WATER QUALITY
BEST MANAGEMENT PRACTICES
FOR THE
AGGREGATE MINING INDUSTRY

Prepared For:
Georgia Construction Aggregate Association
9810-A Medlock Bridge Road
Suite 202
Duluth, Georgia 30097

Prepared By:
Highland Engineering, Inc.
1455 Lincoln Parkway, Suite 200
Atlanta, Georgia 30346

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DISCLAIMER

THIS MANUAL IS INTENDED TO BE USED AS A GENERAL GUIDE TO ASSIST THE REGULATED COMMUNITY IN DESIGNING AND IMPLEMENTING EFFECTIVE WATER QUALITY "BEST MANAGEMENT PRACTICES" IN CONJUNCTION WITH AGGREGATE MINING OPERATIONS. IT IS NOT INTENDED TO BE A SOLE SOURCE FOR SUCH INFORMATION, NOR IS IT INTENDED TO PROVIDE LEGAL ADVICE OF ANY NATURE. USERS OF THIS MANUAL ARE EXPRESSLY CAUTIONED NOT TO RELY SOLELY ON THIS MANUAL FOR "BEST MANAGEMENT PRACTICES" INFORMATION, AND ARE ENCOURAGED TO SEEK LEGAL, TECHNICAL AND ENGINEERING ADVICE FROM QUALIFIED PROFESSIONALS WHO ARE FAMILIAR WITH THE RELEVANT SITE AND PROJECT. THE ORGANIZATIONS AND INDIVIDUALS CONTRIBUTING TO THE PREPARATION OF THIS MANUAL EXPRESSLY DISCLAIM ANY RESPONSIBILITY OR LIABILITY FOR ANY ACTS OR OMISSIONS TAKEN BY ANY PARTY AS A RESULT OF THE USE OF THIS MANUAL.

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APPENDICES

1.0 INTRODUCTION

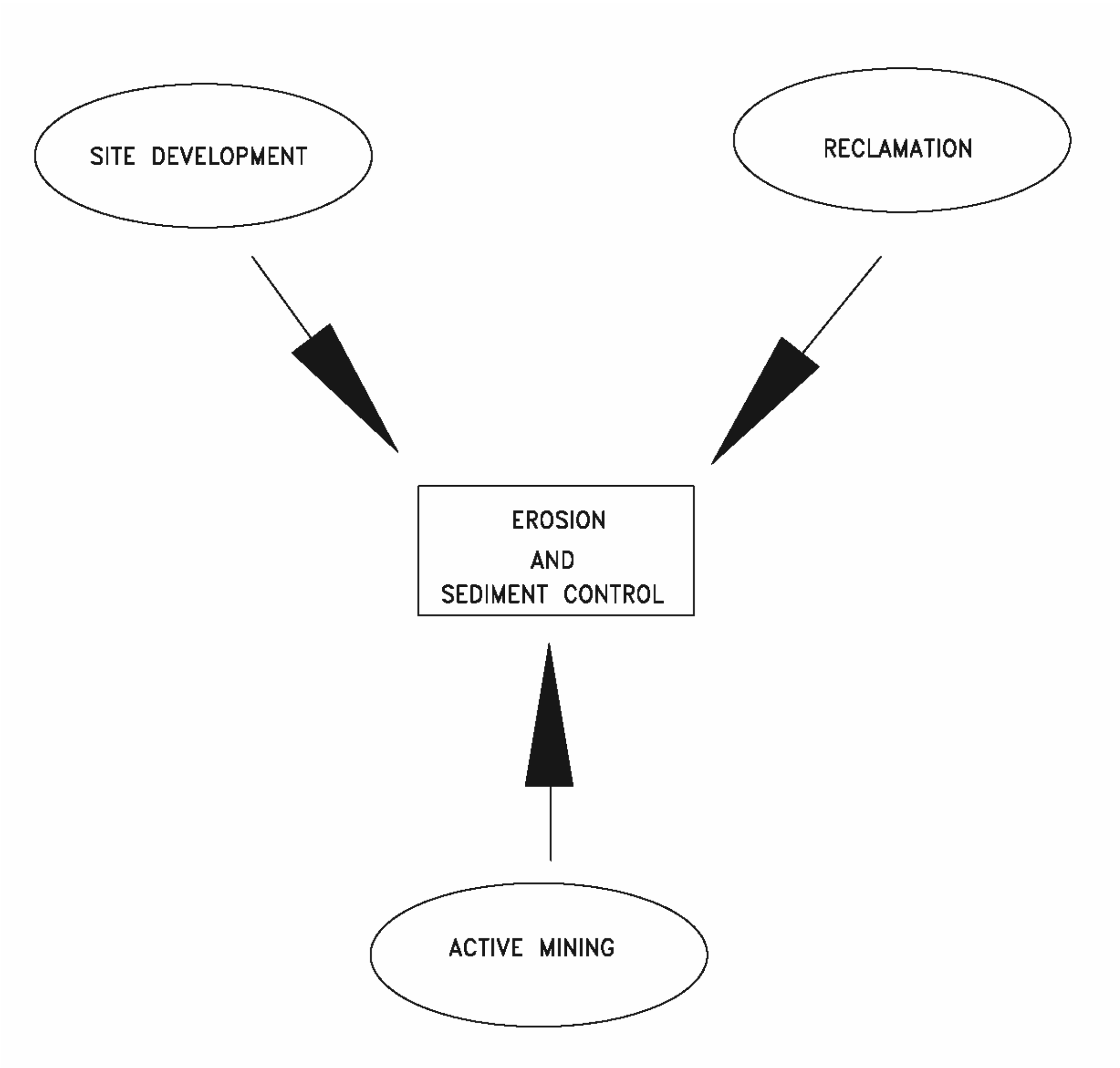
The objective of this manual is to provide the aggregate mining industry with a summary of some of the regulatory requirements, which may be applicable to their operations. In addition this manual provides a description of the practical application of best management practices (BMPs) for improved water quality from both point source and non-point source waters potentially generated on aggregate mining facilities. This manual is prepared as a general guide to water quality management and should not be relied upon as a complete source of all applicable regulatory requirements.

The principal pollutant in both point source and non-point source waters generated on aggregate mining facilities is total suspended solids (TSS). Depending upon the formation being mined and the nature of overburden material, pH may also be a water quality concern for waters discharged from aggregate mining sites. While pH may be a concern on some sites, this manual will generally focus on the control of the more prevalent water quality issue of TSS. The regulatory community has addressed TSS loads and pH on receiving streams from point sources since the enactment of the Clean Water Act (CWA) in 1972. Limitations on the concentration of TSS in process water point discharges are identified and enforced under the National Pollutant Discharge Elimination System (NPDES) permit program. Recently the regulatory community has focused efforts on non-point sources of pollutants, including TSS. These efforts, which are directed at certain industrial classifications, are also enforced by NPDES permit. This permit, the NPDES Storm Water Permit associated with Industrial Activity, is applicable to certain facilities in the aggregate mining industry. In conjunction, these two types of NPDES permits provide regulatory control over potential sources of sediment from process point source discharges and from storm water contacting industrial operations on aggregate mining facilities.

While occasionally faced with periods of drought, Georgia is generally fortunate to have abundant surface water resources with over 40,000 miles of perennial streams and 23,000 miles of intermittent streams. In addition the state has over 425,000 acres of lakes and reservoirs and 4.8 million acres of wetlands. The surface waters provide the majority of drinking water supplies for the state and offer significant aesthetic and recreational benefits. Excessive sediment loads cause changes to stream channel morphology resulting in changes to depth, width and flow velocity. Excessive sediment has a negative impact biologically as well. It can be abrasive to fish gills, scour benthic organisms, and dislodge stream vegetation. Excessive sediment loads can also result in increased water temperatures and can play a significant role in the transport and fate of other pollutants. While extreme pH conditions can have direct effect on the biological constituents of receiving waters, the role of pH in determining the solubility and biological availability of chemical constituents such as nutrients (e.g., phosphorus, nitrogen, and carbon) and contaminants (e.g. heavy metals) is perhaps a greater concern.

The Georgia Environmental Protection Division (GAEPD) has permitted 80 operating quarries in Georgia. The average land area of these facilities is approximately 360 acres (total) 360K which includes pits, aggregate processing plant, rail and undisturbed buffers.

Erosion and sediment control is a major focus of all mine operators during all phases of the quarry operating life.



