biennial sampling and testing, plant sampling and testing during production for Department contracts, special sampling and testing indicated by the need to resolve uncertainties, and field inspection when the resolution of a problem appears to lie in a change in mining or processing.

A. Biennial sampling and testing

Every two years each approved aggregate source is sampled for the following tests:

Biennial Tests

COARSE AGGREGATE	FINE AGGREGATE
Magnesium sulfate soundness ¹ 703-07 P,G	Magnesium sulfate soundness ¹ 703-06 P,G
Freeze - Thaw ² 703-08 P,G	
Los Angeles Abrasion ¹ 703-11 P,G (AASHTO T96)	
Specific Gravity & Absorption ³ 703-09 P,G (AASHTO T85)	Specific Gravity & Absorption ³ 703-05 P,G (AASHTO T84)
Acid Insoluble Residue ⁷ MM 28	Acid Insoluble Residue MM 28
Percent crushed ⁴ (ASTM D 5821)	Uncompacted Voids ⁵ (AASHTO T 304)
Flat and Elongated Pieces (ASTM D 4791)	Organic Impurities ⁶ 703-03 P,G (AASHTO T21)
Petrographic analysis ⁷ Deleterious material determination (ASTM C 295)	

1. Sample must pass this test to be accepted.
2. Sample must pass this test to be used in PCC.
3. Information test, not for acceptance.
4. Samples not meeting minimum % crushed may not be tested

5. Superpave™ consensus property
6. Sample failing this test requires further evaluation if it is to be used in PCC.
7. Also used as an indicator of ASR potential for crushed stone.

The results of these tests will be issued under a new biennial test number which supersedes the biennial test number previously issued. If the results do not confirm current acceptability or are at variance with testing history, refer to *IV., B., 3., Procedures for dealing with out-of-specification or abnormal results*, in this document, for guidance.

B. Plant samples

Plant inspectors take these samples during production for Department projects and portions are sent to regional Materials and to the Geology Section laboratory in Albany. The purpose of these samples is to determine that the correct aggregate is being used in accordance with the job mix formula (asphalt) or mix design (concrete) and that, for wearing surfaces, friction aggregate requirements are met.

C. Special samples

Samples are sometimes taken in the course of an investigation of variation in quality or specification compliance or to address specific quality concerns. Main Office or Regional Materials personnel sometimes take these samples in addition to those described in A or B, above. Sampling is designed with a specific purpose and may be unprocessed ledge rock, gravel or sand, may be processed or partially processed aggregate, may be mixed with asphalt or cement, or may be cores taken from a pavement or a structure.

D. Field inspection

Occasionally field inspections are conducted to monitor mining or processing at approved aggregate sources. The Geological Source Report documents the mining, processing, storage, and quality control methods used by the producer to supply Department approved aggregates. These reports are used in the field inspection process.

VII. Problem Resolution

Aggregate problems are discovered through testing, petrographic analysis, field inspection of aggregate sources, and field inspection of pavements and structures.

A. Protocol for dealing with non-specification aggregate in a project.

The presence of non-specification aggregate, as confirmed by the analysis of core samples, may result in a variety of actions. The resolution hinges on the potential consequences of the non-specification aggregate's use and whether or not it must be replaced. Substantial

conformance, reduced payment, performance monitoring, warrantee, overlay, and replacement are all possible resolutions. Each particular situation calls for the application of engineering and geologic judgment.

1. *Non-specification aggregate that may not negatively impact performance*

Such installations are probably not candidates for remediation and may be considered to be in substantial conformance.

2. *Non-specification aggregate that may shorten the life of the project*

These materials may be candidates for replacement after evaluation by the Department. Reduced payment, performance monitoring, and warrantee are possible resolutions.

3. *Non-specification aggregates that are judged to be potential failures or will cause unsafe or hazardous highway condition*

The materials are likely candidates for overlay or replacement.

B. Protocol for performance problem resolution

Performance problems confirmed as having been caused by aggregate components will be remediated as appropriate. The consequence to the aggregate source is determined, in part, by the nature of the problem. Aggregates that are found to be out of compliance with specifications are considered quality control failures. This section deals with proper aggregates that cause unexpected problems.

1. *Deleterious materials*

Occasionally, aggregate components that are considered less than desirable are found to be deleterious. This is usually a consequence of the aggregate's not having been used in a particular application where its deleterious nature would be noticed. When this happens, the following steps are taken:

- a. Field confirmation – The Department will identify the aggregate component causing distress. Core samples may be required. In addition, all exacerbating factors should be identified.
- b. Source investigation - The aggregate source must be investigated by the Department to determine the petrography and abundance of the potentially deleterious component.

- c. Testing - An attempt should be made to duplicate the problem distress in the Department's laboratories. In addition, the potentially deleterious material must be isolated to investigate its response to relevant tests.
- d. Deleterious confirmation - If the Department's investigation confirms that the questionable aggregate component is deleterious, a method must be developed by the Producer, with the concurrence of the Department, by which the deleterious material may be identified. This may be through geologic or petrographic definition and/or testing.
- e. Other aggregate sources - All aggregate sources with similar petrography must be surveyed to determine if the deleterious component is present in amounts in excess of those allowable in Table 703-3, Deleterious Materials, of the specifications. If so, those sources must be investigated to confirm the postulated similarity using reference samples.

2. *Non-durable aggregate*

Approved aggregates that are non-durable are identified by significant loss of service life. The assessment of this loss of service life is generally through the evaluation of a number of projects containing this aggregate. If it is found that there is a significant likelihood that projects containing this aggregate will not meet minimum service life expectations, consideration must be given to modifying or terminating its approval.

3. *Low friction pavement*

Aggregate, for which there is evidence of failure to provide the design target level of friction, must be restricted in use. The evidence required is generated from pavement friction testing in accordance with ASTM E 274 using a ribbed tire. Sites tested are inspected for interfering factors, such as excess asphalt at the surface, loose particles, or oily contaminants. Cores are taken to confirm the identity of the aggregate.

Use restriction will be determined as appropriate from the evidence and may include traffic volume, highway design type, highway geometric (ramps, curves, grades, and intersections), or location restriction.

C. Protocol for dealing with variable sources

Many sources generate materials of differing quality and application, produced by selective mining. The Operations Plan deals with procedures for maintaining separate identities for these materials. Samples taken from mix plants are used to monitor the proper use of aggregate materials by checking the petrographic identity of mix components.

VIII. Change in Aggregate Source Approval Status

The items for which an aggregate is approved may change in response to an actual change at the source or may change because of new information. This section does not address rejection of a source due to non-compliance with administrative procedures. A letter will be sent to the producer, with a copy to the Regional Materials Engineer, notifying of the change of status.

A. Reasons for change

1. *Change in test results*

Test results may indicate either an improvement or a diminishment in quality of the aggregate. The Standard Specifications and the requirements for various items will dictate the items for which that aggregate may be approved.

There should be a reason established for substantial change in the quality or characteristics of an aggregate source in order for there to be a change in approval status. Change in quality may be as a result of intentional change in mining or processing. A change in quality due to contamination or mistakes that are corrected subsequently, even if stockpiles have been rejected as a consequence, does not constitute a reason for a change in approval status.

2. *Petrographic change*

A change in the petrography of an aggregate is an indication that the operation has moved into different material or that processing has changed to that result. As with a change in test results, a change in quality due to contamination or mistakes that are corrected subsequently, even if stockpiles have been rejected as a consequence, does not constitute a reason for a change in approval status. If new materials are being encountered in mining, that circumstance must be addressed in the Geological Source Report. The new material must have acceptable test results and may either be mined separately through selective mining or included with the old. In either case, the approval status of the aggregate containing the new material will be determined on its merits.

3. *Performance problems*

Section V. deals with performance evaluations. A change in approval status could follow from the results of such an evaluation.

4. *Change at the aggregate source*

Changes at the aggregate source will generally be reflected in test results or in petrography. The quality and characteristics of the aggregate following the change will determine its approval status.

5. *Operational problem*

A problem that cannot be corrected may result in a change of approval status. Testing and/or petrographic history may demonstrate that aggregates cannot be produced to consistently meet certain requirements. In such cases, a change in approval status may be indicated.

B. Review of proposed change

Changes in approval status are made only with strong justification. Before a proposed change is made, any or all of the following actions may be taken:

1. *Additional testing*
2. *A review of petrographic and testing history*
3. *Field inspection*

If there is a change in the material, as indicated by test results or petrographic analysis, a field inspection of the source is indicated. If the change in status is suggested by performance, a field inspection of the problem highway installation is indicated. In the case of performance evaluation, see Section V.

C. Determination of the extent of the proposed change

When it is established that a real change in the quality or characteristics of an aggregate has occurred and that a change in the approval status of that aggregate is appropriate, the extent of that change must be determined.

1. *Disapproval*

This is the most radical change and is only done under unusual circumstances. Approval may be suspended, or stockpiled materials may be rejected, when aggregate does not meet minimum requirements due to a potentially correctable situation. Approval is discontinued permanently when all feasible alternatives are exhausted as determined by the Director, Materials Bureau.

2. *Use/ Locality restriction*

Under special circumstances, in order to make use of resources, the Department may elect to approve the source with restrictive use. There must be compelling evidence that the restricted use will benefit the Department.

3. *Other similarly situated aggregate sources to be affected*

When the approval status of an aggregate source is changed, the Department will consider other similarly situated aggregate sources to determine if the change in status should be extended to include those other sources.

D. Procedure for maintaining aggregate source approval

Every approved aggregate source must have a currently accepted Geological Source Report and a current biennial test showing that the aggregate represented by that sample meets specifications. Whenever aggregate source approval status changes, a letter will be sent to the producer, with a copy to the Regional Materials Engineer, notifying of the change of status. The Aggregate Source Approval Status Letter currently in affect is evidence of acceptability.

1. *Maintaining a current Geological Source Report (GSR)*

- a. The prescribed submission schedule for updated GSRs (2-year or 4-year) and Operations Plan (every year) must be maintained.
- b. Only those GSR components that have changed since the last update must be included. Inactive sources may require only a letter explaining the status of the source.

2. *Maintaining a current biennial test number*

- a. Every two years a biennial sample is taken by the Department for physical testing and petrographic analysis. When a source is inactive, this sample may be provided by various methods.
 1. Stockpiles of aggregates produced from the source may be maintained on the premises from which biennial samples can be taken. These stockpiles may be no more than two years old before fresh material must be produced. If it is feasible to maintain a stockpile of aggregate for a period beyond two years, a stockpile approval may be granted.
 2. Raw materials from the source (30 tons minimum) may be processed at the site for the purpose of biennial sampling.

3. Raw materials from the source (30 tons minimum) may be hauled to a plant off-site for processing for the purpose of biennial sampling.
- b. When the testing and petrographic analysis is completed, the following actions may be taken:
 1. If the biennial sample meets all specifications and a currently accepted GSR is on file, a Source Approval Letter will be issued. A biennial test number is published in the *Approved List of Sources of Fine and Coarse Aggregates*.
 2. If the biennial sample test results show either substantial variance with test history or exceed specification limits, refer to *IV. B., 3. Procedures for dealing with out-of-specification or abnormal results*, in this document, for guidance.
- E. Procedure on reactivating an aggregate source whose approval has lapsed

An aggregate source may be removed from the *Approved List of Sources of Fine and Coarse Aggregates* either by default, for failure to fulfill the requirements for continued approval, or by request from the producer. In either case, all documents relating to that source will be maintained by the Materials Bureau for historical reference. Should the producer desire to reinstate such a source to the Approved List, the following procedure should be followed:

1. *Notify the Regional Materials Engineer of the desire to reinstate the source to the Approved List.*
2. *If the source has been active during the lapse from the Approved List then:*
 - a. Arrange with the Regional Materials Engineer to sample the source. The sample will be used for biennial testing if two or more years have elapsed since the previous biennial sampling.
 - b. The Geological Source Report requirements must be satisfied. The schedule for submission, established prior to the lapse, will be maintained. Therefore, any unfulfilled report requirements must be satisfied before reinstatement to the Approved List. If either an annual or cyclic module was due during the time of the lapse, it is due to be submitted upon reinstatement or if the time of lapse is beyond the previous cyclic coverage a new cyclic module is due.
3. *If the source has been inactive during the lapse from the Approved List then:*
 - a. Arrange with the Regional Materials Engineer to sample the source. The sample will be used for biennial testing if two or more years have elapsed since the

previous biennial sampling.

- b. A letter of intent to reactivate must be sent to the Department that states that: the aggregate is to be produced from reserves approved by the Department under the previous biennial test; the aggregate is being processed in substantially the same manner as when it was previously approved; and the active reserves have been stripped of any overgrowth, contaminants, debris, or any other objectionable material accumulated during the period of inactivity.
- c. The source will be re-approved by the Department upon receipt and review of this letter of intent to reactivate from the producer. The Department will send a Letter of Change of Approval Status that will then serve as evidence of approval. During a hiatus in mining activity (see **Note**) and lapse from the Approved List, the submission schedule for Geological Source Reports is suspended. At the end of the hiatus, the submission schedule will be resumed where it was suspended.

Note: A hiatus in mining activity is herein defined as a period of time during which no excavation of reserves takes place. A hiatus starts from the year the Department receives the letter of intent to deactivate or is notified that deactivation has taken place (see page 22, Modules and Submission Schedule) and ends in the year the Department receives the letter of intent to reactivate.

If it is determined by petrographic analysis of the sample, that the aggregate is similar to previously approved material, provisional approval may be granted pending the outcome of physical testing.

APPENDIX A

GEOLOGICAL SOURCE REPORT REQUIREMENTS FOR CRUSHED STONE AND
SAND & GRAVEL OPERATIONS

**GEOLOGICAL SOURCE REPORT REQUIREMENTS FOR CRUSHED STONE AND
SAND & GRAVEL OPERATIONS**

PREFACE: The Department recognizes the geology of an aggregate source in large part controls its engineering properties.

I. SCOPE

The Standard Specifications for Fine and Coarse Aggregate (Sections 703-01 and 703-02) specify that, as part of the requirements for acceptance, the operator of each source must submit an annual report to the Department. The report must be submitted in modules, each of which must be revised and submitted according to a schedule. The Geological Source Report shall describe the characteristics of the aggregate to be excavated and the products to be furnished for Department use. Those portions of the Report that relate to the geology of the source shall be prepared by a qualified geologist in accordance with the requirements contained herein. The Operations Plan component, which must be addressed annually, should be prepared by company personnel in accordance with the requirements contained herein. Any questions concerning Report preparation should be directed to the Department of Transportation, Materials Bureau, Engineering Geology Section ((518) 457-1038).

One copy of the source report shall be submitted to Director, Materials Bureau and one copy to the Regional Materials Engineer by February 1 of the year for which approval is requested. Acceptance action on the report will be taken by the Materials Bureau, Engineering Geology Section. Electronic submissions are encouraged. Large graphics, including maps and cross sections, must be submitted in hardcopy so they may be used in the field. The receipt of all electronic submissions will be acknowledged electronically.