In compliance with the provisions of the Georgia Water Quality Control Act (CWA) and the rules and Regulations promulgated to each of the Acts, new and existing storm water point sources within the State of Georgia are required to have a permit to discharge storm water associated with industrial activity to the waters of the State of Georgia. Through proper planning and implementation of erosion and sediment control measures, the aggregate mining operations effectively manage the quality of water discharged from its operations. This manual discusses specific BMPs to control the quality of water discharged from aggregate mining facilities. Information is presented in two parts, beginning with a discussion of environmental regulations affecting water quality from the aggregate mining industry. The remainder of the manual addresses the planning and implementation of BMPs through each of the stages of an aggregate mining operations including planning and permitting, construction, operation and reclamation.

2.0 ACKNOWLEDGEMENTS

This manual was prepared to establish the best current practices for the protection of our environmental resources while still providing a needed natural construction product for the economic viability of our communities. The construction and aggregate industry is composed of a combination of open pit quarry operations, sand and gravel facilities, borrow pits and underground operations. The materials in this document are primarily applicable to open pit quarry operations.

In Georgia, over 90% of construction aggregate is produced in open pit quarry operations. These operations produce approximately 90 million tons per year of product. These products are used in three principal markets; highway construction, residential home construction and commercial construction. The use is equally divided between these three categories. In essence, construction aggregates are the essential building blocks for our infrastructure. Our motto is that construction aggregates are the "Foundation for a Quality Life."

We are thankful for several individuals who have been responsible for the creation of this document. The document was developed by Highland Engineering under contract to the Georgia Construction Aggregate Association (GCAA). The Work was managed by the Environmental Committee of the GCAA. Committee members collaborating on this document include Jim Zadorozny (Hanson Aggregates), Joyceann Lee (Lafarge Aggregates), Dean Pease (Agg. USA), Nils Thompson (Leaggette, Brashears & Graham), and Gary Canter (Vulcan Materials). Thanks go to Randy Quintrell, GCAA Legal Counsel, for his review and editorial content. In addition, the authors and committee thank John Cardosa and the GCAA staff for maintaining regulatory liaison and providing the structure and schedule for the preparation of this document

There are many sources for the materials in this document. A list of these sources is found in the appendices. A list of contributors is also found in the appendices.

This is not an engineering manual. It is intended to provide guidance for best practices in our industry.

3.0 REGULATORY DISCUSSION

The aggregate mining industry is regulated by a number of government agencies. Following is a discussion of the agencies responsible for water quality at aggregate mining facilities and the principal regulations applicable to aggregate mining operations.

3.1 Georgia Department of Natural Resources, Environmental Protection Division (GAEPD)- Land Protection Branch - Surface Mining Unit

Agency Description

The lead agency for the aggregate mining industry in Georgia is the Land Protection Branch - Surface Mine Unit of the Georgia Environmental Protection Division. This agency is responsible for reviewing, approving and permitting surface mining activity. The Surface Mining Unit also is the principal enforcement agency for aggregate mining operations. GAEPD's authority for the regulation of surface mining activity is described in The Surface Mining Act of Georgia (O.C.G.A. § 12-4-96). The regulations promulgated under the Surface Mining Act are at Ga. Rule 391-3-3.

Regulations

The surface mining unit regulates land disturbing activities on permitted surface mining sites. The Mining Land Use Plan required for each surface mining facility includes provisions for "… erosion and siltation control, including adequate measures to control erosion on the periphery of affected land where mining ceases or becomes inactive …" and "… protection of contiguous natural and other resources …" For surface mining operations, the Surface Mining Act, therefore, assumes the role of the Georgia Erosion and Sedimentation Act. Language in O.C.G.A. § 12-7-17 of the Georgia Erosion and Sedimentation Act concurs with this interpretation by listing in the exemptions to the Act surface mining and "granite quarrying and land clearing for such quarrying." Surface mining in the Georgia Erosion and Sedimentation Act is defined as "…any activity constituting all or part of a process for the removal of minerals, ores, and other solid matter for sale or for processing of for consumption in the regular operation of a business". Specifically excluded from this definition are tunnels/shafts, borrow pits less than 1.1 acre and dimension stone quarries.

It should be noted that the Surface Mining Act only applies to land included within a Surface Mine Permit. Land not included in the Surface Mining Permit will likely be subject to the requirements of the Georgia Erosion and Sedimentation Act.

3.2 Georgia Department of Natural Resources, Environmental Protection Division-Watershed Protection Branch

Agency Description

The Watershed Protection Branch regulates water resources in Georgia through permits to entities such as local governments and industry to discharge treated wastewater and to entities such as local governments, industry, farmers and subdivisions for surface water and groundwater withdrawals. The Watershed Protection Branch ensures that Georgia's public water systems operate properly to supply safe drinking water to citizens, works to control nonpoint sources of pollution, and manages storm water discharges. This branch of the Agency also regulates point source discharges in addition to conducting water quality monitoring and modeling of Georgia's waterways.

Statute

Process Water and Non-Point Source Water Discharge

The principal statute associated with water quality control is the Federal Clean Water Act 33 U.S.C. § 1251 (CWA) enacted in 1972. The CWA is the cornerstone of water quality protection in the United States. The statute employs a variety of tools to reduce direct pollutant discharges into waterways and manage polluted runoff.

Point Source Discharge

In the initial period of the CWA's implementation, efforts were focused on regulating discharges from traditional "point source" or "end of pipe" facilities, such as municipal sewage plants and industrial facilities. The principal regulatory tool for point source discharges is Section 402 of the CWA that created the National Pollutant Discharge Elimination System (NPDES) permit program. Facilities with point source of process water discharges must obtain a discharge permit from the GAEPD.

The permits are typically issued for a period of five years. Permitted pollutants for the aggregate mining industry generally include TSS and pH. Sampling, analyses and reporting are required under these permits. Sample frequency is typically 1 to 2 samples per month with discharge monitoring reports required to be submitted monthly.

Non-Point Source Discharge

By Congressional mandate under the Federal Clean Water Act, the NDPES Storm Water Program addresses non-agricultural sources of storm water discharges that may impact the quality of our nation's waters. The NPDES Program requires regulated dischargers to implement and maintain appropriate storm water Best Management Practices (BMPs) to control harmful pollutants in their storm water discharges and prevent such pollutants from reaching water bodies. This is accomplished by issuing and enforcing NPDES storm water permits. The GAEPD amended the Georgia Rules and Regulations for Water Quality Control (Rules) in April 1990 to allow the issuance of general permits. GAEPD was granted authority to issues NPDES general permits by EPA in January 1991. GAEPD first issued the NPDES General Permit No. GAR000000 (permit) for storm water discharges associated with industrial activity on June 14, 1993. The current permit was reissued on August 1, 2006 with an expiration date of July 31, 2011.

The NPDES permit for Storm Water Associated with Industrial Activity will likely be applicable to most aggregate mining facilities. The exception will be facilities where all storm water discharge from the facility is directed through an existing permitted point source discharge or in the rare situation where no industrial activities are exposed to precipitation. In these rare situations the facility must file a Certification of Non Exposure, documenting that site conditions have been evaluated and the NPDES for industrial activity is not applicable. For those facilities subject to this permit the following is required to acquire and comply with the NPDES for Storm Water Associated with Industrial Activity:

- Existing facilities file Notice of Intent (NOI) 30-days after the effective date of the Permit.
- New facilities file NOI 7-days prior to the initiation of industrial activity.
- Prepare or update Storm Water Pollution Prevention Plan (SWPPP) 90-days following active date of permit or before the commencement of industrial activities for new facilities.
- File Annual Report after the 26th month of permit acquisition and annually thereafter

The SWPPP is the principal operating document for this permit and generally includes:

- Description of exposed industrial operations and stored materials
- BMPs that will be employed to prevent or control sediment loss
- Frequency of inspection/sampling – minimum of quarterly sampling and annual comprehensive review and amendment of SWPPP as needed

Presently this NPDES permit does not require quantitative analyses of samples collected from aggregate mining operations, unless the facility discharges to an impaired stream segment listed on the 303(D) list. For those facilities not discharging to a 303(D)stream, representative storm water samples should be collected quarterly and visually evaluated for water quality concerns (discoloration, odor, foaming, sediment load, etc). Samples should be collected within the first 30-minutes of discharge during periods of normal facility operation and from precipitation events greater than 0.1-inch. The precipitation event sampled must occur at least 24-hours after the previously measurable storm event greater than 0.1-inch.

For those facilities discharging to a 303(D) stream or within 1-linear mile upstream of and within the same watershed as any portion of a 303(D) stream and who also potentially discharge the pollutant of concern (POC), quantitative sampling is required. The sampling regime for these facilities is as follows:

Initial Sampling Period

- Twice quarterly sampling for the POC for a period of 12 consecutive months (8 total samples).
- If the 8 samples collected have an average below the applicable benchmark value (i.e. below 100 mg/l for TSS) *or* at least 75% (6-samples) of the samples collected meet or exceed the standard for the POC (i.e. 100 mg/l for TSS) the benchmark will have been met and sampling for the POC may be discontinued.
- A detailed description of benchmark sampling can be found in Part III C of the Permit.

Supplemental Sampling Period

If the initial sampling period benchmarks are not met, then the facility has failed the benchmark requirement. Those facilities that do not pass the benchmark requirement for the first 12-month sampling period must conduct the following:

- The facility may take up to one year to budget, select, design and construct/implement additional BMPs at the facility.
- Once the supplemental BMPs have been implemented, an additional 12-month (two samples per quarter) period of sampling must be conducted.
- If a facility is unable to pass the benchmark requirement after the 12-month sampling period following the implementation of supplemental BMPs, then GAEPD will determine what further action is required, which may include, but is not limited to, applying for an individual NPDES permit.

Bulk Petroleum Storage

The Pollution Prevention Rule initially became effective in January 1974 under the authority of the Section 311(j)(1)(C) of the Clean Water Act. The rule is found in 40 CFR Part 112, Oil Pollution Prevention and Response. These regulations were revised on July 17, 2002 by amendments from Federal Register Volume 71, Number 247 dated December 26, 2006. As of the writing of this manual, the Spill Prevention Control and Countermeasure (SPCC) regulations are in the process of being revised, with a compliance date of July 1, 2009. Facilities subject to the rule, those with a cumulative threshold quantity of 1,320 gallons of oil or petroleum product stored onsite in bulk containers, drums or equipment, are required to prepare and implement a Spill Prevention, Control, and Countermeasures (SPCC) Plan. Based on the nature of aggregate mining operations that includes the operation and maintenance of vehicles and equipment, most aggregate mining operations will be subject to SPCC requirements.

The proposed SPCC rule provides an alternative compliance option for secondary containment for oil-filled operational equipment. Oil-filled operational equipment is defined as "equipment, which includes an oil storage container (or multiple containers) in which the oil is present solely to support the function of the apparatus or the device." EPA clarified that this equipment includes operational equipment, such as hydraulic systems and lubricating systems, as well as electrical equipment such as transformers, but that it does not include generators. Importantly, oil-filled manufacturing equipment is not covered by the alternative compliance provision. Oil-filled manufacturing equipment includes any equipment used in processing or refining oils, including animal fats and vegetable oils; such equipment remains subject to SPCC secondary containment requirements.

Under the proposed alternative compliance option for oil-filled operational equipment, facilities may meet secondary containment requirements by having an oil spill contingency plan and written commitment of manpower and materials to control any discharges, without having to make the impracticability determination that otherwise would be required under the regulations. Facilities also must have a documented inspection or monitoring program to detect equipment failures or discharges. To qualify for the alternative compliance provision, the facility must not have had in the preceding three years: (1) a discharge over 1,000 gallons; or (2) two discharges each exceeding 42 gallons in any 12-month period.

Potentially affected facilities should stay abreast of regulatory requirements until SPCC rules are finalized. Information on SPCC can be viewed at the following EPA web address: www.epa.gov/osweroe1/content/spcc/index.htm. Facilities meeting the following criteria are subject to the SPCC regulations.

- A non-transportation facility (aggregate mining facilities are defined as industrial facilities using and/or storing oil)

- Aggregate aboveground storage capacity greater than 1,320-gallons or a completely buried storage capacity of greater than 42,000-gallons.
    - All containers equal to or greater than 55-gallons in size are counted toward the threshold limit of 1,320-gallons.
    - Oil-filled operational equipment (excluding mobile sources) containing greater than 55-gallons are counted toward the threshold limit of 1,320-gallons.
- The facility has a reasonable potential for discharge of oil to navigable waters

SPCC Plan Contents

SPCC Plans are the EPA's principal tool to prevent oil spills from reaching navigable waters. Unlike oil spill contingency plans that typically address spill cleanup measures after a spill has occurred, SPCC Plans ensure that facilities put in place containment and other countermeasures that would prevent oil spills that could reach navigable waters. Under EPA's Oil Pollution Prevention regulation, facilities must detail and implement spill prevention and control measures in their SPCC Plans. At locations where secondary containment is impossible or impractical, a spill contingency plan is required.

Each SPCC Plan, while unique to the facility it covers, must contain the following:

- A description of the physical layout and a facility diagram
- Contact list and phone numbers for the facility response coordinator, National Response Center, cleanup contractors, and all appropriate federal, state, and local agencies, which must be contacted in case of a discharge.
- A prediction of the direction, rate of flow, and total quantity of oil that could be discharged where experience indicates a potential for equipment failure.
- A description of containment and/or diversionary structures or equipment to prevent discharged oil from reaching navigable waters. (For on-shore facilities, one of the following must be used at a minimum: dikes, berms, or retaining walls; curbing; culverting, gutters, or other drainage systems; weirs, booms, or other barriers; spill diversion ponds; retention ponds; sorbent materials.)
- Where appropriate, a demonstration that containment and/or diversionary structures or equipment are not practical; periodic integrity and leak testing of bulk containers and associated valves and piping; oil spill contingency plan; and a written commitment of manpower, equipment, and materials to quickly control and remove spilled oil.
- A complete discussion of the spill prevention and control measures applicable to the facility and/or its operations including but not limited to:

    - Inspection and/or integrity testing
    - Personnel training
    - Security
    - Loading and unloading procedures

- The SPCC Plan must include a demonstration of management's approval and must be certified by a licensed professional engineer
- The owner or operator must complete a review and evaluation of their facility's SPCC Plan at least once every five years

A copy of the entire SPCC Plan must be maintained at the facility if the facility is normally attended for at least four hours per day. Otherwise, it must be kept at the nearest field office. The SPCC Plan must be available to EPA for on-site review and inspection during normal working hours.

3.3 United States Army Corps of Engineers (USACE)

The origins of the USACE date back to the late 1800's, with enactment of the Rivers and Harbors Acts of 1890. The initial charge of the USACE was to establish permit requirements to prevent unauthorized obstruction or alteration of any navigable water of the United States. The 1972 CWA added Section 404 authority to the USACE. Under Section 404 the USACE is authorized to issue permits for the discharge of dredged or fill material into waters of the United States. **"**Waters of the United States" include "essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters". The subset of jurisdictional water referred to as wetlands are characterized by growth of wetland vegetation (hyrophytic vegetation), have soil that is saturated during a portion of the growing season (hydric soils) and locations where the surface is flooded during some part of most years.

Section 404 of the Clean Water Act requires approval prior to discharging dredged or fill material into the waters of the United States. Typical activities requiring Section 404 permits are:

- Depositing of fill or dredged material in waters of the U.S. or adjacent wetlands.
- Site development fill for residential, commercial, or recreational developments.
- Construction of levees, dams, dikes, and weirs.
- Placement of riprap and road fills.

Recent developments have occurred in connection with the USACE's jurisdiction over wetlands triggered by the U.S. Supreme Courts decision in Rapanos vs. U.S. (547 U.S. 715 (2006)). Any party contemplating any development activity near an area that could be classified as a wetland should seek experienced counsel familiar with such developments.

In addition to permitting planned impacts to jurisdictional waters, the USACE has enforcement authority to address excessive sediment load to jurisdictional waters resulting from ineffective, poorly designed or absent BMPs.

3.4 Local Jurisdiction

Operators of aggregate mining industry will have little or no involvement with the local permitting jurisdiction. However, the Erosion and Sedimentation Act of Georgia delegates land disturbance responsibilities to the local jurisdiction. Since, as discussed above, the Erosion and Sedimentation Act exempts surface mining activity, interaction with the local authority will only occur when land disturbance outside the permitted mine limits occurs. It should be noted that this exemption is for land disturbing activity and associated erosion and sediment control and is not applied to other areas of local control including zoning, building codes, septic tank and other building, wastewater or transportation related items.

Any land disturbance conducted outside the limits defined by the mine permit will be subject a land disturbance permit from the local jurisdiction. If this activity results in land disturbance of greater than 1-acre, an NPDES Permit Associated with Construction Activity issued by the GAEPD will be required. Basic requirements of this permit include the following items:

- Filing NOI
- Permit fee of $80.00 per disturbed acre
- Preparation of an Erosion, Sedimentation and Pollution Control Plan
- Quantitative sampling utilizing Nephlometric Turbidity Units (NTU) limitations
- Implementation of BMPs in accordance to the Georgia Manual for Erosion Control and Sedimentation ("Green Book")
- Filing Notice of Termination ("NOT") upon site stabilization

4.0 MINE LIFE CYCLE AND CORRESPONDING BMPS

The typical mine life cycle includes planning/permitting, construction, operation and reclamation. Erosion and sediment control is a common element present in each of these stages. In reality these stages reoccur over the life of the mine in the form of expansions and other facility modifications. The importance of erosion and sedimentation control in each of these mine stages is discussed below.