II. CONTENTS	<u>Page</u>
I. SCOPE	28
II. CONTENTS	29
III. REPORT REQUIREMENTS	29
A. Modules and submission schedule	29
B. Components of the Static Module	29
1. Body of the Report	30
2. Location Map	31
3. Drill holes and Core Logging (crushed stone only)	31
4. Geologic Columnar Section (crushed stone only)	33
5. Petrographic Analyses (sand & gravel only)	33
C. Components of the Cyclically Updated Module	37
1. Source Map	37
2. Geologic Cross Sections	39
3. Plant Flow Information (sand & gravel and stone sand)	40
D. Operations Plan of the Annual Module	41
E. Special submissions	45
F. Field Work for Report preparation	45
IV. OPERATIONS PLAN TEMPLATE AND EXAMPLES	47

III. Report Requirements

A. Modules and submission schedule

Geological Source Reports (GSRs) are to be submitted in a modular format consisting of a *Static Module*, containing GSR components that may not change during the life of the mine, a *Cyclically Updated Module*, containing GSR components that are revised on a 2-year (sand & gravel operations) or 4-year (crushed stone operations) schedule, and an *Annual Module* consisting of a current Operations Plan. If there has been no change to the previously submitted Operations Plan, a letter attesting to this fact must be submitted as the Annual Module. If mining activity is, or will be, suspended, a letter attesting to this fact must be submitted and the timing on the submission schedule will be halted. When mining activity is resumed, the submission schedule will also be resumed. These modules will be submitted in a loose leaf binder so that it may be easily kept current.

B. Components of the Static Module

Each module must have a cover sheet that identifies the source by name, location, and

NYSDOT source number. In addition, the cover sheet must state that it is the Static Module and have the name of the person or persons who prepared the module. Each module should be marked “Confidential”.

1. The body of the Report

- a. Table of Contents
- b. A clear, easily readable, general description of the geology of the source. It must include a regional geologic history as well as any information on local geologic history as it pertains to the site.
- c. A color photocopy of a surficial (for sand & gravel operations) or bedrock (for crushed stone operations) geologic map that encompasses the site and surrounding area.
- d. A detailed, site-specific geologic description of the source.
 - (1) For crushed stone operations this must include:
 - (a) A geologic description of the formations and their subdivisions present in the quarry. Those geologic units covered by drill cores and exposed in the quarry faces shall be described in detail. Included in the description must be the thickness of all formations and their subdivisions.
 - (b) A geologic description of marker horizons (easily recognized units used for stratigraphic reference). The marker horizons must be included in the Geologic Column (III.B.4.) and shown in the photographs (III.B.1.e.).
 - (2) For sand & gravel operations this must include:
 - (a) A discussion of the mode of deposition of the unconsolidated material (kame, esker, delta, outwash, etc.). A clear, easily readable glacial history of the deposit shall be presented in enough detail to indicate the relationship of the deposit to other glacial deposits in the immediate area.
 - (b) The agricultural soil type associated with the deposit and its geologic genesis must be discussed. A map showing the soil association in the vicinity of the deposit must be included.

- e. Photographs or color copies of photographs of the operation. The photographs must show all materials and lifts being excavated. The depositional units (sand & gravel only), formations and their subdivisions (including marker horizons) in the quarry lifts being mined and any prominent structural features (crushed stone only) must be shown. A panoramic overview of the operation is recommended.
- f. A bibliography of all references used in preparing the GSR.

2. Location map

The location of the plant and area of operations must be shown on a map containing enough information to enable one to travel to the site, when used in conjunction with a state highway map. A 7 ½ minute U.S.G.S. Quadrangle map, or its equivalent, modified to show major routes and distances to nearest towns, is acceptable.

3. Drill Holes and core logging (crushed stone only)

- a. All drill holes must be located by survey. Their locations, total depths, collar elevations, and years drilled shall be shown on the Quarry Map (III.C.1.) and Geologic Cross Sections (III.C.2.).
- b. Core holes must penetrate at least 5 feet below the proposed operating horizon.
- c. In stratified or layered rock, drill holes should intersect all strata, or layers, that will be quarried. Holes may be vertical, horizontal, or at any angle in order to meet this requirement.
- d. Size “NX” (2 1/8 inches in diameter) cores are recommended. Experience indicates that maximum recovery is best accomplished with larger cores.
- e. The size of the area explored by drill holes need not be confined to the area intended to be quarried during one 4-year reporting cycle. If, in the opinion of the producer’s geologist, the structural and stratigraphic continuity permits, the drill holes may be located up to 1000 feet apart. Operations are limited to a maximum of 250 feet) beyond the farthest drill hole in any direction. Exceptions may be made with the approval of the Materials Bureau. A detailed geologic face log may be used in lieu of a core hole with the approval of the Bureau.
- f. New cores shall be drilled whenever the proposed quarrying will extend beyond the area or depth covered by existing cores, i.e. when the operation is to be

extended more than 250 feet beyond the farthest drill hole or when strata are to be quarried that have not been intersected previously.

- g. All rock cores shall be retained by the operator and shall be made available to the Department for examination. The cores shall be stored where they are reasonably protected from the weather. They shall not be discarded, as they may be required for problem resolution.
- h. Core logging shall meet the following requirements:
 - (1) Cores shall be split lengthwise as necessary to provide an accurate geologic description of the rock in order to show the fractured surface. A minimum of one piece per run in uniform strata is required, or whenever there is a variation in lithology.
 - (2) Written logs shall be prepared in sufficient detail to show all pertinent geologic features and variations.
 - (3) Written logs shall be legible and each log shall be individually tabbed with a label of the log number.
 - (4) Each log shall show collar elevation, angle drilled, year drilled, and total depth from the surface.
 - (5) Logs shall contain basic descriptive information including, but not limited to:
 - Geologic formations and subdivisions including markers
 - Rock type
 - Grain size
 - Color (GSA standard color)
 - Accessory minerals
 - Fossiliferous zones
 - Vein or fracture fillings
 - Bedding and cleavage
 - Degree of weathering
 - Fractures and their angles to the axis of the core
 - (6) Logs shall indicate the core box number(s), lengths of run(s), and lengths of core recovered.
 - (7) A summary sheet which presents the stratigraphic interval intersected by the cores shall be included.

4. Geologic Columnar Section (crushed stone only)

A generalized Geologic Columnar Section is required to graphically and descriptively show the stratigraphic relationships within the quarry environs. The column must show stratigraphy both above and below the units to be quarried, as available information allows. Marker beds (easily recognized units used for stratigraphic reference) must be shown and labeled. The stratigraphic horizons to be quarried for Department aggregate items, particularly when more than one aggregate item is to be produced, must be delineated. Formations must be subdivided into members and units to the degree that they appear in the core logs (III.B.3.h.). When approval for friction aggregate items depends on acid insoluble residue content, and that information is available, it should be included on the Columnar Section. The legend must show all symbols, patterns, and colors used on the columnar section. The name of the source and the NYSDOT Source Number shall be included. All text, labels, and numbering must be legible.

5. Petrographic Analyses (sand & gravel only)

Petrographic analyses shall be completed by a geologist in accordance with ASTM C 294 and C 295. All petrographic descriptions must include detailed lithologic descriptions of each rock type including the color, cement, and grain size as appropriate. Distinct lithologies cannot be lumped, but must be separated for the petrographic report.

- a. A petrographic sample must be analyzed for each depositional unit to be excavated. The materials above and below the water table are considered as belonging to separate depositional units even though, geologically, they may have been deposited in the same episode. When materials from both above and below the water table are excavated together, they need not be separated, but considered as though from one depositional unit. Additional petrographic samples must be analyzed whenever:

- (1) The proposed area of operations moves into a different depositional unit.
- (2) There is a change in the depth of excavation with respect to the water table (see III.B.5, above). If a source produces from above and below the water table, a petrographic sample must be analyzed from each of the two horizons, except as noted (see III.B.5.a).
- (3) The proposed area of operations is extended beyond the area covered by existing petrographic samples. Petrographic samples may be spaced up to 1000 feet apart if, in the opinion of the producer's geologist and with the approval of the Department, no depositional boundaries will be crossed. This

distance may be increased by the producer's geologist with the approval of the Materials Bureau. Conversely, sample spacing may be decreased if warranted by the complexity of the source, as determined by the Director, Materials Bureau.

- b. Petrographic samples are used to demonstrate the continuity and uniformity of the aggregate to be supplied. For the purposes of the GSR, the term "petrographic sample" includes all sample components that are required, according to the following table:

Table 1

Petrographic Sample Components		
Type of Approval	Processing Conditions	Sample Components Required
Sand <u>only</u>	Screened only, no crushed gravel or crushed stone screenings included	(1)Unprocessed bank sand only
	Crushed stone screenings added	(1)Unprocessed bank sand (2) Processed concrete sand ¹
	Crushed gravel screenings included	(1)Unprocessed bank sand (2)Processed concrete sand ¹ (3)Unprocessed bank gravel
Crushed Gravel <u>only</u>	Crushed and screened	(1)Unprocessed bank gravel only ²
Screened Gravel <u>only</u>	Screened only	(1)Unprocessed bank gravel
Sand <u>and</u> Crushed Gravel	Crushed gravel screenings included in sand product	(1)Unprocessed bank sand (2)Processed concrete sand ¹ (3)Unprocessed bank gravel ²
	Crushed gravel screenings <u>not</u> included in sand product	(1)Unprocessed bank sand (2)Unprocessed bank gravel ²
Sand <u>and</u> Screened Gravel	Screened only	(1)Unprocessed bank sand (2)Unprocessed bank gravel

(1) If concrete sand is not produced, sand intended for use in bituminous mixes may be sampled.

(2) The Materials Bureau analyzes the petrography of crushed gravel in the course of biennial testing.

- c. The size of the area covered by petrographic samples need not be confined to that which may be mined within one reporting period, but may include any desired area for future operations. In special cases, such as active stream deposits, bars, or dredging operations, the petrographic sampling requirement will be tailored to suit the operation, and approved by the Materials Bureau.

d. Preparation and Size of Petrographic Sample.

- (1) In the case of operating sources, representative samples shall be obtained at the plant before crushing or obtained from the active faces of the deposit. In addition, if crushed material is blended with or used instead of natural sand, a sample from the finished stockpile is required. Each operating deposit must be represented by a petrographic sample. When more than one mode of deposition is represented within the area of proposed operation, at least one petrographic sample is required from each deposit.
- (2) In the case of deposits that are not excavated, samples may be obtained from test pits or trenches, auger holes, etc. Such deposits must be evaluated individually to determine the best sampling method. The sampling method must be described in the GSR.
- (3) To prepare a petrographic sample for analysis, it must be separated on the following screens and a determination of the percentages of each rock type present in each size fraction shall be made in accordance with ASTM C 295.

Table 2

GRAVEL

Size Fraction Passing (inches)	Size Fraction Retained (inches)	Field Sample Size (pounds)	Test Sample Size (particles)
12+	-	300*	-
12	6	-	150*
6	4	-	150*
4	2	150	150
2	1	90	150
	1/2	50	150
1/2	1/4	22	150

* When present, size fractions greater than 4" may be analyzed in the field. If less than 150 particles are present, record the number of particles used in the analysis.

Table 3

SAND		
Size Fraction Passing (inches or U.S. Standard Sieve No.)	Size Fraction Retained (U.S. Standard Sieve No.)	Test Sample Size (particles)
1/4	No. 4	150
No. 4	No. 8	150
No. 8	No. 16	150
No. 16	No. 30	150
No. 30	No. 50	150
No. 50	No. 100	150

C. Components of the Cyclically Updated Module

Each module must have a cover sheet that identifies the source by name, location, and NYSDOT source number. In addition, the cover sheet must state that it is the Cyclically Updated Module and have the name of the person or persons who prepared the module. Each module should be marked "Confidential".

Geological Source Reports (GSRs) for crushed stone operations will have components described in this section updated on a 4-year cycle. GSRs for sand & gravel operations will have components described in this section updated on a 2-year cycle.

1. A Source Map that meets the following requirements:
 - a. The map must be topographic and contain reference features necessary for

updating.

- b. The scale should be appropriate to the size of the proposed source area and the relative size of the details being shown. Scales of 1:500, 1:1000, or 1:2500 are preferred. Generally, 1:2500 is the smallest acceptable scale. The map must be extensive enough to cover the entire proposed operating area shown on the Source Map and may be extended to include reserves representing the anticipated life of the operation.
- c. A permanently established bench mark (Optional). Elevation need not be elevation above sea level, but if an empirical elevation is used, avoid negative values.
- d. Geologic Cross Sections must be shown with lines and labeled.
- e. Direction of True or Magnetic North (indicate which).
- f. Original survey date and the date of the most recent revision.
- g. Elevations shown by means of contour lines with the contour interval not greater than 20 feet nor less than 5 feet. If the mined out area is not contoured, there must be spot elevations along the toe and crest lines of the faces at a spacing adequate to depict their true configuration.
- h. The proposed operating area, including the location of all active faces and lifts must be indicated as such. These areas shall be lightly colored, patterned, or highlighted in some way for clarity.
- i. The proposed area of any selective mining must be indicated as such in a way that makes it distinct from the other operations. The reasons for the selective mining must be indicated in the report.
- j. Locations of any drill holes, auger holes, test pits, or trenches used for exploratory purposes and for which logs or descriptions are included in the text or which are used to construct Geologic Cross Sections, or from which samples were obtained for petrographic analysis or testing, must be shown and labeled with the collar or surface elevation, total depth, and year drilled or dug.
- k. Petrographic sampling locations (sand & gravel only) or ledge sampling locations (crushed stone only) must be shown and labeled, including year sampled, if the tests are referred to in the Report.
- l. Depositional boundaries must be shown when they occur within the mine site (sand & gravel only).

- m. Locations of major geologic structures and other pertinent geologic information must be shown (crushed stone only).
 - n. The base map may be prepared by photogrammetric or land surveys, by an enlargement of a 7 ½ minute U.S.G.S. topographic map showing the entire area intended to be mined.
 - o. The base map may be revised for any number of succeeding submissions by outlining the proposed operating area and revising elevations or contours in areas undergoing active mining. Remove the lines indicating working faces and all topographic contour lines that are not current. Each operating lift must be indicated in a distinct manner. The map must conform to existing topography.
 - p. The legend must show all symbols, patterns, and colors used on the map that are peculiar to this map and are not U.S.G.S. Topographic Map Symbols. The name of the source and the NYSDOT Source Number shall be included. All map text, labels, and numbering must be legible.
 - q. Locations and directions from which report photographs were taken.
2. Geologic Cross Sections that meet the following requirements:
- a. Two or more cross sections are required and each must intersect at least one other cross section. The sections shall be aligned so that at least one face in each operating area and all operating levels or lifts are intersected.
 - b. The cross sections shall be extensive enough to cover the proposed operating area shown on the Source Map. The proposed operating area must be colored, patterned, or highlighted in some way that is consistent with the Source Map.
 - c. Cross sections shall be drawn on a grid and elevations shall be shown along both sides of each section. In generally flat-lying strata, sections may be drawn with an exaggerated vertical scale if necessary to show all stratigraphic units. Exaggeration should be no greater than four times the horizontal scale.
 - d. For crushed stone operations, Geologic Cross Sections must include the following elements:
 - (1) All drill holes shown on the map shall be labeled with the hole number, collar elevation, total depth, and year drilled.
 - (2) Stratigraphy shall be shown in sufficient detail to evaluate the operation. Marker beds shall always be identified.

- (3) In folded strata, at least one section shall be normal to the strike and at least one shall be parallel to the strike.
 - (4) The location and thickness of all weathered or altered zones, including fault zones, shall be shown if the material in that zone affects the quality of the aggregate.
- e. For sand & gravel operations, Geologic Cross Sections must include the following elements:
- (1) All auger holes, test pits, trenches or other exploratory excavations that are referenced in the text shall be labeled with the hole or pit number, surface elevation, total depth, and year drilled or dug.
 - (2) The position of the ground water table and bedrock, if encountered, must be shown.
 - (3) The attitude of bedding and any significant geologic features, such as channels, alluvial fans, etc., shall be shown if such features impact the operation of the source.
 - (4) The location and thickness of any major lenses of sand, gravel, clay, etc. shall be shown if such features impact the operation of the source.
 - (5) The contact between different depositional units, e.g. the contact between river gravel and glacial deposits, must be shown if they are known and if there is a significant difference in quality between the units.
 - (6) The depth of overburden shall be shown. If the overburden is too thin to be drawn to scale, its thickness should be indicated.
- f. The legend must show all symbols, patterns, and colors used on the cross sections. The name of the source and the NYSDOT Source Number shall be included. All text, labels, and numbering must be legible.
3. Plant Flow Information (sand & gravel operations only) shall include the following:
- a. The name and location of the plant.
 - b. Approximate plant capacity under normal operation (optional)
 - c. A Plant Flow Diagram which indicates in a general manner the normal flow of aggregate material being processed for Department use. A written description of

the equipment that constitutes the plant shall include the following:

- (1) Type of equipment, e.g. jaw crusher, screw washer, vibratory screen deck, hydrosizer, etc.
- (2) Type of screen opening, e.g. square wire, slotted, harp, etc.
- (3) Points of separation of processed items
- (4) Points of washing, wetting, scrubbing, etc.