4.1 Planning and Permitting

Plan Development Considerations

The long-term effectiveness of sediment control begins at the planning stage of the project. The permit package required by GAEPD should include BMPs for both point source and non-point discharge waters resulting from aggregate mining facilities. The permit package should include phases of mine development including evolving erosion and sediment control for the 5-, 10-, 20- and 50-year time frames as well as the reclamation plan.

The mine planner should have a good working understanding of the GAEPD's requirements, erosion principles, vegetative BMPs, and structural BMPs. The erosion and sediment control portion of the mine plan must contain sufficient information to describe the site development and the systems intended to control erosion and off-site sedimentation. The complexity of the plan should be commensurate with the size and complexity of the project, severity of site conditions, and the potential for off-site damage. Development of the sediment and erosion control plan should take the following into consideration:

- *Overall objective of the facility* – the site plan required for pit development, stone processing, stockpile storage and tenant site locations.
- *Project Size* – aggregate mining facilities in Georgia average in excess of 350 total acres in size, with approximately 75% typically impacted by site development
- *Topography* – the primary topographic considerations are slope steepness and slope length. The longer and steeper the slope, the greater the erosion potential from surface runoff. Slope gradients can be grouped into three general ranges of soil erodibility:

    - 0-2% - Low erosion hazard potential
    - 2-5% - Moderate erosion hazard potential
    - over 5% - High erosion hazard potential

  Within these slope gradient ranges, longer slope lengths further increase the erosion hazard and therefore should be avoided. As a general rule, the erosion hazard will become critical if slope lengths exceed these combined values:

Slope (%)	Slope Length (Ft)
0-2	300
2-5	150
>5	75

- *Soil Type and Geology* – Soil properties such as natural drainage, depth to bedrock, depth to seasonal water table, permeability, shrink-swell potential, texture, and erodibility should exert a strong influence on land development decisions.

- *Adjacent Land Areas* – Generally, the analysis of adjacent properties should focus on areas downslope or downstream from the construction project. Watercourses that will receive direct runoff from the site should be of major concern and these streams should be analyzed to determine their characteristics. The potential for sediment pollution of these watercourses should be considered as well as the potential for downstream channel erosion due to increased velocity and peak flow rate of storm water runoff from the site. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment retention measures can be planned.

- *Buffer and Setbacks* – The planner should determine the allowable limits of clearing and grading and should note required mine limit buffer (typically 100 feet). Stream buffers typically range from 25 feet to 50 feet, but special conditions may result in stream buffers of greater than 100 feet.
  Note: Local ordinances buffer requirements may vary.

Selection of BMPs

The BMPs to address this potential sediment load can be classified into three general categories; management measures, vegetative measures, and structural measures. These broad categories are defined below, with specific BMPs fully described in subsequent sections.

Management Measures

Management measures include items such as construction management practices, which if properly utilized can minimize the need for more costly vegetative/structural erosion and sediment control measures. These management measures include:

- *Minimize Upslope Water Contributions* – Upslope water should be diverted around disturbed areas and existing drainage features located within the planned disturbed area should be protected from erosion. These controls should be installed prior to any other site disturbance in order to minimize the amount of water flowing across disturbed areas that would contribute to site erosion and place a greater burden on sediment vegetative and structure control practices.

- *Phase Development* – Where possible phase-in disturbed area as needed and avoid mass grading. Ideally subsequent phases will be disturbed after prior disturbed areas have been stabilized.

- *Minimize impervious areas* – Keep paved areas, such as parking lots and roads, to a minimum. The more land that is kept in vegetative cover, the more water will infiltrate, thus minimizing runoff and erosion.

- *Recycle* – To avoid discharge and serve site water needs (road dust suppression, truck wash and other suitable needs) incorporate recycling of point source and non-point source water.

- *Closed Loop System* – A closed-loop water system recycles and recirculates process water. Makeup water is generally only required to compensate for evaporation. Under ideal operation, the closed loop system achieves the zero process water discharge goal, with discharges only required should the system be overloaded due to excess precipitation or partially supplemented in order to maintain water quality required by the process..

Vegetative Controls

Exposed soils due to clearing and grading are subject to erosion and subsequent sedimentation. Vegetative controls provide ground cover/protection to intercept rainfall, reduce soil detachment, promote infiltration and subsequently reduce the volume of water and sediment directed to structural controls and receiving streams. Examples of vegetative controls include mulching, seeding, and matting.

Structural Controls

Structural practices used in sediment and erosion control convey runoff, prevent sediments from moving offsite, and can also reduce the erosive forces of runoff water. The controls can either be used as permanent or temporary measures. Measures can include silt barriers, diversion structures, sediment traps, outlet protection and land contouring.

4.2 Site Development

Site development in the aggregate mining industry may involve expansion of existing quarry operations, development of "greenfield" sites or preparation of tenant sites. In all of these activities the project will typically require clearing, grubbing and disposing of vegetation and debris within the limits of the project. Clearing and grubbing will be followed by earth work including grading, cutting and filling. Since the majority of quarry operations retain cut or stripped material onsite, final placement of earthen materials will need to be managed.

Perimeter Controls

Perimeter controls include BMPs that control down slope sediment migration from the work area and ideally divert upslope water around the project area. Prior to land disturbance within the project area perimeter controls should be established.

Sediment Barriers – Sd1

Sediment barriers are temporary structures used to prevent the transport of sediment by sheet flow. The barriers are designed to slow the velocity of storm water runoff, allowing sediment to be deposited at the barrier. The most common sediment barrier is silt fence; however, sand bags, hay bales and brush piles can be used. The following section discusses two sediment barrier types, silt fence and brush piles, that are broadly applicable to aggregate mining operations.

Silt Fence (Sd1-A and Sd1-C)

The most common Sd1 used is silt fence. Silt fence is a sediment control practice that is designed to detain water long enough for the sediment to drop out of suspension while the water passes through the fabric of the fence. Silt fences are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Silt fence should never be placed in live streams or other areas of concentrated flow.

Two principal types of silt fence are type A and type C. Type A is 36-inches wide and is typically attached with wood stakes. Type C is also 36-inches wide but has metals stakes and is wire reinforced allowing much greater flow rates. Most applications at quarry sites would benefit by using Type C fence.

Typical Applications

- Perimeter of site
- Along stream channels and drainage ways
- Around ponds, wetlands and tree save areas

Design/Installation Guidance

- Typically double row required
- Separation between rows is slope dependent

CRITERIA FOR SILT FENCE PLACEMENT

Land Slope	Maximum Slope Length Above Fence
Percent	Feet
< 2	100
2 to 5	75
5 to 10	50
10 to 20	25
> 20*	15

*In areas where the slope is greater than 20%, a flat area length of 10 feet between the toe of the slope to the fence should be provided.

- Fence should be trenched to a minimum of 6-inches below grade
- If connecting more than one section make sure the last stake of the first section is interlocked with the first stake of the next section. Connecting two sections of silt fence can be accomplished by overlapping end stakes and rolling a portion of the filter fabric
- Drainage area per 100- feet of silt fence should not exceed 0.25-acre

- Silt fence should remain in place until disturbed area has been permanently stabilized.
- Type C silt fence installation diagram is shown on following page

Silt fence should not be installed in live streams or areas of concentrated storm water flow.