It is recognized that plant operations must change to accommodate material feeding the plant and the final product. Therefore, providing this information is not to be construed by the Department or by the producer to mean that the producer cannot make changes to the plant to suit daily needs. The Department, however, shall be notified of changes to the plant that may affect the quality of the aggregate products, exclusive of gradation. This notification should be made at the time the change is made. Plant Flow Information is for use only by the Materials Bureau to evaluate the finished product and not as criteria for acceptance.

4. Photographs of the current working face(s).

Photographs representing current operations will be included with each cyclic submission. Previously submitted photographs will be archived. Each photograph must contain an object of commonly known size for scale in lieu of actual measurements.

D. Operations Plan - The Annual Module

Each module must have a cover sheet that identifies the source by name, location, and NYSDOT source number. In addition, the cover sheet must state that it is the Annual Module - Operations Plan and have the name of the person or persons who prepared the module. Each module should be marked "Confidential".

A copy of the Operations Plan must be signed by the producer or by an employee of the producer's who is responsible implementing the Operations Plan. Whenever it is revised or amended, a new signed Operations Plan must be submitted. If there has been no change to the previously submitted Operations Plan, a letter attesting to this fact must be submitted. The purpose of the Operations Plan is to describe the process by which the producer controls the quality of the finished product during excavation, processing, and stockpiling. Appendix A contains Operations Plan Templates. The appropriate Operations Plan must be filled out with the required information. Such elements that do not apply to the operation will be designated as such (see the

examples that accompany the Operations Plan Template).

1. Basic information and Personnel

- a. The name and address of the property owner and the lessee (if any). *This is the entity having control of the operation.*
- b. The name, title, mail address, email address and telephone number of the company contact person. *This is the person who is contacted first.*
- c. The name and telephone number of the person responsible for administration of the Operations Plan. *This person may be the Superintendent, Plant Manager or Plant Administrator, or other, as is appropriate, and is likely to be the person who prepares and revises the Operations Plan.*
- d. The name and association email address and telephone number of the geologist familiar with the operation. *This may be the geologist who prepares the Geological Source Report.*

2. Controls implemented during excavation:

- a. Removal of organic-rich and weathered overburden. *Organic materials are undesirable particularly in hydraulic cement concrete. Weathering usually reduces the durability of an aggregate by leaching and chemical alteration.*
 - (1) Depth of stripping. *Generally, the proper depth of stripping is to the base of the soil horizon plus the zone of weathering. The color change that occurs between fresh and weathered material is usually sharp.*
 - (2) Proper separation between edge of stripping and production face. *The separation is to prevent overburden from sloughing down the face.*
 - (3) Avoidance of sloughed-off overburden. *This usually occurs in areas that are inactive and becomes a potential problem when the operation moves back into those areas.*
 - (4) Storage of overburden away from the operating faces. *Stripped material stored for use in reclamation may become a source of contamination if located with the area to be mined.*
- b. Controls on mining and particularly on selective mining. *There are usually limits to mining based on product quality considerations. In addition, there may be selective mining of two or more aggregate products, such as friction and non-friction aggregates, which must be kept separate.*

- (1) Describe how proper lift or face configuration is maintained through visual examination by the producer's geologist or by other trained personnel, by testing of unprocessed or ledge materials, or by other means deemed appropriate. *The stratigraphic location of each ledge being quarried or sand & gravel horizon being excavated is usually indicated by marker beds or zones, by visual inspection, or by depth measurement. Maintaining proper lift or face configuration is a key quality control element where significant variations in quality occur.*
- (2) Proper clean-out of materials from old ramps, overlying lifts, or stripping or from floor leveling. *These areas often contain contaminated materials. In crushed stone operations floors are sometime leveled using aggregate which may affect the quality of the product being produced either above or below the floor level.*
- c. Controls to minimize product non-uniformity when faces are non-uniform. *When quarry or pit faces contain zones of materials having different geologic characteristics, care must be exercised to promote uniformity of feed to the plant.*
 - (1) Describe how non-uniform faces are blended during mucking or load-out (horizontally and vertically). *Established load-out patterns create a feed to the plant that promotes uniformity.*
 - (2) Describe any other procedure(s) used to minimize non-uniformity. *Examples include creative excavation or blast design.*
3. Controls implemented during processing
 - a. Describe how factors that contribute to aggregate non-uniformity will be minimized. *Any blending must be automated or otherwise mechanically controlled.*
 - (1) Separate stockpiling of raw material or blending at the hopper. *Materials that cannot be mixed during load-out from the face (such as those that come from different locations within the operation or when blending materials originate off-site) should be combined from separate feeds. The blending should be automated or mechanically controlled. Atypical setups should be discussed with the Materials Bureau.*
 - (2) Blending or mixing in the plant. *See the comments in 1., above.*
 - b. Describe how quality will be enhanced through equipment selection, plant flow

design, or material process control. *Improvements are made at the discretion of the producer and should be undertaken advisedly. When a program of quality enhancement is undertaken with the intent of producing an aggregate to meet minimum or specialty item requirements, results should be evaluated by the producer before seeking Department approval.*

4. Stockpiling

a. Address factors that cause aggregate non-uniformity. There are stockpiling methods that may be employed such as :

(1) Blending during material transfer using established load-out patterns from beneath stackers or bins.

(2) Moving radial stackers to mix aggregate on the ground.

b. Describe how contamination will be minimized in stockpiles. *The unintended presence of material that changes the composition of an aggregate in an undesirable way, is contamination. Contaminants may affect durability, pavement friction, etc. and may be avoided by:*

(1) Orderly storage area and adequate separation of piles. *Usually barriers between materials or enough separation to allow a loader to pass between is adequate.*

(2) Informing operators of the location of the various aggregate products.

(3) Labeling piles

c. Describe how stockpiles will be monitored. *This description shall include the tests being used, minimum testing frequency, the person who will do the tests, and the actions that will be taken if tests show the material does not meet requirements. There are various methods available to check stockpiles for uniformity and for contamination which include:*

(1) Visual examination by the producer's geologist or other trained personnel. *Maintaining a set of reference samples in the laboratory greatly facilitates visual examination, particularly by personnel other than geologists.*

(2) Testing of stockpiled materials by whatever method is appropriate to address the particular uniformity concern. *This may include acid insoluble residue content, specific gravity, unit weight, percent crushed, uncompacted voids content, flat & elongate, organic color, magnesium sulfate soundness, or freeze-thaw. See Appendix C for details.*

5. Friction

- a. What MM28 tests will be used to monitor friction aggregate production and what is the minimum testing frequency? *Testing in accordance with MM28 is mandatory to address friction aggregate specification compliance. The producer may choose to test at a frequency greater than the minimum prescribed in MM28.*
- b. Who will do the tests? *This may be a geologist or specially trained person.*
- c. What actions will be taken if tests show the material does not meet requirements? *There must be a mechanism in place that prevents aggregates that do not meet friction requirements from being supplied to jobs.*

6. Records

- a. Records of quality monitoring may be needed in problem and dispute resolution.
- b. Identify those elements of the Operations Plan that call for record keeping. *Records of testing, visual inspection of faces or materials, or other quality-related monitoring are important.*
- c. Identify how and under what condition records are kept. *The records may be kept on-site or off-site; in the laboratory, office, scale house, etc.*
- d. Identify the person responsible for maintaining these records.

E. Special Submissions

When important information is developed for which a timely submission is advantageous, that information may be submitted at any time and it will be inserted in the proper GSR module. Examples of such submissions are drill core information and petrographic analyses required so that operations may extend beyond the approved limits. All Report elements that are affected should be submitted at the same time. These may include a revised Source Map and Geologic Cross Sections, or possibly other elements. It is recommended that the producer or his geologist contact the Materials Bureau prior to making the submission to confirm that all necessary elements will be included.

F. Field Work for Report Preparation

All geologic field work shall be done under conditions that permit visual inspection

of all strata to be excavated in the proposed operating area and to verify proper face configuration.

OPERATIONS PLAN TEMPLATE

1. Basic Information and Personnel

- a. Name and address of property owner and lessee.
- b. Name, title, mail address, email address and telephone number of company contact person.
- c. Name, title, and telephone number of the person responsible for administration of the Operations Plan.
- d. Name, association, email address and telephone number of the geologist familiar with the operation.

2. Controls implemented during excavation

- a. Overburden removal
 1. To what depth is overburden removed?
 2. What is the minimum separation between the edge of overburden stripping and the production face?
 3. How will sloughed overburden be avoided?
 4. Will the overburden be stored within the area to be mined?
- b. Mining controls
 1. Describe how proper lift configuration will be maintained. Who will make the determination?
 2. How will clean-out materials from old ramps, overlying lifts, stripping, or floor leveling be handled?
- c. Product uniformity controls
 1. Describe the method for loading out shot rock or sand & gravel from a face to minimize non-uniformity.
 2. Describe any other procedure(s) used to minimize non-uniformity.

3. Processing controls

1. Describe how non-uniformity will be minimized during aggregate processing.
2. Describe how aggregate quality will be improved by processing.

4. Stockpiling

- a. Describe how non-uniformity will be minimized in stockpiling.
- b. Describe how contamination will be minimized in stockpiles.
- c. Describe how stockpiles will be monitored for non-uniformity and contamination.
 1. How will segregation and contamination be visually monitored, and by whom?
 2. What physical tests will be employed to monitor non-uniformity and contamination?
 3. What is the minimum testing frequency?
 4. Who will do the tests?
 5. What actions will be taken when material does not meet requirements?

5. Friction

- a. What MM28 tests will be conducted to monitor friction aggregate production?
- b. What is the minimum testing frequency (see MM 28)?
- c. Who will do the tests?

- d. What actions will be taken when material does not meet requirements?
- 6. **Records**
 - a. What quality monitoring records are maintained?
 - b. Where are these quality monitoring records kept?
 - c. Who is responsible for maintaining these records?

Sample 1 OPERATIONS PLAN TEMPLATE

(Sample Operations Plan for a Crushed Stone Operation)

1. Basic Information and Personnel

a. Name and address of property owner and lessee:

Ledgerock Stone Co.,
RD #2,
Cato, NY 55555

b. Name, title, mail address, email address and telephone number of company contact person:

Joseph Bushey Quality Control Manager, jbushey@ledgerock.com, (315) 555-1212
Ledgerock Stone Co.
RD #
Cato, NY 55555

c. Name, title, and telephone number of the person responsible for Operations Plan administration: J. Jones, Plant Administrator, (315) 555-4357

d. Name, affiliation, email address and telephone number of the geologist (s) familiar with the operation:

James Hall, Consulting Geologists, jhall@EHconsulting.com. (518) 555-1234
Eaton & Hall
Albany, NY 55555

2. Controls implemented during excavation

a. Overburden removal

1. To what depth is overburden removed? Soil has been removed throughout the area to be quarried. In addition, the upper horizon is weathered and discolored and found to be of lower quality. This brown weathered ledge is removed prior to blasting.

2. What is the minimum separation between the edge of overburden stripping and the production face? The soil has been completely removed and is not a factor. The weathered capstone if pealed back from the fresh ledge when the active face moves within 25 feet of the capstone bench.

3. How will sloughed overburden be avoided? Not applicable.

4. Will the overburden be stored within the area to be mined? The soil overburden forms a berm at the perimeter of the property and will never be close to an operating face.

b. Mining controls

1. Describe how proper lift configuration will be maintained. Who will make the determination? Proper lift configuration is described and shown in the Geological Source Report (pages 3 and 4, Geological Cross Sections and Columnar Section). This configuration was determined in consultation with the geologist who prepared the Report (James Hall) and approved by the Materials Bureau. The Upper Lift extends vertically from beneath the weathered horizon (see 2.a.1.) to approximately 8 feet below Marker Bed “A” and the Lower Lift extends from the base of the Upper Lift to the top of the sandstone bed, Marker Bed “B”. Drilling for blasting is based on measurements from Marker Bed “A” and Marker Bed “B”. The identity of these marker beds was established by the geologist who checks their location biennially. The Laboratory Manager (Robert Rocks) checks the locations of the lift floors and works with the driller in determining the depth to be drilled prior to each shot.

2. How will clean-out materials from old ramps, overlying lifts, stripping, or floor leveling be handled? Old ramps, debris, and weathered capstone are processed for fill items periodically and stored in an area away from the stockpile area. No crushed stone is used for floor leveling.

c. Product uniformity controls

1. Describe the method for loading out shot rock or sand & gravel from a face to minimize non-uniformity. Shot rock is mucked from side-to-side and from back-to-front in an established pattern to minimize non-uniformity.

2. Describe any other procedure(s) used to minimize non-uniformity. The blaster loads the blast holes so that the lower portion of the face is kicked out and the upper portion lays on top. This minimizes back-to-front non-uniformity.

3. Processing controls

a. Describe how non-uniformity will be minimized during aggregate processing. Shot rock is first passed through a jaw crusher that reduces it to approximately plus 12" materials. This material is conveyed to a surge pile from which it is drawn through a reclaim tunnel to the crushing and screening plant. The surge pile not only creates a uniform feed to the plant, but causes a mixing that further reduces non-uniformity.

b. Describe how aggregate quality will be improved by processing. The crushing and screening improves the overall soundness of the stone by removing minor shaly interbeds. Aggregate shape characteristics are optimized by the selection of crushing equipment and feed rates.

4. Stockpiling

a. Describe how non-uniformity will be minimized in stockpiling. Sized aggregate is removed from beneath stackers and trucked to the stockpile area. Randomized dumping increases the mixing that has already occurred in the quarry and plant.

b. Describe how contamination will be minimized in stockpiles. Contamination by weathered capstone or by material from the overlying lift or from the floor is controlled in the quarry. Mixing of materials from the two lifts is controlled by maintaining concrete barriers between. Each aggregate bay is labeled indicating the item it contains.

c. Describe how stockpiles will be monitored for non-uniformity and contamination:

1. How will non-uniformity and contamination be visually monitored, and by whom?

The Laboratory Manager inspects stockpiles for the presence of either weathered capstone or sandstone from the floor of the lower lift. Reference samples help in making the inspection.

2. What physical tests will be employed to monitor non-uniformity and contamination?

Visual inspection addresses contamination from above or below the approved ledge. Friction aggregates derived from the Lower Lift will not affect the acceptability of the Upper Lift aggregate. The greatest risk is contamination of the Lower Lift friction aggregate with material derived from the Upper Lift. This risk is addressed in the MM28 testing.

3. What is the minimum testing frequency? (See Section 5, Friction)

4. Who will do the tests? (See Section 5, Friction)

5. What actions will be taken when material does not meet requirements?

No aggregates will be shipped to state jobs until the extent of the contamination is determined. Corrective action will be taken. Only aggregates that have passed the visual inspection will be shipped.

5. Friction

a. What MM28 tests will be conducted to monitor friction aggregate production?