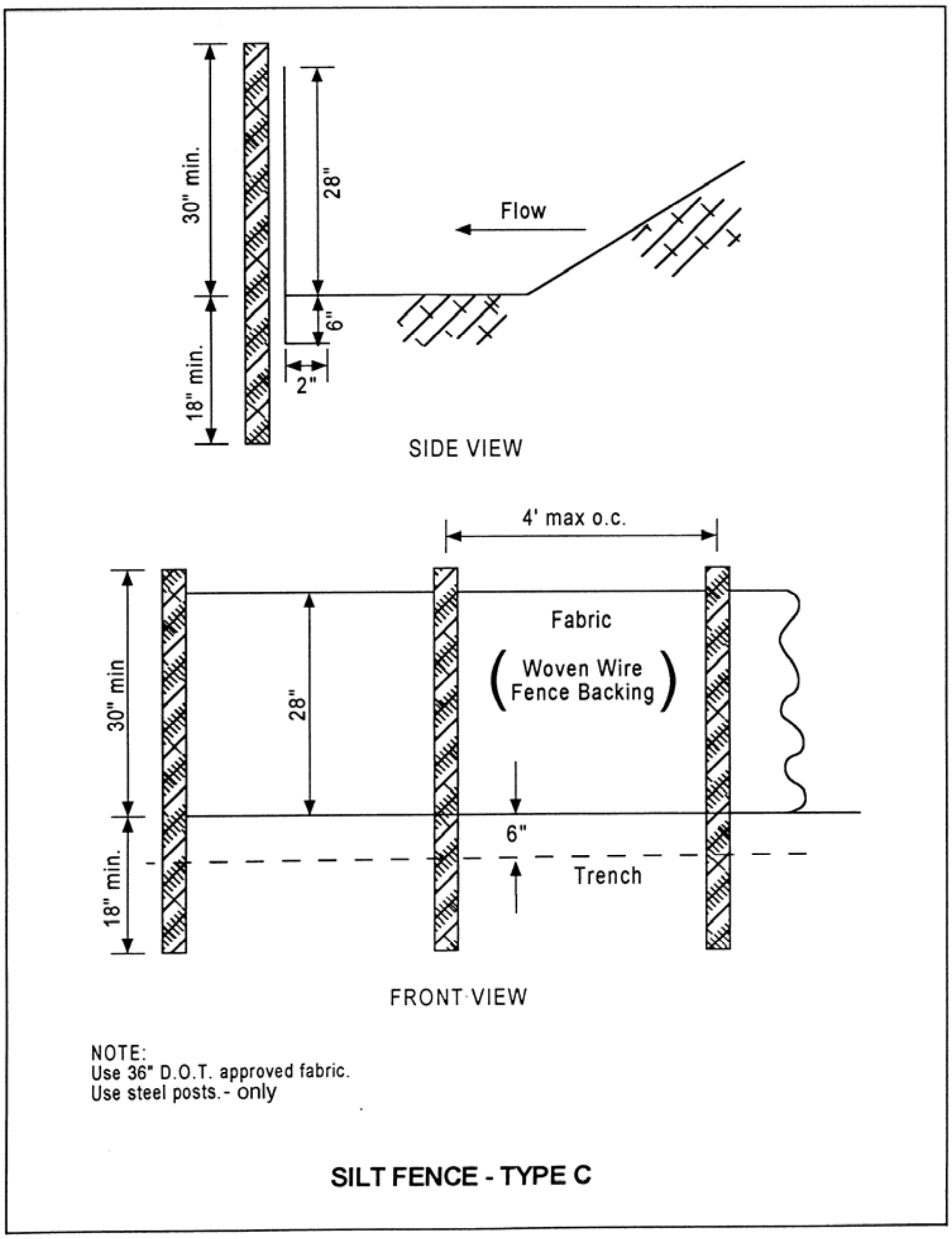


Figure 6-20.6

GaSWCC (Amended - 2000) 6-135

Maintenance

- Accumulated sediment should be removed when silt fence is at one-half capacity
- Replace deteriorated filter fabric

Properly Installed Type C Silt Fence

Poorly Installed and Maintained Type C Silt Fence

Brush Barriers (Sd1-Bp)

The development of aggregate mining facilities often begins with the clearing of vegetation. This cleared and grubbed vegetation can be employed for perimeter control.

Typical Applications

Similar application, although generally less effective, as silt fence

Design/Installation Guidance

- Windrow brush along land contour
- Compact brush to increase conformity to land surface and increase density of pile.
- Width of windrow should be between 5 and 20 feet
- Height of windrow should be 3 to 5 feet

Diversion Di

Diversion structures intercept and divert runoff waters around the planned disturbed area. Diversion structures principally include ditches but can also include berms.

Typical Applications:

- Diverting runoff from upslope drainage areas away from disturbed areas and toward a stabilized outlet.

- Diverting sediment-laden runoff from a disturbed area to a sediment containment structure helping to ensure that sediment-laden stormwater will not leave the site without treatment.

Design/Installation Guidance

- Diversion ditches on steeper slopes should be deep and narrow
- Diversion ditches on gentle slopes should be shallow and wide (swale)
- To avoid sediment deposition, design flow velocity should be near ditch maximum
- Avoid flow velocities in excess of 10 ft/sec
- Diversion ditch outlets should be adequately protected
- Channels should be stabilized
- Service length design considerations (see below)

Duration	Design Storm Event	Freeboard	Minimum Width
Temporary	10-year	0.3 feet	4 feet
Permanent	25-year	0.3 feet	4 feet

Diversion Ditch Directing Flow to Sediment Basin

Poorly Maintained Diversion Ditch

Maintenance

Routine inspection and repair as needed.

Channel Stabilization Ch

Channel stabilization is conducted to prevent excessive channel erosion due to storm water flow. Channel stabilization prevents excessive channel erosion but does not impede the channel's basic function to convey sediment laden storm water to a treatment or detention structure.

Typical Applications

- Constructed diversion ditches (Di)
- Existing ditches and swales

Design/Installation Guidance

- Flow velocity and channel configuration determine appropriate stabilization method – flow velocities can be estimated using Manning's equation
- Vegetation can be used where flow velocities are less than 5 ft/sec
- Rip rap should be used where flow velocities exceed 5 ft/sec
- Poured concrete should be considered for flow velocities in excess of 10 ft/sec

Channel Stabilization

Check Dams (Cd)

The principal purpose of check dams is to reduce erosion in a channel by reducing flow velocity. Secondarily check dams will capture sediment that drops out of suspension due to decreased water velocity behind the dam. Check dams are generally constructed of stone or staked straw bales. The dam should extend the entire width of the ditch or swale and should be lower in the middle to encourage flowing water to remain in the center of the channel.

Check Dam

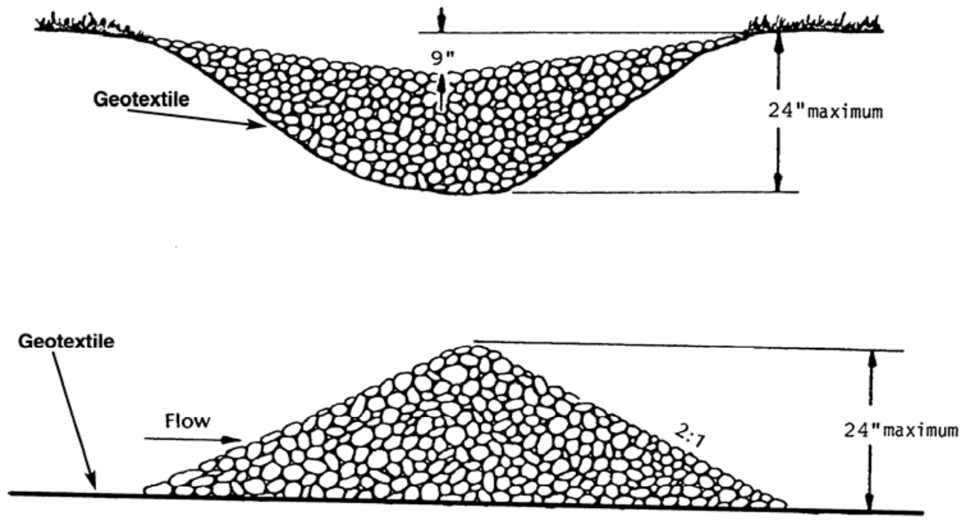
Typical Applications

- Diversion Ditches
- Natural Drainage Ditches and Swales
- Other areas of concentrated flow
- Check dams should not be placed in live streams

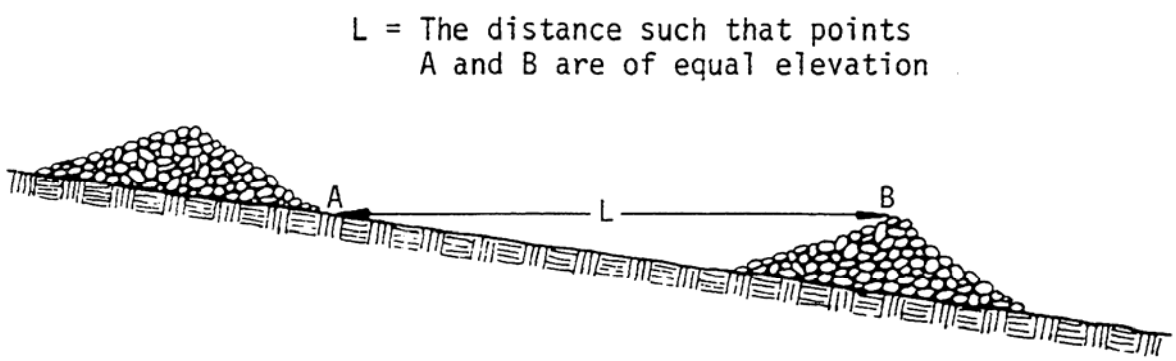
Design/Installation Guidance

- Maximum height of 2-feet at center of dam
- Center of dam should be a minimum of 9-inches lower than end of dam
- Maximum side slope should be 2:1

STONE CHECK DAM



- Drainage area to the check dam should not exceed 2- acres for stone dams 1-acre for straw bales
- Multiple dams should be installed for drainage areas exceeding one acre. Observing height guidelines presented above, the toe of upslope dam should be at similar elevation as the top of the nearest down slope dam.



SPACING BETWEEN CHECK DAMS

- Ideally dam will be underlain by geotextile and keyed into the upslope and extend two feet beyond down slope side of dam.

Do Not Place Check Dams in Live Streams

Maintenance

- Periodic inspection should be conducted
- Accumulated sediment should be removed when sediment depth is one-half the dam height.

Rock Filter Dam (Rd)

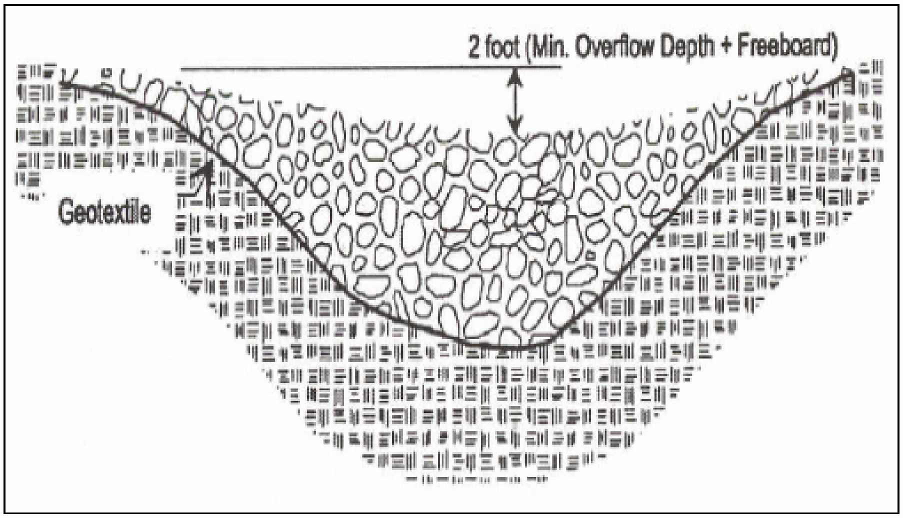
Rock filter dams are similar in construction and function as check dams. Unlike check dams, rock filter dams are designed to filter water in addition to reducing flow velocity. This filtering aspect is achieved by temporarily impounding water.

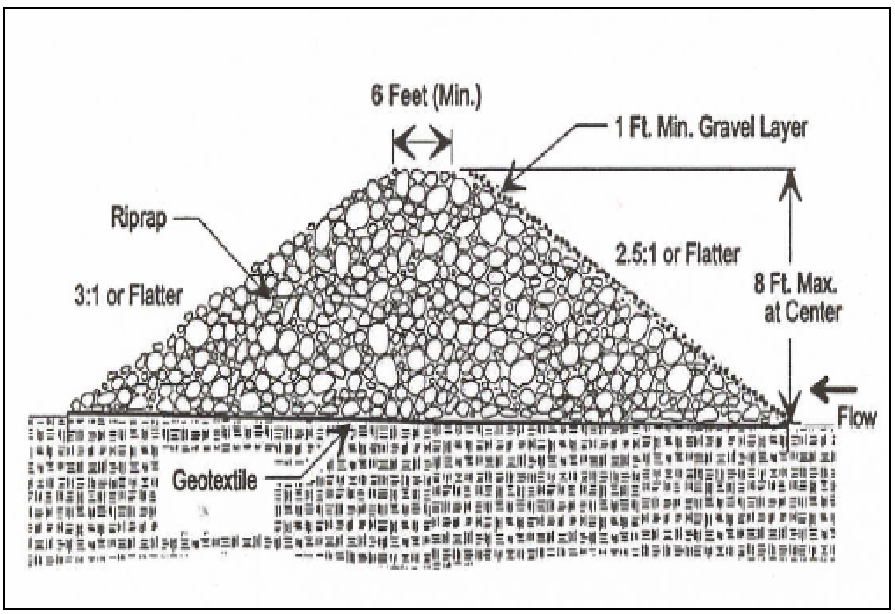
Typical Applications

- Small stream channels (note: regulatory approval from GAEPD and/or USACE may be required) with total drainage area of 50-acres or less
- At the upstream end of ponds and lakes to prevent discharge of sediment
- At locations downstream of in-stream construction activities such as installation of stream crossings.

Design/Installation Guidance

- Maximum height should not exceed channel banks
- Center of dam should be a minimum of 6-inches below ends of dam
- Minimum dam width of 6 feet
- Maximum side slope should be 2:1
- Stone sizes based on anticipated flow velocity
- Drainage area to the rock filter dam should not exceed 50- acres
- Multiple dams should be installed for drainage areas exceeding one acre. Observing height guidelines presented above, the toe of upslope dam should be at similar elevation as the top of the nearest down slope dam.
- Ideally dam will be underlain by geotextile and keyed into the upslope and extend five feet beyond down slope side of dam.





Maintenance

- Collected sediment should be removed when it reach one-half the design height of the dam
- Dam should be removed as soon as contributing disturbed area is stabilized

Temporary Sediment Basin (Sd3)

Temporary sediment basins are commonly used in the aggregate mining industry. These structures have been applied to control sediment from all types land disturbing activities. This section specifically addresses temporary basins. These structures are situated at a topographic low point where storm water naturally flows or is directed by other sediment control structures (i.e. diversion structures). They are designed to detain storm water runoff and trap sediment and are generally the final structural measure applied before water is discharged from the site.

Temporary sediment basins, which have a designed life of 18-months or less, are typically constructed by placing an earthen impoundment structure across an area of concentrated flow and/or by excavating a basin. The other design features of temporary sediment basins include a principal outlet structure and emergency spillway.

Temporary Sediment Basin

Typical Applications

- Final protection of critical areas (i.e. receiving streams, wetlands)
- Confluence of storm water flows sometimes containing high concentrations of TSS
- Runoff from overburden stockpiles and berm construction

Design/Installation Guidance

The Manual for Erosion and Sediment Control in Georgia ("Green Book") contains a detailed procedure for the design of temporary sediment basins. The design sheets are attached. The general design criteria include the following:

- Maximum total drainage area should not exceed 150 acres
- Sediment storage volume should be a minimum of 67 cubic yards per disturbed acre
- Minimum length to width ratio of pond surface should 2:1
- Principal outlet structure should be sized for the 2-year 24-hour storm event
- Impound structure should be constructed of suitable soil (i.e. no cap rock, highly pervious soil (i.e. sand, gravel) or vegetation should be present
- Impoundment structure slope should not exceed 2.5 to 1 and should have a minimum of 1-foot of freeboard above the crest elevation of the principal outlet structure
- Anti-seep collar around principal outlet structure should be used if impound structure is higher than15-feet or if smooth pipe in excess of 8-inches in diameter or corrugated pipe in excess of 12-inches in diameter is used
- Emergency spillway should be sized for 25-year 24-hour event with a 20-foot level control section and 25-feet straight outlet section

Maintenance

- Routine inspection and repair
- Basin should be cleaned when accumulated sediment is approximately 1/3 of the designed storage volume

Outlet Protection (St)

The outlets of pipes and channels are points of potential erosion. Stormwater directed in designed conveyance structures can potentially reach velocities that result in erosion. To prevent scour at stormwater outlets they should be protected with structures that absorb energy and decrease flow to non-erosive velocities.

Riprap

For most aggregate mining application the channels will typically be lined with riprap. A riprap lined apron is frequently used for its low cost and ease of installation. This method of outlet protection is typically used at the transition from a pipe or constructed channel (i.e. diversion ditch) to a natural channel. Outlet protection is provided by having a sufficient length and width to dissipated energy by expanding flow.

Riprap Outlet Protection

In addition to riprap, grouted riprap or poured in-place concrete can also be used as outlet protection. Other engineered devices, can be used including concrete stilling pools/plunge pools and concrete baffles (i.e. energy dissipating headwalls).

Typical Applications

- All storm drains, culverts and other concentrated flows discharging to natural or constructed earthen channels.