Applicable MM28 tests to determine percent noncarbonate (visual inspection and copper

nitrate staining) or acid insoluble residue content will be conducted at the frequency called for. The primary method of monitoring friction is by percent noncarbonate determination. If problems are detected, they will be verified using acid insoluble residue determinations and testing frequency will be increased to an appropriate level until complete resolution.

b. What is the minimum testing frequency? The No. 2's, 1's, 1A's and Concrete Sand will be tested once per week, as prescribed by MM28.

c. Who will do the tests? The Laboratory Manager does the routine testing. If there is a question, the geologist will be called in.

d. What actions will be taken when material does not meet requirements? All aggregates produced since the previous passing test are segregated from the rest. Visual inspections of the stockpiles are conducted to assure that there is no contamination of state stockpiles. Corrective action is taken and at least two tests must pass before material is again placed in state stockpiles.

6. Records

a. What quality monitoring records are maintained? Records are kept of when visual checks are made of the faces and stockpiles, and of the MM28 tests.

b. Where are these quality monitoring records kept? All inspection and test records are kept in the plant office on the premises.

c. Who is responsible for maintaining these records? J. Jones is responsible for maintaining all records of testing and inspection.

The Operations Plan described herein is a true and accurate representation of the quality management activities to be conducted on behalf of this aggregate source.

(signed)

J. Jones, Plant Administrator

Sample 2 OPERATIONS PLAN TEMPLATE

(Sample Operations Plan for a Sand & Gravel Operation)

1. Basic Information and Personnel

a. Name and address of property owner and lessee:

Glacier Sand & Gravel, Inc.
Gravel Pit Road
Sand Lake, NY 12121

b. Name, title, mail address, email address, and telephone number of company contact person:

Joseph Bushey, Quality Control Manager, jbushey@glacier.com, (315) 555-1212
Glacier Sand & Gravel, Inc.
Gravel Pit Road
Sand Lake, NY 12121

c. Name, title, and telephone number of the person responsible for Operations Plan administration: J. Jones, Plant Administrator, (315) 555-4357

d. Name and affiliation, email address and telephone number of the geologist (s) familiar with the operation:

James Hall, Consulting Geologists, jhall@EHconsulting.com. (518) 555-1234
Eaton & Hall
Albany, NY 55555

2. Controls implemented during excavation

a. Overburden removal

1. To what depth is overburden removed? Overburden is stripped to an average depth of approximately 3 feet and is based on the color change from the reddish brown of the soil and weathered material to the gray of the fresh sand and gravel.

2. What is the minimum separation between the edge of overburden stripping and the production face? Overburden is generally stripped approximately 25 feet beyond the short-term projected location of the active face.

3. How will sloughed overburden be avoided? Any overburden that has inadvertently

fallen into an area to be mined, it will be removed prior to any mining in that area.

4. Will the overburden be stored within the area to be mined? Stripped overburden will be stored outside the mining limit.

b. Mining controls

1. Describe how proper lift configuration will be maintained. Pit faces will have the overburden removed from the top and will be excavated no deeper than the top of the underlying hardpan.

2. Who will make the determination? The loader operator has received training to recognize both the color change for the overburden and the hardpan characteristics. The hardpan is tight and hard to dig and is often wet at its upper surface. Periodically, the Quality Control Manager or the Geologist will check the active faces.

3. How will clean-out materials from old ramps, overlying lifts, stripping, or floor leveling be handled? All materials, except for stripped overburden, will be processed. Stripped overburden is discussed above in (2.a.).

4. What tests are used to verify that proper materials are being mined? At this stage, no tests are required for verification as long as the proper face configuration is maintained. See (2.b.1.), above.

c. Product uniformity controls

1. Describe the method for loading out shot rock or sand & gravel from a face to minimize non-uniformity. The active faces vary in coarseness laterally. For that reason, a side-to-side pattern of excavation has been adopted.

2. Describe any other procedure(s) used to minimize non-uniformity. No other procedures are deemed necessary.

3. Processing controls

a. Describe how non-uniformity will be minimized during aggregate processing. Material, as it is loaded out of the face (see 2.c.1.) is well mixed and no further special handling is required.

b. Describe how aggregate quality will be improved by processing. A 12-inch grizzly removes large particles, many of which are unsound local sandstones. Crushing will remove additional unsound particles from the minus 12-inch feed.

4. Stockpiling

a. Describe how non-uniformity will be minimized in stockpiling. The crushing and screening plant is equipped with radial stackers that will be moved from side-to-side.

b. Describe how contamination will be minimized in stockpiles. Contamination from overburden or hardpan is controlled at the face. Mixing of material from adjacent stockpiles is controlled by maintaining a minimum loader-width separation.

c. Describe how stockpiles will be monitored for non-uniformity and contamination:

1. How will non-uniformity and contamination be visually monitored, and by whom? The Laboratory Manager (Robert Rocks) will visually compare weekly stockpile gradation samples to reference samples maintained in the lab. In addition, the lab manager will examine all stockpiles daily for non-uniformity and contamination.

2. What physical tests will be employed to monitor segregation (non-uniformity) and contamination? No physical tests are needed. Only visual inspections are conducted.

3. What is the minimum testing frequency? Visual inspections are conducted daily.

4. Who will do the tests? The Laboratory Manager

5. What actions will be taken when material does not meet requirements? No aggregates will be shipped to state jobs until the extent of the contamination is determined. Corrective action will be taken. Only aggregates that have passed the visual inspection will be shipped.

5. Friction

a. What MM28 tests will be used to monitor friction aggregate production? Who will do the tests? The gravel No. 2s have noncarbonate content in excess of 70%. Visual analysis will be used to monitor the percent noncarbonate content of the gravel No. 2s, No. 1s, and No. 1As, and will be done by the Quality Control Manager. If there appears to be a change in the percent noncarbonate, a sample will be sent to their geologist for confirmation. The concrete sand has an acid insoluble residue (AIR) content of approximately 45% in the plus No. 30 size fraction. AIRs will be used to monitor the sand. The Quality Control Manager will do the AIR determination.

b. What is the minimum testing frequency? With respect to the gravel, although a minimum testing frequency of one sample per week is prescribed by MM28, a sampling and testing frequency of one sample every two months has been negotiated with the Materials Bureau based on the high percentage of noncarbonate in the source and the fact that the gravel

will not be mixed with a low noncarbonate aggregate for a friction aggregate blend. If the gravel is to be used as part of a friction blend, the testing frequency of one sample per week will apply. With respect to the sand, the MM28-prescribed testing frequency of one sample per week will be tested for AIR content whenever sand is being produced for concrete plants.

c. Who will do the tests? The lab manager will perform these tests and compare the separations to reference samples of carbonate and noncarbonate components.

d. What actions will be taken when material does not meet requirements? Failure to meet friction requirements would indicate either a contamination from outside the source or a basic change in the bank material. All shipments to state projects would stop until the problem is resolved. Regional Materials Engineer would be informed of the situation.

6. Records

a. What quality monitoring records are maintained? Records of when visual checks are made of the faces and stockpiles and of MM28 tests.

b. Where are these quality monitoring records kept? All inspection and test records are kept in the laboratory. Records for previous years will be archived in the company main office.

c. Who is responsible for maintaining these records? J. Jones is responsible for maintaining records during the construction season. J. Bushey is responsible for archived records.

The Operations Plan described herein is a true and accurate representation of the quality management activities to be conducted of behalf of this aggregate source.

(signed)

J. Jones, Plant Administrator

APPENDIX B

MODIFIED GEOLOGICAL SOURCE REPORT REQUIREMENTS FOR LONG ISLAND
AND SOUTHERN NEW JERSEY SAND & GRAVEL OPERATIONS

MODIFIED GEOLOGICAL SOURCE REPORT REQUIREMENTS FOR LONG ISLAND AND SOUTHERN NEW JERSEY SAND & GRAVEL OPERATIONS

PREFACE: The Department recognizes the geology of an aggregate source in large part controls its engineering properties.

I. SCOPE

The Standard Specifications for Fine and Coarse Aggregate (Sections 703-01 and 703-02) specify that, as part of the requirements for acceptance, the operator of each source must submit an annual report to the Department. The geology of Long Island and of Southern New Jersey allow for the substantial modification of the standard Geological Source Report Requirements to reflect the overall uniformity and high quality of sand and gravel mined there. These Modified Geological Source Report Requirements call for an initial report that shows the location of the mine and processing plant, a plant flow diagram, and an Operations Plan. The Operations Plan component, which must be submitted annually, may be prepared by company personnel in accordance with the requirements contained herein. Any questions concerning Report preparation should be directed to the Department of Transportation, Materials Bureau, Engineering Geology Section ((518) 457-1038).

One copy of the source report shall be submitted to Director, Materials Bureau and one copy to the Regional Materials Engineer by February 1 of the year for which approval is requested. Acceptance action on the report will be taken by the Materials Bureau, Engineering Geology Section. The receipt of all electronic submissions will be acknowledged electronically.

II. CONTENTS	<u>Page</u>
I. SCOPE	55
II. CONTENTS	55
III. REPORT REQUIREMENTS	56
A. Modules and submission schedule	56
B. Components of the Static Module	56
1. Location Map	56

2. Plant Flow Information	56
C. Operations Plan of the Annual Module	57
Operations Plan Template	61
Sample completed Operations Plan	62

III. Report Requirements

A. Modules and submission schedule

Geological Source Reports (GSRs) are to be submitted in a modular format consisting of a *Static Module*, containing GSR components that may not change during the life of the mine, and an *Annual Module* consisting of a current Operations Plan.

B. Components of the Static Module

Each module must have a cover sheet that identifies the source by name, location, and NYSDOT source number. In addition, the cover sheet must state that it is the Static Module and have the name of the person or persons who prepared the module. Each module should be marked “Confidential”.

1. Location map

The location of the plant and area of operations must be shown on a map containing enough information to enable one to travel to the site, when used in conjunction with a state highway map. A 7 ½ minute U.S.G.S. Quadrangle map, or its equivalent, modified to show major routes and distances to nearest towns, is acceptable.

2. Plant Flow Information shall include the following:

- a. The name and location of the plant.
- b. Approximate plant capacity under normal operation (optional)
- c. A Plant Flow Diagram which indicates in a general manner the normal flow of aggregate material for Department use. A written description of the equipment that constitutes the plant shall include the following:
 - (1) Type of equipment, eg. jaw crusher, screw washer, vibratory screen deck, hydrosizer, etc.
 - (2) Type of screen opening, eg. square wire, slotted, harp, etc.

(3) Points of separation of processed items

(4) Points of washing, wetting, scrubbing, etc.

It is recognized that plant operations must change to accommodate material feeding the plant and the final product. Therefore, providing this information is not to be construed by the Department or by the producer to mean that the producer cannot make changes to the plant to suit daily needs. The Department, however, shall be notified of changes to the plant that may affect the quality of the aggregate products, exclusive of gradation. This notification should be made at the time the change is made. Plant Flow Information is for use only by the Materials Bureau to evaluate the finished product and not as criteria for acceptance.

C. Operations Plan - The Annual Module

Each module must have a cover sheet that identifies the source by name, location, and NYSDOT source number. In addition, the cover sheet must state that it is the Annual Module - Operations Plan and have the name of the person or persons who prepared the module. Each module should be marked "Confidential".

A copy of the Operations Plan must be signed by the producer or by an employee of the producer's who is responsible implementing the Operations Plan. Whenever it is revised or amended, a new signed Operations Plan must be submitted. If there has been no change to the previously submitted Operations Plan, a letter attesting to this fact must be submitted. The purpose of the Operations Plan is to describe the process by which the producer controls the quality of the finished product during excavation, processing, and stockpiling. The Operations Plan Templates can be found in Appendix B. The Operations Plan must be filled out with the required information. Such elements that do not apply to the operation will be designated as such (see the examples that accompany the Operations Plan Template).

1. Basic information and Personnel

- a. The name and address of the property owner or the lessee (if any). *This is the entity having control of the operation.*
- b. The name, title, mail address, email address and telephone number of the company contact person. *This is the person who is contacted first.*
- c. The name and telephone number of the person responsible for administration of the Operations Plan. *This person may be the Superintendent, Plant Manager or Plant Administrator, or other, as is appropriate, and is likely to be the*

person who prepares and revises the Operations Plan.

d. Photographs representing current operations and working faces.

2. Controls implemented during excavation:

a. Removal of organic-rich and weathered overburden. *Organic materials are undesirable particularly in portland cement concrete. Weathering usually reduces the durability of an aggregate by leaching and chemical alteration.*

(1) Depth of stripping. *Generally, the proper depth of stripping is to the base of the soil horizon plus the zone of weathering. The color change that occurs between fresh and weathered material is usually sharp.*

(2) Proper separation between edge of stripping and production face. *The separation is to prevent overburden from sloughing down the face.*

(3) Avoidance of sloughed-off overburden. *This usually occurs in areas that are inactive and becomes a potential problem when the operation moves back into those areas.*

(4) Storage of overburden away from the operating faces. *Stripped material stored for use in reclamation may become a source of contamination if located with the area to be mined.*

3. Controls implemented during processing

a. Describe how factors that contribute to aggregate non-uniformity will be minimized. *Any blending must be automated or otherwise mechanically controlled.*

(1) Separate stockpiling of raw material or blending at the hopper. *Materials that cannot be mixed during load-out from the face (such as those that come from different locations within the operation or when blending materials originate off-site) should be combined from separate feeds. The blending should be automated or mechanically controlled. Atypical setups should be discussed with the Materials Bureau.*

(2) Blending or mixing in the plant. *See the comments in 1., above.*

b. Describe how quality will be enhanced through equipment selection, plant flow design, or material process control. *Improvements are made at the discretion of the producer and should be undertaken advisedly. When a program of quality*

enhancement is undertaken with the intent of producing an aggregate to meet minimum or specialty item requirements, results should be evaluated by the producer before seeking Department approval.

4. Stockpiling

- a. Address factors that cause aggregate non-uniformity. There are stockpiling methods that may be employed such as :

(1) Blending during material transfer using established load-out patterns from beneath stackers or bins.

(2) Moving radial stackers to mix aggregate on the ground.

- b. Describe how contamination will be minimized in stockpiles. *The unintended presence of material that changes the composition of an aggregate in an undesirable way, is contamination. Contaminants may affect durability, pavement friction, etc. and may be avoided by:*

(1) Orderly storage area and adequate separation of piles. *Usually barriers between materials or enough separation to allow a loader to pass between is adequate.*

(2) Informing operators of the location of the various aggregate products.

(3) Labeling piles

- c. Describe how stockpiles will be monitored. *This description shall include the tests being used, minimum testing frequency, who will do the tests, and the actions that will be taken if tests show the material does not meet requirements. There are various methods available to check stockpiles for uniformity and for contamination which include:*

(1) Visual examination by the producer's geologist or other trained personnel. *Maintaining a set of reference samples in the laboratory greatly facilitates visual examination, particularly by personnel other than geologists.*

(2) Physical testing of stockpiled materials by whatever method is appropriate to address the particular uniformity concern. *This may include specific gravity, unit weight, percent crushed, uncompacted voids content, flat & elongate, organic color, magnesium soundness, or freeze-thaw.*

5. Records

- a. Records of quality monitoring may be needed in problem and dispute resolution.
- b. Identify those elements of the Operations Plan that call for record keeping. *Records of testing, visual inspection of faces or materials, or other quality-related monitoring are important.*
- c. Identify how and under what condition records are kept. *The records may be kept on-site or off-site; in the laboratory, office, scale house, etc.*
- d. Identify the person responsible for maintaining these records.