Design/Installation Guidance

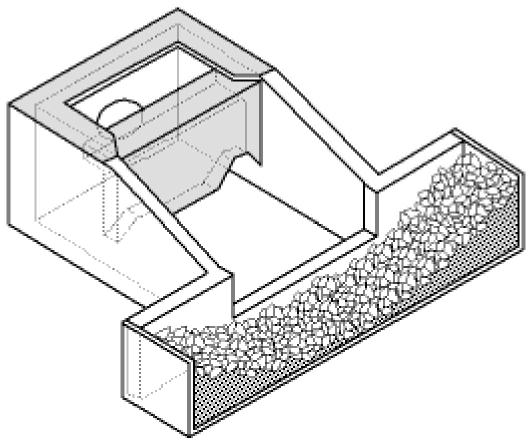
- Channel lining material should be sized for the 25-year 24-hour event
- Apron length and width based on tailwater conditions
- Stone size and apron thickness based on tailwater conditions (discharge velocity)
- Width of apron on well-defined receiving channels should extend 1-foot above the maximum tailwater elevation.
- Width of apron onto flat areas shall have an upstream width equal to 3-times the diameter of the discharge pipe.
- Downstream width of apron in minimum tailwater conditions to be equal to diameter of pipe plus the length of apron.
- Downstream width of apron in maximum tailwater conditions to be equal to diameter of pipe plus 0.4 time the length of apron.
- The apron shall be constructed with no grade (0% slope)
- Geotextile should generally be used between lining material and underlying soil.

Maintenance

- Routine inspection and repair

Energy Dissipating Headwall

Energy dissipating headwalls typically work by the water impacting the vertical hanging baffle. When the high velocity flow exits the culvert, it strikes the baffle and is turned upstream in vertical eddies, thus reducing the energy and velocity of flow. It is important that energy dissipating headwalls be appropriately designed to anticipated flow. If headwalls are to large, the incoming flow of water may pass under the baffle and effective energy dissipation will not occur. If energy dissipating headwalls are too small the water may overflow the baffle potentially causing erosion around the sides and along the toe of the headwall.



Energy Dissipating Headwall

Plunge Pool

A plunge pool is an energy dissipating structure located at the outlet of a spillway. Energy is dissipated largely as a function of the hydraulic jump that occurs as the discharge flows into the plunge pool. Plunge pools are commonly lined with rock riprap or other material to prevent excessive erosion of the pool area. Discharge from the plunge pool should be at the natural streambed elevation.

Roads and Construction Exits

Areas graded for construction vehicle traffic and parking can be prone to significant erosion. The potential for erosion is increased due to the generally long duration of exposure and continual disturbance.

Construction Exit (Co)

Greenfield sites and occasionally tenant locations will require exit onto public roads instead of using existing site customer roads. In these instances a specific construction exit should be built. In general these exits provide transition from the bare soil to public paved roads and provide for minimizing the tracking of mud onto public right of ways. A stabilized construction entrance is typically a pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving the construction site.

Construction Exit

Typical Applications

- Any construction exit onto public right of ways
- Transition from bare ground surface to paved surface

Design/Installation Guidance

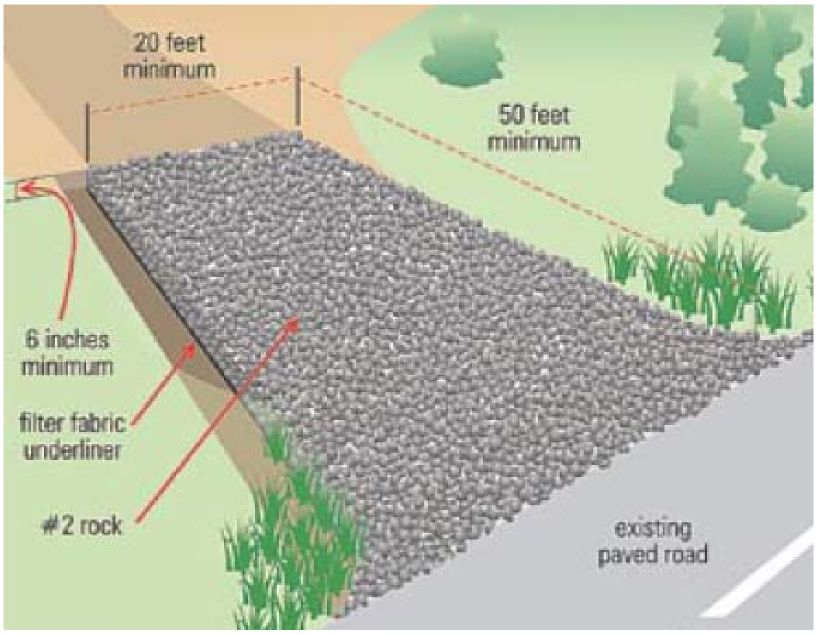
- Minimum width of 20-feet (if larger equipment is leaving site exit should be increased)
- Minimum length of 50-feet
- Excavate pad to a depth of approximately 3-inches and remove vegetation
- Pad thickness from 6-inches to 12-inches
- Typical stone size range from 1.5 to 2.5 inches diameter

- Construct diversion ridge 6-inches to 8-inches high across construction exit 15 to 20 feet from paved surface.
- Stone should be underlain by geotextile

Comparison of Field Observations to Geotechnical Testing

Soil Consistency	Visual Assessment	CBR [1]	Geotextile Function
Stiff	Pick Up Truck Ruts ½”-1”	1.50 – 3.5	Stabilization
Very Stiff	Loaded Dump Truck Ruts 1”-2”	3.6-6.4	Separation
Hard	Loaded Dump Truck no Significant Ruts	>6.4	Separation

(1) California Bearing Pressure per ASTM Standards D1883 and D4429



Typical Construction Exit Specifications

Maintenance

- Routine inspection and repair
- Top dress with additional stone as needed

Construction Road Stabilization (Cr)

Due to the size of the typical aggregate mining operation construction of long service roads is typically required.

Design/Installation Guidance

- Roads should follow contour as much as possible with grades between 2% and 10%. Steeper gradients, not to exceed 15% are permissible for distances up to 300 feet.
- Outslope the entire width of the road where road gradient will permit. Inslope the road toward the bank as a safety precaution on sharp turns, road gradients of 10% or greater and on clay.
- Breaking or changing grade frequently, less erosion problems will be encountered.
- Soils with severe erosion hazard, grade should be 8% or less. Grades up to 12% are acceptable if less than 150 feel long**.** Water diversion by cross drainage is often needed to keep excess water off the steeper grades.
- Where roads are insloped it is recommended that cross drain interception of surface water be placed 25 feet up-grade of any short stretches of roads where gradients exceed 10%.
- Provide a minimum essential width of 12 to 14 feet for a single track road. Increase width as necessary at curves and turnouts.
- Road-bank cuts should be sloped and seeded to prevent erosion.
- Ensure good road drainage with turnouts, broad-based dips, culverts and bridges. Turnouts should be constructed so water will be dispersed and will not cut channels across buffer zone.
- Install rip-rap or rock at the outlets of culverts to absorb force and spread water.

Maintenance

- Inspect the road at regular intervals to detect problems and schedule corrective work.
- Keep roadway and water control structures free of windfalls, logging debris and other obstructions.
- Restrict traffic on road during wet periods.
- Ensure the free flow of water in road drainage systems, especially during logging operations.
- Upon completion of any treatment operation, grade the road surface to reshape it so that it shed water as originally designed.
- Fill in ruts and holes as they develop.

Road Retirement

- Smooth and shape all road and landing surfaces to original design standards.
- When culverts are removed, replace them with water bars or ditches. If culverts are covered by more than 2 feet of fill and inlets and outlets are effectively stabilized, leaving them in place should be considered.
- Remove all temporary stream crossings
- Seed and mulch critical areas near streams or where erodible soil or slippage area exist.

Road Retirement (cont.)

- whenever stabilization is required silt fences should be placed to trap any sediment that may be eroded during the unstable period.
- Consider employing alternative methods of soil stabilization such as brush mulching, stone surfacing or water bars.

Recommended Maximum Spacing for Drainage Structures

Slope (Percent)	Broad-Based Dips and Culverts (feet)	Water Bars and Turnouts (feet)
2	300	245
5	180	125
10	140	80
15	125	60
20	120	50
25	115	40

Active Area Management

The principal BMPs applied to areas under active operation are designed for erosion control.

Soil Cover

Aggregate mining facilities often result in large disturbed areas. Providing soil cover can significantly limit erosion by:

- Shielding the soil surface from the impact of falling rain drops
- Reducing the velocity of runoff
- Maintaining the soil's capacity to absorb water, and
- Holding soil particles in place.