OPERATIONS PLAN TEMPLATE

1. Basic Information and Personnel

- a. Name and address of property owner or lessee.
- b. Name, title, email address and telephone number of company contact person.
- c. Name, title, and telephone number of the person responsible for administration of the Operations Plan.
- d. Photographs

2. Controls implemented during excavation

- a. Overburden removal
 1. To what depth is overburden removed?
 2. What is the minimum separation between the edge of overburden stripping and the production face?
 3. How will sloughed overburden be avoided?
 4. Will the overburden be stored within the area to be mined?

3. Processing controls

- a. Describe how non-uniformity will be minimized during aggregate processing.
- b. Describe how aggregate quality will be improved by processing.

4. Stockpiling

- a. Describe how non-uniformity will be minimized in stockpiling.
- b. Describe how contamination will be minimized in stockpiles.
- c. Describe how stockpiles will be monitored for non-uniformity and contamination.
 1. How will segregation and contamination be visually monitored, and by whom?
 2. What physical tests will be employed to monitor non-uniformity and contamination?
 3. What is the minimum testing frequency?
 4. Who will do the tests?
 5. What actions will be taken when material does not meet requirements?

5. Records

- a. What quality monitoring records are maintained?
- b. Where are these quality monitoring records kept?
- c. Who is responsible for maintaining these records?

Sample

OPERATIONS PLAN TEMPLATE

(Sample Operations Plan for a Long Island and Southern New Jersey)

1. Basic Information and Personnel

a. Name and address of property owner or lessee:

Glacier Sand & Gravel, Inc.
Gravel Pit Road
Kings Park, Long Island, NY 12121

b. Name, title, mail address, email address and telephone number of company contact person:

Joseph Bushey, Quality Control Manager, jbushey@glacier.com, (315) 555-1212
Glacier Sand & Gravel, Inc.
Gravel Pit Road
Kings Park, Long Island, NY 12121

c. Name, title, and telephone number of the person responsible for Operations Plan administration: J. Jones, Plant Administrator, (516) 555-4357

d. Photographs: (attached)

2. Controls implemented during excavation - Overburden removal

a. To what depth is overburden removed? Overburden is stripped to an average depth of approximately 3 feet and is based on the color change from the reddish brown of the soil and weathered material to the gray of the fresh sand and gravel.

b. What is the minimum separation between the edge of overburden stripping and the production face? Overburden is generally stripped approximately 25 feet beyond the short-term projected location of the active face.

c. How will sloughed overburden be avoided? Any overburden that has inadvertently fallen into an area to be mined, it will be removed prior to any mining in that area.

d. Will the overburden be stored within the area to be mined? Stripped overburden will be stored outside the mining limit.

3. Processing controls

a. Describe how non-uniformity will be minimized during aggregate processing. Material, as it is loaded out of the face (see 2.c.1.) is well mixed and no further special handling is required.

b. Describe how aggregate quality will be improved by processing. A 12-inch grizzly removes large particles. Crushing will remove additional unsound particles from the minus 12-inch feed.

4. Stockpiling

a. Describe how non-uniformity will be minimized in stockpiling. The crushing and screening plant is equipped with radial stackers that will be moved from side-to-side.

b. Describe how contamination will be minimized in stockpiles. Contamination from overburden or hardpan is controlled at the face. Mixing of material from adjacent stockpiles is controlled by maintaining a minimum loader-width separation.

c. Describe how stockpiles will be monitored for non-uniformity and contamination:

1. How will non-uniformity and contamination be visually monitored, and by whom?

The Laboratory Manager (Robert Rocks) will visually compare weekly stockpile gradation samples to reference samples maintained in the lab. In addition, the lab manager will examine all stockpiles daily for non-uniformity and contamination.

2. What physical tests will be employed to monitor segregation and contamination?

No physical tests are needed. Only visual inspections are conducted.

3. What is the minimum testing frequency? Visual inspections are conducted daily.

4. Who will do the tests? The Laboratory Manager

5. What actions will be taken when material does not meet requirements? No aggregates will be shipped to state jobs until the extent of the contamination is determined. Corrective action will be taken. Only aggregates that have passed the visual inspection will be shipped.

5. Records

a. What quality monitoring records are maintained? Records are kept of when visual checks are made of the faces and stockpiles.

b. Where are these quality monitoring records kept? All inspection and test records are kept in the laboratory. Records for previous years will be archived in the company main office.

c. Who is responsible for maintaining these records? J. Jones is responsible for maintaining records during the construction season. J. Bushey is responsible for archived records.

The Operations Plan described herein is a true and accurate representation of the quality management activities to be conducted of behalf of this aggregate source.

(signed)

J. Jones, Plant Administrator

APPENDIX C - 1

NYSDOT AGGREGATE TEST METHODS

NYSDOT AGGREGATE TEST METHODS

The table shows test methods used by the Department to test aggregate samples submitted for evaluation by the Department for use in portland cement and bituminous concrete. For the most part, the Department has adopted AASHTO or ASTM methods, some with modifications. For those remaining tests, the methods are discussed and their texts are included in their entirety.

Test	NYSDOT	AASHTO/ ASTM*	Equivalence**
Sieve Analysis for Fine & Coarse Agg.	703-01 P,G	AASHTO T27	Yes
Minus #200 Material by Washing	703-02 P,G	AASHTO T11	Yes
Organic Impurities in Fine Aggregate	703-03 P,G	AASHTO T21	Yes
Specific Gravity & Absorption - Fine Agg.	703-05 P,G	AASHTO T84	Modified
Specific Gravity & Absorption - Crs. Agg.	703-09 P,G	AASHTO T85	Modified
Soundness of Fine Aggregate in MgSO ₄	703-06 P,G	AASHTO T104	No
Soundness of Crs. Aggregate in MgSO ₄	703-07 P,G		
Soundness of Crs. Agg. By Freeze/Thaw	703-08 P,G	AASHTO T103	No
Unit Weight	703-10 P,G	AASHTO T19	Yes
Los Angeles Abrasion	703-11 P,G	AASHTO T96	Yes
Reducing Field Samples	703-16 P,G	AASHTO T248	Yes
Moisture Content by Drying	703-17 P,G	AASHTO T255	Yes
Percent Non-Carbonate in Friction Agg.	In MM 28	ASTM C295	Modified
Sand-Sized Acid Insoluble Residue Content	In MM 28	ASTM D 3042	Modified
Flat Particles, Elongated Particles, and Flat and Elongated Particles (5:1)	-	ASTM D 4791	-
Percent Crushed Particles	-	ASTM D 5821	-
Uncompacted Voids Content	-	AASHTO T304	-

* AASHTO test methods are preferred

** Yes - NYSDOT has adopted the AASHTO or ASTM method

No - NYSDOT uses a method that is substantially different from AASHTO or ASTM.

Those differences result from NYSDOT research.

Modified- NYSDOT has made slight modifications to the AASHTO or ASTM method.

**MAGNESIUM SULFATE SOUNDNESS TESTS
703-06 P,G, Fine Aggregate, and 703-07, Coarse Aggregate**

Background:

The NYSDOT methods differ significantly from AASHTO T104 (which is equivalent to ASTM C 88) in that the Department's methods specify magnesium, rather than offer a choice of magnesium or sodium sulfate; it specifies the number of cycles (5 cycles for fine aggregate, 10 cycles for coarse aggregate); it also requires tighter control on the specific gravity of the solution, larger sample sizes, and the results are weighted using the same fine or coarse aggregate gradation for each fine or coarse aggregate sample. The construction and dimensions of the sample containers are specified.

Magnesium Sulfate vs. Sodium Sulfate:

Of the two sulfate tests, the sodium sulfate soundness test has been found to be more variable and less harsh than the magnesium test. This has been determined not only by reviewing Department testing history but has been confirmed by other investigators.

10 Cycles vs. 5 Cycles:

Ten-cycle sulfate tests on coarse aggregate have been run for the Department's entire recorded testing history. A 10-cycle test is more severe than a 5-cycle test, and has the advantage of improving discrimination between samples of different quality.

Variation of magnesium sulfate soundness test results:

The test's sensitivity to a number of environmental factors results in an unusually high reported variability. This reported variability is reflected in the precision statement in AASHTO T 104 and is discussed at length by Dolar-Mantuani (ASTM Special Technical Pub. No. 169B, 1978). This variability can be somewhat reduced by using sample containers of uniform design and construction and by being aware of and controlling the affecting environmental factors such as temperature, solution saturation, solution filtration, drying time and temperature. In spite of this, there has been found to be good correlation between low magnesium sulfate soundness losses and good aggregate performance.

**FREEZE - THAW TEST ON COARSE AGGREGATE
703-08 P,G**

Background:

The NYSDOT method differs significantly from AASHTO T103 (equivalent to ASTM) in that the Department's method uses a NaCl brine solution rather than plain water or an alcohol-water solution; does not offer a partial-immersion alternative; is restricted to coarse aggregate only; and specifies the number of cycles (25), a larger sample size, and a different gradation. The construction and dimensions of the sample containers are specified.

NaCl Brine, 3% vs 10%:

The Department tested unconfined coarse aggregate in a 10% NaCl brine until 1992 when it switched to 3% NaCl brine. The 3% solution freeze-thaw test is much harsher than the 10% test and represents pessimum highway conditions. The specification limit on Freeze-Thaw test results has been adjusted upward to reflect the increased harshness.

**ACID INSOLUBLE RESIDUE
IN CARBONATE COARSE AGGREGATES AND IN FINE AGGREGATES
in MM28**

Background:

The NYSDOT method differs from ASTM D 3042 (there is no AASHTO equivalent) in that the Department's methods specify that the determination is to be made of sand sized (+ #200 sieve) residue, rather than giving a choice of sand size or total residue; ASTM specifies reagent grade hydrochloric acid (HCl), a device for agitation during digestion, and sample sizes that are larger. The text of the test method is in MM28 and not included in Appendix C because, although the differences between the NYSDOT and the ASTM methods are numerous, there should be no difference in the outcome of the test using either method.

Acid insoluble residue (AIR) determinations are made on carbonate crushed stone, manufactured fine aggregates and natural fine aggregates. The Materials Bureau uses them for the purpose of determining conformance with friction aggregate specifications and for evaluating potential alkali-silica reactivity. When carbonate rocks (generally limestone, dolomite, or marble) are digested by hydrochloric acid (HCl), particles that do not dissolve constitute the insoluble residue. When natural fine aggregates (sands) are digested by hydrochloric acid (HCl), particles that do not dissolve, including non-carbonate particles, constitute the insoluble residue. In either case, only the sand-size (+ #200 sieve) particles of insoluble residue (mostly quartz sand) are considered.

PERCENT NONCARBONATE DETERMINATION in MM28

Background:

NYSDOT began specifying friction coarse aggregates for surface course HMA mixtures in 1969 and PCC in 2003. Limestone aggregates were allowed, but required a minimum specified amount of noncarbonate aggregate be included. This noncarbonate content could be derived from materials occurring naturally within the limestone (i.e., chert) or from blending noncarbonate materials in a plant. More recently, noncarbonate content has been required of dolomite under certain conditions of traffic volume and/or location.

The test is a modified petrographic analysis (ASTM C 295) and is contained in MM28. It consists of sections on the use of reference samples, visual analysis, reaction with hydrochloric acid, and copper nitrate staining. The results obtained must be considered aids to, not surrogates for, the identification and separation of carbonate and noncarbonate particles.

DELETERIOUS MATERIALS MONITORING Based on Table 703-3 in the Standard Specifications and ASTM C 295

Background:

The presence of deleterious materials in aggregate has been a longstanding Department concern. The Standard Specifications has contained a list or table of deleterious materials and their tolerable limits to address this concern. Maximum allowable limits are shown in Table 703-3 in the Standard Specifications.

Deleterious materials are identified petrographically (ASTM C 295), sometimes with the aid of supplementary tests. The following materials (also shown in Table 703-3) are almost universally regarded as detrimental to aggregate performance.

Shale and shale-like materials:

A detailed note of explanation accompanies this designation. When fissile materials (having the property of splitting easily along closely-spaced parallel planes) are encountered that may fit this designation, they may be separated from the other lithologies in the sample and tested according to 703-08 P,G, Freezing and Thawing. A loss of 20% or greater is indication of its deleterious nature.

Coal/ Lignite/ Sulfides:

Coal and lignite are rarely encountered in New York aggregates and are identified by their light weight and color. Mineral sulfides, such as pyrite, marcasite, and pyrrhotite are

associated with a wide variety of rock types. Bog iron is associated with sand & gravel deposits in some locations.

Clay lumps or wood:

Both materials are easily identifiable and, when dry, are lighter than water.

Metal ore:

The problem with metal ores is their high specific gravity, which may affect the proper proportioning of materials into a volumetrically designed mix. When appropriate adjustments to yield are made, these materials may be used.

Other deleterious materials:



Cemented clusters of particles, weathered materials, and other materials that, in a particular region or locality, have been found to be deleterious, are addressed here. Issues related to their occurrence and controls are properly addressed in the Geological Source Report.

Total deleterious materials:

Occasionally two or more deleterious materials are found at a source. This provision addresses this circumstance.

APPENDIX C – 2 703-06P,G

**STANDARD TEST METHOD FOR SOUNDNESS OF FINE AGGREGATE BY
USE OF MAGNESIUM SULFATE**

	NEW YORK STATE DEPARTMENT OF TRANSPORTATION MATERIALS BUREAU ALBANY, NY 12232	Method No.: 703-06P,G Issue Date: February 1, 1993 Subject Code: 7.42-5
	TEST METHOD	
SUBJECT: STANDARD TEST METHOD FOR SOUNDNESS OF FINE AGGREGATES BY USE OF MAGNESIUM SULFATE		
APPROVED:  Wayne J. Brule, Director, Materials Bureau	Supersedes: NY207A-76 Dated:	

1. SCOPE

1.1 This method covers the procedure to be followed in testing fine aggregates to determine their resistance to disintegration by a saturated solution of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to weathering conditions. The format and wording of this method is similar to AASHTO T 104.

2. REFERENCE DOCUMENTS

- 2.1 AASHTO Standard:
 M 92 Wire cloth sieves for testing purposes
- 2.2 ASTM Standards
 E 11 Wire cloth sieves for testing purposes
 E 100 Specification for ASTM Hydrometers
 C295 Standard Recommended Practice for PETROGRAPHIC EXAMINATION OF AGGREGATES FOR CONCRETE

3. APPARATUS

3.1 **Sieves** - With square openings of the following sizes conforming to AASHTO M 92 or ASTM E 11, for sieving the samples in accordance with selections 5, 6, and 8:

0.3 mm	(No. 50)	2.36 mm	(No. 8)
0.6 mm	(No. 30)	4.75 mm	(No. 4)
1.18 mm	(No. 16)	9.5mm	(3/8 in.)

3.2 **Containers** - Baskets for immersing the samples of aggregate in the solution, in accordance with the procedure described in this method, shall be constructed in such a manner as to permit free access of the solution to the sample, and drainage of the solution from the sample without loss of aggregate. The baskets shall have a stainless steel frame with stainless steel square wire mesh 0.25mm (No. 60). They shall be approximately 1.7cm (5 in.) in diameter, 5.08cm (2 in.) inside

703-06P,G
February 1, 1993
Page 2

and 6.35cm (2 1/2 in.) outside height, with at least six 3.81cm (1 1/2 in.) square windows of mesh on the sides and the recessed bottom entirely of mesh.

3.3 Temperature Regulation - Suitable means for regulating the temperature of the samples during immersion in the magnesium sulfate solution shall be provided. A circulation tank with a filter and a cover to reduce evaporation and prevent the accidental addition of extraneous substances is preferred.

3.4 Balance - The balance shall conform to AASHTO M231, Class G2.

3.5 Drying Oven - The oven shall have circulating fans and shall be capable of being heated continuously at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$). The rate of evaporation, at this range of temperature shall average at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-liter Griffin low-form beakers, each initially containing 500 g of water at a temperature of $21 \pm 2^\circ\text{C}$ ($70 \pm 3^\circ\text{F}$), placed at each corner and the center of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

3.6 Specific Gravity Measurement - A hydrometer conforming to the requirements ASTM E 100, or a suitable combination of graduated glassware and balance, capable of measuring the solution specific gravity within ± 0.001 shall be used.

4. MAGNESIUM SULFATE SOLUTION

4.1 Prepare the solution of magnesium sulphate for immersion of test samples in accordance with Section 4.1.1. The volume of the solution shall be at least five times the solid volume of all samples immersed at any one time.

4.1.1 MAGNESIUM SULPHATE SOLUTION - Prepare a saturated solution of magnesium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 25 to 30°C (77 to 86°F). Add sufficient salt (Note 1), of either the anhydrous (MgSO_4) or the crystalline ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) (Epsom salt) form to ensure saturation and the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to $23.3 \pm 0.6^\circ\text{C}$ ($74.0 \pm 1.0^\circ\text{F}$). Again, stir and allow the solution to remain at the designated temperature for at least 48 hours before use. Prior to each use, break up the salt cake in the container, if any, stir the solution thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity of 1.300 ± 0.002 and a temperature of $23.3 \pm 0.6^\circ\text{C}$ ($74.0 \pm 1.0^\circ\text{F}$). Discolored solution shall be discarded or filtered for use if, when checked, the chemical purity and specific gravity meet the requirements.

Note 1 - For the solution, 350 g of anhydrous salt or 1230 g of the heptahdrate per liter of water are sufficient for saturation at 23.3°C (74.0°F). However, since these salts are not completely stable, with the hydrous salt being the more stable of the two, and since it is desirable that an excess of crystals be present, it is recommended that the heptahdrate salt be used and in an amount of not less than 1400 g per liter of water.

703-06P,G
February 1, 1993
Page 3

5. SAMPLES

5.1 **FINE AGGREGATES** - Fine aggregate for the test shall be passed through a 9.5mm (3/8 in) sieve. The sample shall be of such size that it will yield not less than 100 g of each of the following sizes which shall be available in amounts of 5 percent or more for each of the retained sieve fractions. Should the sample contain less than 5 percent of any of the sizes specified, that size shall not be tested.

<u>Passing Sieve</u>	<u>Retained on Sieve</u>
0.6 mm (No. 30)	0.3 mm (No. 50)
1.18 mm (No. 16)	0.6 mm (No. 30)
2.36 mm (No. 8)	1.18 mm (No. 16)
4.75 mm (No. 4)	2.36 mm (No. 8)
9.5 mm (3/8 in.)	4.75 mm (No. 4)

6. PREPARATION OF TEST SAMPLE

6.1 Dry the 23kg (50 lb.) field sample to remove enough retained water so that a representative sample of the fine aggregate, approximately 1400 grams, may be obtained by either the splitting or quartering method.

6.2 Separate the 1400 gram sample into the different sizes by sieving as follows:

6.2.1 Make a rough separation of the sizes by means of a nest of the standard sieves specified in section 5.1. Shake for ten minutes and weigh out approximately 170 grams of each sieve size.

6.2.2 Combine the 170 gram sieve fractions, place them into a nest of standard sieves and shake for an additional ten minutes. Weigh out approximately 125 grams of each size.

6.2.3 Combine the 125 gram sieve fractions; thoroughly wash the combined sample and dry to a constant weight at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$). Place the sample into the nest of standard sieves and shake for fifteen minutes. Hand tap each size until refusal. Weigh out 100 grams and place into separate baskets for testing. In preparing the sample, do not use any of the fine aggregate sticking in the meshes of the sieves.

Note 2 - The designated steps (6.1 - 6.2.3) have been developed through research by NYSDOT to avoid overloading any sieve fraction, assure adequate material for testing all sieve fractions, and assure proper separation of all sizes during preparation of the test sample.

7. PROCEDURE

7.1 **Storage of Samples** - Immerse the samples in the prepared solution of magnesium sulfate for not less than 16h nor more than 18h in such a manner that the solution covers them to a depth of least 12.5mm (1/2 in.), (Note 3). Maintain the samples immersed in the solution at a temperature of $23.3 \pm 0.6^{\circ}\text{C}$ ($74 \pm 1^{\circ}\text{F}$).

Note 3 - Cover the tank to reduce evaporation and prevent the accidental addition of extraneous substances. For lightweight aggregates it is also necessary to cover each basket with a plastic cover.

703-06P,G
February 1, 1993
Page 4

7.2 Drying Samples After immersion - After the immersion period, remove the aggregate sample from solution, permit it to drain for 15 ± 5 minutes and place in the drying oven. The temperature of the oven shall have been brought previously to $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$). Dry the samples at the specified temperature until constant weight has been achieved. Establish the time required to attain constant weight as follows: with the oven containing the maximum sample load expected, check the weight losses of test samples by removing and weighing them, without cooling, at intervals of 2 to 4 hours. Make enough checks to establish required drying time for the least favorable oven location and sample condition (Note 4). Constant weight will be considered to have been achieved when weight loss is less than 0.1 percent in 4 hours of drying. After constant weight has been achieved, allow the samples to cool to $20\text{-}25^\circ\text{C}$ ($68\text{-}77^\circ\text{F}$) when they shall again be immersed in the prepared solution as described in Section 7.1. Experience has shown that sample temperatures significantly different than 23.3°C (74°F) may change the temperature of the solution temporarily, thereby causing a change in salt saturation, even though the solution returns to 23.3°C (74°F) for most of the soaking period. Cooling of the sample may be aided by use of an air conditioner or fan.

Note 4 - Drying time required to reach constant weight may vary considerably for several reasons. Efficiency of drying will be reduced as cycles accumulate because of the salt adhering to the particles and, in some cases, of increased surface area due to breakdown. The different size fractions of aggregate will have differing drying rates. The smaller sizes will tend to dry more slowly because of their larger surface area and restricted interparticle voids, but this tendency may be altered by the effects of the container size and shape.

7.3 Number of Cycles - Repeat the process of alternate immersion and drying until 5 cycles have been completed. If the test must be interrupted, leave the samples in an oven dried condition (constant weight) at room temperature until testing can be resumed.

8. QUANTITATIVE EXAMINATION

8.1 Make the quantitative examination as follows:

8.1.1 After the completion of the final cycle and after the sample has cooled, wash the sample free from the sodium sulfate or magnesium sulfate. Wash by circulating water at $43 \pm 6^\circ\text{C}$ ($110 \pm 10^\circ\text{F}$) through the samples in their containers by introducing hot water near the bottom and allowing the water to pass through the samples and overflow. The thoroughness of washing shall be checked by obtaining a sample of rinse water after it has passed through the samples and checked with a 10% solution of barium chloride. Further washing is required if sample becomes cloudy upon addition of the barium chloride solution. In areas where the water gives a reaction with barium chloride other analytical means shall be used to assure thoroughness of washing. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

8.1.2 After the magnesium sulfate has been removed, dry each fraction of the sample to constant weight at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$). Sieve the fine aggregate for 15 minutes over the sieve on which it was retained before the test. Do not hand tap sieves. Weigh the material retained on each sieve and record each amount. The difference between the weights is the loss to be expressed

703-06P,G
 February 1, 1993
 Page 5

as a percentage of the initial weight for use in Table 1.

9. REPORT

9.1 The report shall include the following data (Note 5):

9.1.1 Weight of each fraction before test.

9.1.2 Weight of each fraction after test.

9.1.3 Weight lost from each fraction determined by subtracting the weight in 9.1.2 from the weight in 9.1.1. The loss shall be expressed as a percentage of the original weight of each fraction.

9.1.4 Weighted average calculated from the percentage of loss for each fraction, based on the NYSDOT "Standard Gradation (Note 5) except that:

9.1.4.1 For purposes of calculating the weighed average, assume that sizes finer than the 0.3 mm (No. 50) to have 0% loss.

9.1.4.2 For the purpose of calculating the weighted average, consider any sizes in Section 5.1 that contain less than 5 percent of the sample to have the same loss as the average of the next smaller and the next larger size, or if one of these sizes is absent, to have the same loss as the next larger or smaller size, whichever is present.

TABLE 1

SUGGESTED FORM FOR RECORDING TEST DATA
 (With illustrative Test Values)

Retained on Sieve (See Section 5.1)	4.75mm(No.4)	2.36mm(No.8)	1.18mm(No. 16)	0.6mm(No. 30)	0.3mm(No. 50)
Weight of Test Fraction (Before Test, grams)	0.0	100.0	100.0	100.0	100.0
Weight of Test Fraction (After Test, grams)		60.4	68.5	74.5	84.7
Loss in grams		39.6	31.5	25.5	15.3
Loss in Percent	39.6	39.6	31.5	25.5	15.3
Standard Gradation (Percent Retained, Note 5)	5%	15%	15%	22%	23%
Weighted Percent Loss	1.98	5.94	4.73	5.61	3.51
Total Weighted Loss (Percent)	21.8				

Note 5 - The use of sample gradation to calculate a "Weighted Percent Loss" was discontinued in 1965. At that time, it was determined that total weighted loss for a sample could vary by as much as 6% when the sample gradation was used to weight losses. Weighted Percent Loss is now calculated using a "Standard Gradation" which is the mean of the NYSDOT Specification limits

703-06P,G
February 1, 1993
Page 6


expressed as "Percent Retained" for Portland Cement Concrete fine aggregates. All fine aggregates, both portland cement concrete and bituminous sands, are evaluated in this manner to allow comparison of quality between deposits and monitor uniformity of the deposit and its operation. With geologic control and the use of the "Standard Gradation", the magnesium sulfate soundness losses for the deposit in Table 1 have ranged between 18.1% to 21.8% for the years 1965-1992. The magnesium sulfate soundness loss for the same deposit in 1964 was 14.7%.

STANDARD GRADATION

<u>Sieve</u>	<u>Percent Retained</u>
4.75mm (No. 4)	5
2.36mm (No. 8)	15
1.18mm (No. 16)	15
0.6mm (No. 30)	22
0.3mm (No. 50)	23

APPENDIX C – 3 703-07P,G

**STANDARD TEST METHOD FOR SOUNDNESS OF COARSE AGGREGATE
BY USE OF MAGNESIUM SULFATE**

	NEW YORK STATE DEPARTMENT OF TRANSPORTATION MATERIALS BUREAU ALBANY, NY 12232	Method No.: 703-07P,G Issue Date: February 1, 1993 Subject Code: 7.42-5
	TEST METHOD	
SUBJECT: STANDARD TEST METHOD FOR SOUNDNESS OF COARSE AGGREGATES BY USE OF MAGNESIUM SULFATE		
APPROVED: <u>Wayne J. Brule</u> Wayne J. Brule, Director, Materials Bureau	Supersedes: NY207B-83 Dated:	

1. SCOPE

1.1 This method covers the procedure to be followed in testing coarse aggregates to determine their resistance to disintegration by a saturated solution of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to weathering conditions. The format and wording of this method is similar to AASHTO T 104.

2. REFERENCE DOCUMENTS

2.1 AASHTO Standard:

M 92 Wire cloth sieves for testing purposes

2.2 ASTM Standards:

E 11 Wire cloth sieves for testing purposes

E 100 Specification for ASTM Hydrometers

C 295 Standard Recommended Practice for PETROGRAPHIC EXAMINATION OF AGGREGATES FOR CONCRETE

3. APPARATUS

3.1 Sieves - With square openings of the following sizes conforming to AASHTO M 92 or ASTM E 11, for sieving the samples in accordance with sections 5, 6 and 8:

4.75mm (No. 4)	12.5mm (1/2 in.)
6.3mm (1/4 in.)	19.0mm (3/4 in.)
9.5mm (3/8 in.)	25.0mm (1 in.)

3.2 Containers - Baskets for immersing samples of aggregate in solution, in accordance with the procedure described in this method, shall be made entirely of stainless steel with wire mesh sides and bottoms, permitting free access of the solution to the sample, and drainage of solution from the sample without loss of aggregate. The baskets shall be a minimum of 15.24cm (6 in.) in diameter and 15.24cm (6 in.) high, for No. 2 sized aggregate, and a minimum of 10.16cm (4 in.) in diameter and 15.24cm (6 in.) high, for No. 1 sized aggregate.

703-07P,G
February 1, 1993
Page 2

3.3 Temperature Regulation - Suitable means for regulating the temperature of the samples during immersion in the magnesium sulfate solution shall be provided. A circulation tank with a filter and a cover to reduce evaporation and prevent the accidental addition of extraneous substances is preferred.

3.4 Balance - The balance shall conform to AASHTO M 231, Class G5.

3.5 Drying Oven - The oven shall have circulating fans and shall be capable of being heated continuously at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$). The rate of evaporation, at this range of temperature shall average at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-liter Griffin low-form beakers, each initially containing 500 g of water at a temperature of $21 \pm 2^\circ\text{C}$ ($70 \pm 3^\circ\text{F}$), placed at each corner and the center of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

3.6 Specific Gravity Measurement - A hydrometer conforming to the requirements ASTM E 100; or a suitable combination of graduated glassware and balance, capable of measuring the solution specific gravity within ± 0.001 shall be used.

4. Magnesium Sulfate Solution

4.1 Prepare the solution of magnesium sulphate for immersion of test samples in accordance with Section 4.1.1. The volume of the solution shall at least be five times the solid volume of all samples immersed at any one time.

4.1-1 Magnesium Sulphate Solution - Prepare a saturated solution of magnesium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 25 to 30°C (77 to 86°F). Add sufficient salt (Note 1), of either the anhydrous (MgSO_4) or the crystalline ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) (Epsom salt) form to ensure saturation and the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to $23.3 \pm 0.6^\circ\text{C}$ ($74.0 \pm 1.0^\circ\text{F}$). Again, stir and allow the solution to remain at the designated temperature for at least 48 hours before use. Prior to each use, break up the salt cake in the container, if any, stir the solution thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity of 1.300 ± 0.002 and a temperature of $23.3 \pm 0.6^\circ\text{C}$ ($74.0 \pm 1.0^\circ\text{F}$). Discolored solution shall be discarded or filtered for use if, when checked, the chemical purity and specific gravity meet the requirements.

Note 1 - For the solution, 350 g of anhydrous salt or 1230 g of the heptahdrate per liter of water are sufficient for saturation at 23.3°C (74.0°F). However, since these salts are not completely stable, with the hydrous salt being the more stable of the two, and since it is desirable that an excess of crystals be present, it is recommended that the heptahdrate salt be used and in an amount of not less than 1400 g per liter of water.

5. SAMPLES

703-07P,G
February 1, 1993
Page 3

5.1 **Coarse Aggregate** - The sizes of coarse aggregate for the test shall be restricted to the NYSDOT No. 1 and No. 2 sizes, (see Note 2). A representative sample from the source shall be tested using square opening sieves and the sample weights listed below:

<u>NYSDOT Size</u>	<u>Passing Sieve</u>	<u>Retained Sieve</u>	<u>Weight (grams)</u>
No.2	25.0mm (1 in.)	12.5mm (1/2 in.)	2500 ± 50
Consisting of:	25.0mm (1 in.)	19.0mm (3/4 in.)	1500 ± 50
	19.0mm (3/4 in.)	12.5mm (1/2 in.)	1000 ± 30
No. 1	12.5mm (1/2 in.)	6.3mm (1/4 in.)	1000 ± 25

Note 2 - Research completed by the Materials Bureau, NYSDOT indicates that, the surface area of the sample tested, influences the final losses of the magnesium sulfate soundness test. A sandstone lithology may double it's loss each time the particle diameter is reduced by one-half. To eliminate this variable, the NYSDOT Acceptance for the magnesium sulfate soundness test (10 cycles) is based on the No. 2 size fraction. At this time, the No. 1 size fraction is tested for information only.

6. PREPARATION OF TEST SAMPLE

6.1 Thoroughly wash and dry the sample to constant weight at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) and separate into the different sizes shown in Section 5.1 by sieving to refusal. In preparing the sample, do not use any of the material sticking in the meshes of the sieves. The proper weight of each size fraction shall be obtained by splitting or quartering. Combine the plus 19.0mm (3/4 in.) and the plus 12.5mm (1/2 in.) sizes to meet the tolerances of the N.Y.S. No. 2 sizes shown in Section 5.1. Place the No. 1 and the No. 2 sizes in separate baskets. Prior to testing, a petrographic examination shall be made of the No. 2 size test sample. ASTM C 295 "Standard Recommended Practice for PETROGRAPHIC EXAMINATION OF AGGREGATE FOR CONCRETE" shall be followed.

7. PROCEDURE

7.1 **Storage of samples** - Immerse the samples in the prepared solution of magnesium sulfate for not less than 16 h nor more than 18 h in such a manner that the solution covers them to a depth of least 12.5mm (1/2 inch) (Note 3). Maintain the samples immersed in the solution at a temperature of $23.3 \pm 0.6^{\circ}\text{C}$ ($74.0 \pm 1^{\circ}\text{F}$).

Note 3 - Cover the tank to reduce evaporation and prevent the accidental addition of extraneous substances. For lightweight aggregates it is necessary to cover each basket with a tight fitting plastic cover containing perforations.

7.2 **Drying samples after immersion** - After the immersion period, remove the aggregate sample from solution, permit it to drain for 15 ± 5 minutes and place in the drying oven. The temperature of the oven shall have been brought previously to $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$). Dry the samples at the specified temperature until constant weight has been achieved. Establish the time required to attain constant weight as follows: with the oven containing the maximum sample load expected,

703-07P,G
February 1, 1993
Page 4

check the weight losses of test samples by removing and weighing them, without cooling, at intervals of 2 to 4 hours. Make enough checks to establish required drying time for the least favorable oven location and sample condition (Note 4). Constant weight will be considered to have been achieved when weight loss is less than 0.1 percent in 4 hours of drying. After constant weight has been achieved, allow the samples to cool to 20-25°C (68-77°F) when they shall again be immersed in the prepared solution as described in Section 7.1. Experience has shown that sample temperatures significantly different than 23.3°C (74°F) may change the temperature of the solution temporarily, thereby causing a change in salt saturation, even though the solution returns to 23.3°C (74°F) for most of the soaking period. Cooling of the sample may be aided by use of an air conditioner or fan.

Note 4 - Drying time required to reach constant weight may vary considerably for several reasons. Efficiency of drying will be reduced as cycles accumulate because of the salt adhering to the particles and, in some cases, of increased surface area due to breakdown. The different size fractions of aggregate will have differing drying rates. The smaller sizes will tend to dry more slowly because of their larger surface area and restricted interparticle voids, but this tendency may be altered by the effects of the container size and shape.

7.3 Number of Cycles - Repeat the process of alternate immersion and drying until 10 cycles have been completed. If the test must be interrupted, leave the samples in an oven dried condition (constant weight) at room temperature until testing can be resumed.

8. QUANTATIVE EXAMINATION

8.1 Make the quantitative examination as follows:

8.1.1 After the completion of the final cycle and after the sample has cooled, wash the sample free from the magnesium sulfate. Wash by circulating water at $43 \pm 6^\circ\text{C}$ ($110 \pm 10^\circ\text{F}$) through the samples in their containers by introducing hot water near the bottom and allowing the water to pass through the samples and overflow. The thoroughness of washing shall be checked by obtaining a sample of rinse water after it has passed through the samples and checked with a 10% solution of barium chloride. Further washing is required if sample becomes cloudy upon addition of the barium chloride solution. In areas where the water gives a reaction with barium chloride other analytical means shall be used to assure thoroughness of washing. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

8.1.2 After the magnesium sulfate has been removed, dry each fraction of the sample to constant weight at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$). Sieve the coarse aggregate over the sieve shown below for the appropriate size of particle. Sieving shall be done by hand, with agitation sufficient only to assure that all undersize material passes the designated sieve. No extra manipulation shall be employed to break up particles or to cause them to pass the sieves. Weigh the material retained on each sieve and record each amount. The difference between each of these amounts and the initial weight of the fraction of the sample tested, is the loss in the test and is to be expressed as a percentage of the initial weight for use in Table 1.

703-07P,G
 February 1, 1993
 Page 5

<u>Size of Aggregate</u>	<u>Sieve Used to Determine Loss</u>
25.0mm (1 in.) to 12.5mm (1/2 in.)	9.5mm (3/8 in.)
12.5mm (1/2 in.) to 6.3mm (1/4 in.)	4.75mm (No. 4)

9. QUALITATIVE EXAMINATION

9.1 After testing, examine the No. 2 size fraction. Using the lithologies found in the premag petrographic examination, (6.1) determine the weight and percent of each lithology which has been retained on the 9.5mm (3/8 in.) sieve.

9.1.1 Examine the particles passing the (9.5mm) (3/8 in.) sieve and note the type of distress exhibited by each lithology, (See Note 5).

Note 5 - Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking, etc. While only the No. 2 size fraction is required to be examined, it is recommended that an examination of the No. 1 size be made. The information obtained from the petrographic examination shall be used to aid in the interpretation of test results.

10. REPORT

10.1 The report shall include the following data:

10.1.1 Weight of the No. 2 and No. 1 size fractions before test.

10.1.2 Weight of the No. 2 and No 1. size fractions retained on the designated sieve used in Section 8.1.2 to determine loss for these size fractions after test. The loss shall be expressed as a percentage of the original weight of each fraction.

TABLE 1

SUGGESTED FORM FOR RECORDING TEST DATA
 (With illustrative Test Values)

NYS DOT Aggregate Size No.	2	1
Original Weight of Sample (Grams)	2500	1000
Weight After 10 Cycles	2200	760
Weight Loss in Grams	300	240
Loss in Percent	12.0	24.0

APPENDIX C – 4 703-08P,G

**STANDARD TEST METHOD FOR RESISTANCE OF COARSE AGGREGATE
TO FREEZING AND THAWING**

<p>NEW YORK STATE DEPARTMENT OF TRANSPORTATION MATERIALS BUREAU ALBANY, NY 12232-0861</p> <p style="text-align: center;">TEST METHOD</p>	<p>Test Method No. NY 703-08 P,G</p> <p>Issue Date: November 2000 Subject Code: 7.42-5</p>
<p>SUBJECT: STANDARD TEST METHOD FOR RESISTANCE OF COARSE AGGREGATES TO FREEZING AND THAWING</p>	
<p>APPROVED: _____ Robert L. Sack, Director, Materials Bureau</p>	<p>Supersedes: NY 703-08 P, G, M (1996)</p>

1. **SCOPE:**

1.1 This test method describes the procedure for determining the resistance of coarse aggregate to disintegration by repeated exposure to freezing and thawing in a 3% sodium chloride (NaCl) solution.

2. **REFERENCE DOCUMENTS:**

2.1 **AASHTO Standards:**

M 92 Wire cloth sieves for testing purposes
M 231 Weights and Balances used in the testing of Highway Materials

2.2 **ASTM Standard:**

E 100 Specifications for ASTM Hydrometers

3. **SUMMARY OF METHOD:**

3.1 The sample of aggregate is prepared to a specified gradation. It is washed, dried and weighed. It is soaked in a container of NaCl solution (brine). The aggregate in its container of brine is then alternately frozen and thawed for 25 cycles. The sample is washed, dried and backsieved over specified sieves. The mass of aggregate passing those sieves is designated as the aggregate disintegrated by the freezing and thawing in brine.

4. **APPARATUS:**

4.1 **Freezing/Thawing Apparatus** - A room, tank or chamber capable of lowering the internal temperature of the sample in its container of brine from $21.1^{\circ} \pm 2.8^{\circ}\text{C}$ to minus $23.3^{\circ} \pm 2.8^{\circ}\text{C}$ and then raising it to $21.1^{\circ} \pm 2.8^{\circ}\text{C}$ in a 24-hour period. This apparatus is capable of automatic recordation of the temperature of the apparatus and the internal

temperature of the sample.

- 4.2 **Freeze/Thaw Containers** - The containers are cylindrical, open at the top, and capable of holding the aggregate and brine during the test. These containers are made of semi-rigid polyethylene and have the following dimensions:

Outside Diameter	=	135 mm
Inside Diameter	=	125 mm
Outside Height	=	240 mm
Inside Height	=	230 mm
Side Wall Thickness	=	5 mm
Base Thickness	=	8 mm

- 4.3 **Sieves** - Sieves made of wire with square openings of the following sizes conforming to AASHTO M 92:

25.0 mm
19.0 mm
16.0 mm
12.5 mm
9.5 mm

- 4.4 **Oven** - An oven of appropriate capacity capable of maintaining a uniform temperature of $110^{\circ} \pm 5^{\circ}\text{C}$.
- 4.5 **Balance** - The balance shall conform to AASHTO M 231, Class G5.
- 4.6 **Specific Gravity Measurement** - A hydrometer conforming to the requirements of ASTM E 100, or suitable combination of graduated glassware and balance, capable of measuring the brine specific gravity to within ± 0.001 shall be used.

5. SODIUM CHLORIDE SOLUTION (BRINE)

- 5.1 Prepare a solution of sodium chloride (NaCl), having a concentration of 3% by mass, by adding rock salt (halite) to water. Adjust the concentration of the solution by adding either water or rock salt (halite) until the specific gravity of the brine is at 1.020 at $23.3^{\circ} \pm 5^{\circ}\text{C}$.

6. SAMPLE:

- 6.1 **Coarse Aggregate** - NYSDOT size No. 2 coarse aggregate is used for testing. A representative sample from the source is tested having been prepared using wire sieves with square openings and with the sample mass listed below:

Passing Sieve	Retaining Sieve	Mass (grams)
25.0 mm	19.0 mm	1500 \pm 50
19.0 mm	12.5 mm	1000 \pm 30

7. PREPARATION:

- 7.1 Separate the sample into the different sizes shown in Section 6.1. Do not use any of the material sticking in the meshes of the sieves. Obtain approximately the mass indicated in Section 6.1 for each size fraction by splitting or quartering. Thoroughly wash and dry the sample to a constant mass at $110^{\circ} \pm 5^{\circ}\text{C}$. Allow the sample to cool to room temperature. Weigh each fraction and determine that each fraction conforms to the mass shown in Section 6.1. Record the mass of each fraction.

8. PROCEDURE:

- 8.1 **Soaking of sample** - Place each fraction in a freeze/thaw container add 950 milliliters of a 3% NaCl solution. Allow the sample to soak for 24 hours \pm 4 hours at a temperature of $23.3^{\circ} \pm 5^{\circ}\text{C}$.
- 8.2 **Freezing the sample** - Immediately following Step 8.1, place the sample in the freeze/thaw apparatus and cool until the internal temperature (NOTE 2) of the sample reaches minus $23.3^{\circ} \pm 2.8^{\circ}\text{C}$.
- 8.3 **Thawing the sample** - Immediately following completion of the freezing portion of each cycle, heat the sample until the internal temperature (NOTE 2) reaches $21.1^{\circ} \pm 2.8^{\circ}\text{C}$. The thawing portion of each cycle is completed in approximately 11 hours.

NOTE 2- Determine the internal temperature by placing the sensor of the temperature recorder in the sample approximately 38 mm from the bottom of the sample container and equidistant from the sides of the container. In actual practice the temperature sensor is placed in one of the many samples being tested. However, the Laboratory should determine and should be capable of demonstrating that the internal temperature of all samples reaches $21.1^{\circ} \pm 2.8^{\circ}\text{C}$ and minus $23.3^{\circ} \pm 2.8^{\circ}\text{C}$.

- 8.4 **Cycles** - Each cycle consists of one period of freezing and one period of thawing. Repeat the process of alternate freezing and thawing until 25 cycles have been completed. One complete cycle should not exceed 24 hours. If the test is interrupted, leave the sample covered in a thawed condition until testing can be resumed.

8.5 **Solution Change** - After the completion of 12 or 13 cycles of freezing and thawing, replace the 3% NaCl solution with fresh brine.

9. **QUANTITATIVE EXAMINATION:**

9.1 **Washing** - After the completion of 25 cycles of freezing and thawing, wash the sample to remove all of the NaCl solution. Dry each sample at $110^{\circ} \pm 5^{\circ}\text{C}$.

9.2 **Backsieving** - Sieve the aggregate by hand over the sieve shown below for the appropriate size fraction. Use only enough agitation to assure that all the undersize material passes the designated sieve. Do not use any extra manipulation to break up particles or cause them to pass the sieve. Record the mass of the material retained on each sieve.

Size of Aggregate	Sieve Used to Determine Loss
25.0 mm to 19.0 mm	16.0 mm
19.0 mm to 12.5 mm	9.5 mm

9.3 **Calculation** - The original mass determined in Section 7.1 for each size fraction minus the mass retained on the corresponding sieve used in Section 9.2 is the mass loss for that size fraction.

10. **REPORT:**

10.1 **Data** - Include the following data in the report (see Table 1, “Suggested Form for Recording Test Data”).

10.1.1 The mass of the aggregate retained on the 19.0 mm sieve and on the 12.5 mm sieve before the test.

10.1.2 The mass of the aggregate retained on the 16.0 mm and the 9.5 mm sieves; the mass loss of each size fraction; and the mass loss of each fraction expressed as a percentage of the original mass of that fraction.

10.1.3 The combined original mass (the sum of the original masses retained on the 19.0 mm and 12.5 mm sieves); the combined mass loss; and the total loss expressed as a percentage, determined by dividing the combined mass loss by the combined original mass.

TABLE 1

SUGGESTED FORM FOR RECORDING TEST DATA
(With Illustrative Test Values)

Aggregate Data	Aggregate Size	
	19.0 mm	12.5 mm
Original mass of sample (grams)	1500	1000
Mass after 25 cycles (grams)	1400	900
Mass loss (grams)	100	100
Loss (percent)	6.7	10.0
Combined original mass (grams)	2500	
Combined loss (grams)	200	
Total loss (percent)	8.0	

APPENDIX D

DUE DATES AND ACTION TIMES

DUE DATES AND ACTION TIMES

ITEM	DUE DATE	ACTION TIME
Geological Source Report for crushed stone operations, cyclic module due every 4 years by:	February 1 st	
Geological Source Report for sand & gravel operations, cyclic module due every 2 years by:	February 1 st	
Request for extension of GSR submission by:	February 1 st	
Geological Source Report review ² by the Materials Bureau to determine the Level 1 ¹ revisions required for approval to be completed within:		60 days of receipt ⁴
Geological Source Report Level 1 ¹ revisions, required of the Producer, due to the Department for approval within:		60 days of receipt ⁴
Level 1 ¹ revisions review ² by Materials Bureau to be completed within:		60 days of receipt ⁴
Geological Source Report review ² by the Materials Bureau to determine the Level 2 ³ revisions required for the next submission		1 year of receipt
Operations Plan annual submission due:	February 1 st	
Operations Plan review ² by the Materials Bureau to determine the revision required for approval to be completed within:		60 days of receipt ⁴
Operations Plan revisions required of the Producer due to the Department within:		60 days of receipt ⁴
Operations Plan revisions review ² by Materials Bureau to be completed within:		60 days of receipt ⁴

- Level 1 revisions are those that, in the judgment of the Materials Bureau, may impact the quality of the aggregate because they are linked to the Operations Plan. Geology, face configuration, petrography, and stripping are examples.
- Current source approval will not be interrupted during the review process.
- Level 2 revisions are those that are not linked to the Operations Plan and are incident to aggregate quality.
- If there has been no communications requesting report revisions sent during the 60-day review period, any subsequent requests for revisions to that report need not be submitted until the next scheduled submission year.

APPENDIX E

GEOLOGICAL SOURCE REPORT CYCLIC SUBMISSIONS SCHEDULE

GEOLOGICAL SOURCE REPORT CYCLIC SUBMISSIONS SCHEDULE (See Note)

YEAR	CRUSHED STONE	SAND & GRAVEL
0	Original Report & Operations Plan	Original Report & Operations Plan
1	Operations Plan	Operations Plan
2	Cyclic Submission & Operations Plan	Cyclic Submission & Operations Plan
3	Operations Plan	Operations Plan
4	Cyclic Submission & Operations Plan	Cyclic Submission & Operations Plan
5	Operations Plan	Operations Plan
6	Operations Plan	Cyclic Submission & Operations Plan
7	Operations Plan	Operations Plan
8	Cyclic Submission & Operations Plan	Cyclic Submission & Operations Plan
9	Operations Plan	Operations Plan
10	Operations Plan	Cyclic Submission & Operations Plan
11	Operations Plan	Operations Plan
12	Cyclic Submission & Operations Plan	Cyclic Submission & Operations Plan
13	Operations Plan	Operations Plan
14	Operations Plan	Cyclic Submission & Operations Plan
15	Operations Plan	Operations Plan
16*	Cyclic Submission & Operations Plan	Cyclic Submission & Operations Plan

* Subsequent years follow the pattern of submission established in years 13 through 16.

Note: For Long Island and Southern New Jersey Sand & Gravel Operations, a Static Module and Annual are due for the first year. An Annual Module is due for every following year.

APPENDIX F

BLENDING AGGREGATES TO MEET FRICTION OR QUALITY REQUIREMENTS

BLENDING AGGREGATES TO MEET FRICTION OR QUALITY REQUIREMENTS

Aggregates are often blended to meet gradation requirements and the results are routinely controlled and monitored at the plant. When blending is used to meet other requirements, such as friction, soundness, particle angularity and deleterious materials, the additional layer of complexity needs to be addressed in the Operations Plan. Because of its particular importance to highway safety, friction is addressed in every Operations Plan. Blending to meet other quality requirements should also be addressed in the Operations Plan in a separate section.

In general, a good candidate aggregate for beneficiation through blending is one that nearly meets specifications. The blending aggregate should be capable of boosting the desired characteristic with a relatively small proportion in the blend.

Friction:

Aggregates are relied upon to provide long term pavement friction which represents a very high risk aspect of pavement performance. Blending has been used extensively for decades to meet friction aggregate requirements. The proliferation of friction specifications to address specific highway needs requires the producer to be cognizant of the particular requirements the aggregate must meet. While friction blending has traditionally taken place at the mix plant, plant-blended aggregates, using imported aggregates and blends of on-site aggregates have been approved.

Angularity/ Shape/ Texture:

Superpave has placed special emphasis on characteristics of angularity, shape and texture in both fine and coarse aggregates. When a blend is designed to meet these requirements one must consider the gradations of the blend components and have a plan to monitor each aggregate's shape characteristics.

Deleterious Materials:

A good candidate aggregate for deleterious materials beneficiation through blending is one that meets quality specifications in all other respects. The deleterious material must be clearly identifiable petrographically and its identity firmly established and agreed upon by the producer, the producer's geologist, and the Department. Reference samples of the deleterious material should be maintained by both the producer and the Department. Mitigation is by diluting the deleterious materials with aggregate containing little or no such materials. The details of the blending scheme and how it is to be monitored must be included in the Operations Plan.

Soundness (As indicated by Magnesium Sulfate or Freeze-Thaw tests):

A good candidate aggregate for soundness beneficiation through blending is one that falls just short of meeting the magnesium sulfate soundness or freeze-thaw specifications. There are many very low-loss aggregates available as blending aggregates. Monitoring the blending process

should be done petrographically and verified by either magnesium sulfate soundness or freeze-thaw testing as appropriate. When petrographic monitoring is not possible, acceptance is on a stockpile-by-stockpile basis.

APPENDIX G

FINE AGGREGATE DEFINED

FINE AGGREGATE DEFINED

Natural Sand (F):

- Fine aggregate derived from an unconsolidated deposit which may contain some crushed gravel.
- For use in PCC or HMA, this fine aggregate must meet the requirements of 703-01, Fine Aggregate.

Gravel Screenings (G) and Manufactured Sand from Gravel Screenings (GFM):

- Fine aggregate produced by crushing gravel.
- For use in PCC, this fine aggregate must meet the requirements of 703-01, Fine Aggregate. In addition, it must also meet the requirements of either 703-03, Mortar Sand, 703-04, Grout Sand, 703-05, Fine Aggregate for White Portland Cement Concrete, or 703-07, Concrete Sand. Each of these items requires gradations that are usually only achievable by grading the fine aggregate.
- For use in HMA, this fine aggregate must either have been produced from gravel that meets the requirements of 703-02, Coarse Aggregate, or meet the requirements of 703-01, Fine Aggregate, independently.

Stone Screenings (R) and Manufactured Sand from Stone Screenings (RFM, RSFM):

- Both are fine aggregates produced by crushing stone or slag.
- For use in PCC, manufactured sand from stone screenings (RFM, RSFM) must meet the requirements of 703-01, Fine Aggregate. In addition, it must also meet the requirements of either 703-03, Mortar Sand, 703-04, Grout Sand, 703-05, Fine Aggregate for White Portland Cement Concrete, or 703-07, Concrete Sand. Each of these items requires gradations that are usually only achievable by grading the fine aggregate.
- For use in HMA, this fine aggregate must either be produced from stone or slag that meets the requirements of 703-02, Coarse Aggregate, or meet the requirements of 703-01, Fine Aggregate, independently.

Mixtures of Two or More Fine Aggregates (F1, F2, F3,...) (see NOTE 1 and NOTE 2)

These are blends of materials that derive their primary identity (source number) from the identity (source number) of one of the blend constituents (usually the primary constituent), eg. 3-100F. Each blend made with that primary constituent receives a source number based on the primary identity and with a sequential number added, eg. 3-100F1, 3-100F2, 3-100F3, etc. Categories of such mixtures are as follows:

Mixtures of Natural Sand and Either Stone Screenings or Manufactured Sand from Stone Screenings:

- Fine aggregate composed of a mixture of natural sand and graded or ungraded stone screenings, each in proportions of >5%, by weight.
- For use in PCC or HMA, each of the two components, natural sand and graded or ungraded stone screenings, must individually or in combination, meet specification requirements.

Mixtures of Natural Sand and Either Gravel Screenings or Manufactured Sand from Gravel Screenings:

- Fine aggregate composed of a mixture of natural sand and graded or ungraded gravel screenings, each in proportions of >5%, by weight.
- For use in PCC or HMA, each of the two components, natural sand and graded or ungraded gravel screenings, must individually or in combination, meet specification requirements.

Blends of Two or More Fine Aggregates Derived from Similar Sources:

- Fine aggregate proportioned according to a prescribed formula to meet specific requirements.(friction, quality, gradation, etc.)

NOTE 1: Fine aggregates may also be given sequential number designations (F1, F2, F3, ...) when two or more are derived from the same source, but which meet different quality or petrographic requirements. This situation may be encountered where above- and below-water deposits are mined or where different depositional units (sand & gravel), bedrock strata, or rock types are encountered at the same source.

NOTE 2: Fine aggregate sources assigned a sequential number designation (F1, F2, F3,...) are defined by annotation in the *Approved List of Coarse and Fine Aggregates*.

AASHTO, 8, 9, 18, 69, 70, 71, 88, 89
 absorption, 9, 69
 acid insoluble residue (AIR), 1, 2, 10, 12, 33, 44, 52, 55, 71
 ACR (alkali-carbonate reactivity), 12, 16
 aggregate tests, 9
 AIR (acid insoluble residue), 10, 12, 55, 56, 71
 alkali-aggregate reactivity, 15, 16
 alkali-carbonate reactivity (ACR), 12, 16
 alkali-silica reactivity (ASR), 10, 16, 71
 angularity, 9, 98
 annual, 5, 6, 25, 28, 29, 41, 58, 59, 60, 94, 96
 approval status, 1, 22, 23, 24
 Approved List of Fine and Coarse
 Aggregates, 1, 6, 10, 13, 14, 15, 25, 26, 102
 area of operations, 31, 33, 59
 ASR (alkali-silica reactivity), 10, 12, 16
 ASTM, 8, 9, 10, 12, 13, 18, 21, 33, 36, 69, 70, 71, 72, 88, 89
 auger holes, 36, 38, 40
 bench mark, 38
 bibliography, 31
 biennial, 8, 17, 18, 19, 24, 25, 26, 35
 blending, 43, 61, 62, 72, 98
 bog iron, 73
 brine, 8, 71, 88, 89, 91
 carbonate, 1, 2, 10, 12, 13, 16, 56, 69, 71, 72
 channels, 40
 chert, 2, 10, 12, 72
 clay, 40, 73
 cleanliness, 16
 coal, 72
 confidential, 30, 37, 41, 59, 60
 containers, 89
 contamination, 22, 42, 44, 47, 51, 52, 55, 56, 61, 62, 64, 66
 contour, 38, 39
 core, 6, 19, 20, 31, 32, 33, 45

INDEX

core holes, 31
 core log, 6, 31, 32, 33
 core logging, 31, 32
 core logs, 6, 33
 cross sections, 28, 39
 crushed, 1, 2, 5, 9, 12, 18, 29, 30, 31, 33, 35, 36, 37, 38, 39, 43, 49, 50, 69, 71, 94
 crushed stone, 1, 2, 5, 29, 30, 31, 33, 35, 37, 38, 39, 43, 50, 71, 94
 cyclic, 5, 6, 25, 41, 94, 96
 cylinder mold, 9
 D-cracking, 16
 deadline, 5, 6
 deleterious, 9, 10, 13, 15, 18, 20, 21, 72, 73, 98
 deleterious materials, 10, 15, 20, 72, 73, 98
 depositional units, 31, 33, 40, 102
 destructive tests, 8
 deval, 1
 disapproval, 23
 drill holes, 31, 38, 39
 drilling, 5, 50
 durability, 16, 42, 44, 61, 62
 elongate, 9, 18, 44, 62, 69
 equipment, 41, 43, 51, 59, 61
 expansion, 10, 12, 16
 extension, 6, 94
 extensions, 6
 field inspection, 6, 15, 17, 19, 23
 flat, 9, 18, 39, 44, 62, 69
 flat and elongate, 9
 formations, 30, 31, 32, 33
 freeze-thaw, 8, 44, 62, 70, 71, 98
 friction, 1, 2, 10, 15, 16, 19, 21, 33, 42, 44, 45, 47, 51, 55, 56, 62, 69, 71, 72, 98, 102
 friction testing, 21
 frictional, 1
 geologic columnar section, 33
 geologic cross sections, 5, 31, 38, 39, 40, 45

- geologist, 6, 15, 28, 31, 33, 42, 43, 44, 45, 47, 49, 50, 52, 53, 54, 55, 62, 98
- glacial, 30, 40
- gravel, 1, 9, 12, 19, 35, 40, 53, 55, 58, 65, 96, 101, 102
- hiatus, 26
- inactive, 6, 24, 25, 42, 61
- insoluble residue, 1, 10, 52, 71
- lenses, 40
- lift configuration, 47, 50, 54
- lightweight, 5, 13
- location map, 31, 59
- logs, 32, 38
- Los Angeles Abrasion, 1, 9, 18, 69
- magnesium sulfate, 8, 18, 44, 70, 98
- map-cracking, 16
- marker horizons, 30, 31
- modular, 5, 29, 59
- mortar bar, 11, 12
- new aggregate sources, 13
- noncarbonate, 10, 51, 55, 56, 72
- non-specification, 19, 20
- non-traditional aggregates, 13
- non-uniformity, 43, 44, 47, 50, 51, 54, 55, 61, 62, 64, 66
- North, 38
- operational problem, 23
- Operations Plan, 2, 5, 14, 21, 24, 28, 29, 41, 42, 45, 47, 49, 52, 53, 56, 58, 59, 60, 63, 64, 65, 67, 94, 96, 98
- ore, 73
- organic, 18, 42, 44, 61, 62, 69
- out-of-specification, 14, 19, 25
- overburden, 40, 42, 47, 49, 50, 53, 54, 55, 61, 64, 65, 66
- particle shape, 9, 13
- percent crushed, 9, 18, 44, 62
- performance evaluation, 16, 22, 23
- petrographic, 1, 5, 6, 9, 10, 12, 14, 16, 18, 19, 21, 22, 23, 24, 25, 26, 33, 34, 35, 36, 38, 45, 72, 99, 102
- petrographic sample, 33, 34, 35, 36
- photographs, 5, 30, 31, 39, 41, 61, 64, 65
- plant administrator, 42, 52, 53, 56, 60, 65, 67
- plant flow, 5, 43, 58, 61
- plant samples, 12, 19
- pocking, 16
- popouts, 16
- portland cement, 2, 9, 10, 12, 13, 16, 61, 69
- potholes, 16
- problem resolution, 20, 32
- quadrangle, 31, 59
- railroad ballast, 9
- raveling, 16
- reactivating an aggregate source, 25
- reactive, 10, 11
- re-approved, 26
- records, 45, 48, 52, 56, 62, 63, 64, 66, 67
- recycled materials, 13
- reinstate, 25
- resample, 15
- retest, 14
- review, 6, 14, 15, 23, 26, 94
- rock core, 32
- rut resistance, 9
- sample containers, 8, 70, 71
- sampling, 13, 14, 17, 18, 19, 24, 25, 26, 35, 36, 38, 55
- sand & gravel, 5, 6, 29, 30, 31, 33, 37, 38, 40, 43, 47, 50, 54, 73, 94, 102
- scaling, 16
- screened, 35
- screenings, 35, 101, 102
- selective, 21, 22, 38, 42
- shape, 9, 16, 51, 98
- silica gel, 10, 16
- SKARP (Skid Accident Reduction Program), 16
- slag, 5, 13, 101
- soil type, 30
- spalling, 16
- special samples, 19
- specific gravity, 8, 44, 62, 70, 73, 89
- static, 5, 29, 30, 59, 96
- stockpile rejection, 15
- stockpile resampling, 15

strata, 9, 12, 31, 32, 39, 40, 46, 102
stripping, 42, 43, 47, 49, 50, 53, 54, 61, 64,
65, 94
sulfate soundness, 1, 8, 18, 70, 99
Superpave™, 19, 98
Template (Operations Plan), 42, 47, 49, 53,
60, 64, 65
test, 1, 8, 9, 10, 12, 13, 14, 15, 18, 19, 22, 23,
24, 25, 26, 36, 37, 38, 40, 45, 52, 56, 67,
69, 70, 71, 72, 88, 89, 90, 91, 92
test pits, 36, 38, 40

test results, 8, 9, 14, 15, 22, 23, 25, 70, 71
testing, 1, 8, 10, 12, 13, 14, 15, 17, 18, 19,
21, 23, 24, 25, 26, 35, 38, 43, 44, 45, 47,
51, 52, 55, 62, 63, 64, 66, 70, 88, 89, 90,
99
texture (aggregate surface), 98
timetable, 6, 14
uncompacted voids (fine aggregate
angularity) (FAA), 9, 44, 62
water table, 33, 40
workability (PCC), 9