Soil Covering Efficiency

Soil Cover	Erosion Reduction
Mulch	
½ ton per acre	75%
1 ton/acre	87%
2 ton/acre	98%
Grass	
40 percent coverage	90%
60 percent coverage	96%
90 percent coverage	99%
Shrubs and Bushes	
25 percent coverage	60%
75 percent coverage	72%
Trees	
25 percent coverage	58%
75 percent coverage	64%
Erosion Mat	95% - 99%

Mulching (Ds1)

This practice is the application of plant material such as hay and straw to the soil surface. This reduces erosion by shielding the soil from the force of raindrop impact and reducing the velocity of runoff flowing over the soil. Mulch also can aid in seed growth by conserving moisture and shielding the young plants from extremes of heat, cold, or dry conditions.

Typical Applications

- Temporary cover for exposed soil surfaces

Design/Installation Guidance

- Typical design duration of 6-months or less
- Apply organic material (hay, straw, wood chips) to a depth of 2-inches to 4-inches
- Apply uniformly and supply minimum of 90% coverage
- Anchor as needed by disk harrow, netting, or application of tackifiers

Maintenance

- Routine inspection and reapplication of mulch as needed

Matting (Mb)

This practice is similar to mulching except that a manufactured product constructed from a combination of natural materials (jute, coconut fiber) and synthetic fibers is used. For most applications at aggregate mining facilities it is used as a temporary measure. Due to its expense matting is best confined to use in critical areas.

Erosion Mat

Typical Applications

- Steep slopes with high erosion potential (slopes in excess of 2.5:1)
- Concentrated flow areas
- At locations where establishment of vegetation will be slow

Design/Installation Guidance

- Typical design duration of 6-months or less
- Land surface should be graded sufficiently smooth to provide good mat contact
- Rocks, soil clods, disturbed roots should be removed to provide good mat to soil contact
- Matting should be stapled to the underlying surface
- Staples to be U-shaped, 6-inches in length and sufficiently strong to be driven without bending

Maintenance

- Routine inspection and repair as needed

Temporary Seeding (Ds2)

Quick growing grasses used to establish temporary vegetative cover for seasonal protection on disturbed areas.

Typical Applications

- To stabilize areas that will not be active but are not yet on final grade.
- To improve soil conditions for subsequent permanent plantings
- Companion crop to permanent plantings
- Sides of temporary basins and impoundments structures
- Soil stockpiles
- In place or mulching (Ds1)

Design/Installation Guidance

- Typical design duration of 6-months or less
- Provide minimum of 90% coverage
- Prepare seed bed if needed by pitting or scarifying
- Analyze soil and apply fertilizer as needed
- Select appropriate cover crop for the season applied
- Table 6-4.1 in the Manual for Erosion and Sediment Control in Georgia provides species recommendations, planting schedule, and application rates for temporary vegetative cover

Permanent Seeding (Ds3)

Permanent vegetation provides final stabilization to disturbed areas and provides the secondary benefits of improved aesthetics, visual screening, and wildlife habitat. The types of vegetation for permanent cover can consist of grasses, legumes, shrubs or trees.

Typical Applications

- Final stabilization to disturbed areas on final grade that will not be covered by permanent structures
- Sides of basins and impoundments structures
- Soil stockpiles

Design/Installation Guidance

- Final grading should be conducted to facilitate establishment of vegetation and to provide for safe use of maintenance equipment
  - Avoid slopes in excess of 3:1
  - Eliminate concentrated water flow
- Analyze soil and apply lime and fertilizer as needed
  - Typical lime application rate – 2 tons per acre
  - Fertilizer application rates are species dependent (Table 6-5.1)
  - Apply appropriate topsoil layer, avoid cap rock, low organic soils and other unsuitable material.
- Prepare seedbed as needed
  - Hydraulic application of seed may not require seedbed preparation
  - Conventional seeding will likely require tilling of soil
- Apply mulch to maintain soil moisture and minimize establishment of undesirable species
- Table 6-5.2 in the Georgia Manual for Erosion and Sediment Control in Georgia provides species recommendations, planting schedule, and application rates for permanent vegetative cover.

Slope Protection

Aggregate mining operations frequently contain long slopes, principally from the construction of berms for the placement of stripped overburden material. When placed this material is highly subject to erosion due to its loose compaction and frequently long slopes. Sediment and erosion control practices applicable to slope management are as follows.

Construction Management

The initial erosion control measures for overburden stockpiles is construction management. Many of the construction management practices are dictated by the GAEPD Mining Section requirements and are defined in the permitted mine plan.

Typical Applications

- Overburden stockpiles/berm construction

Design/Installation Guidance

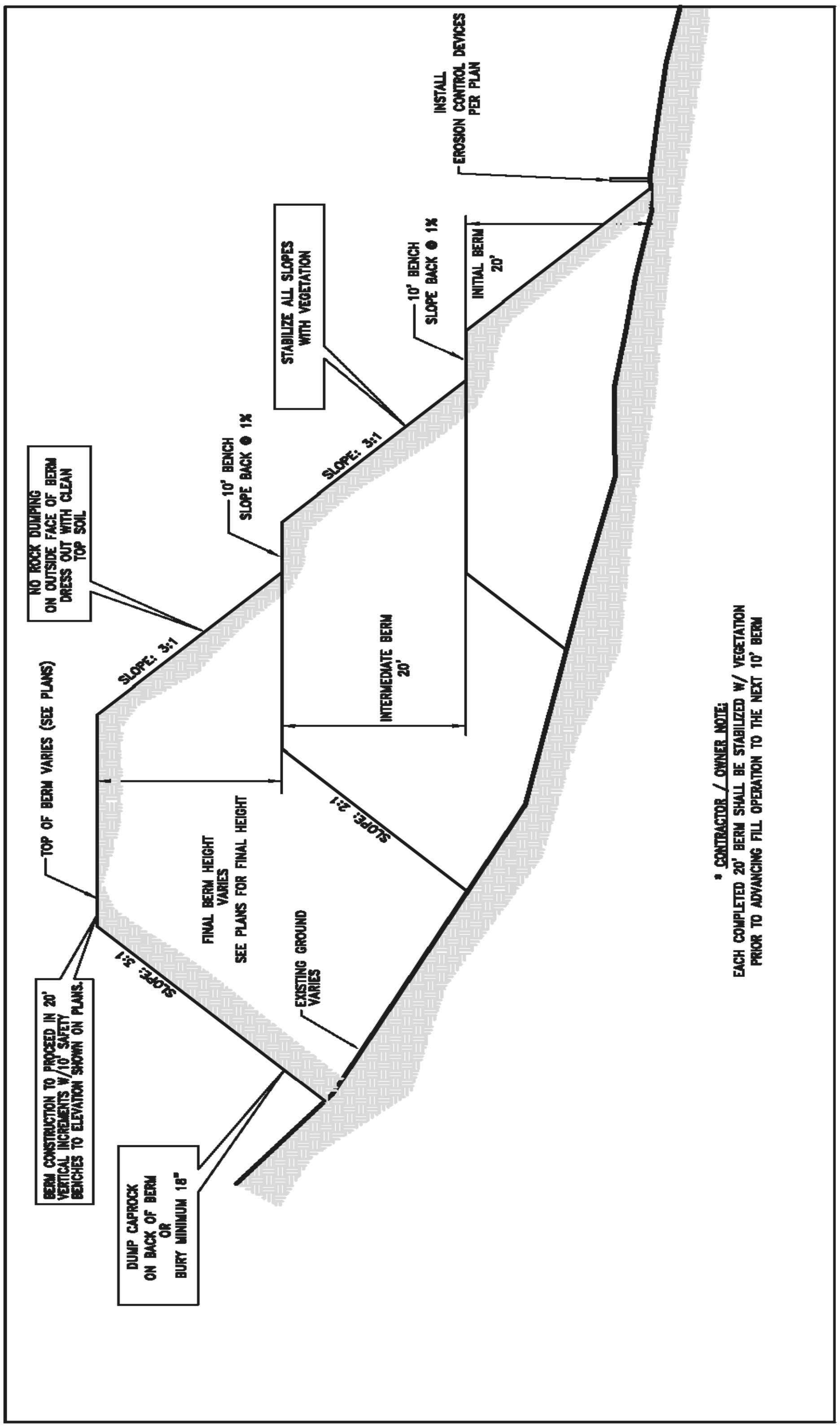
Berm construction is the placement of overburden on engineered slopes. Berms accomplish several objectives including a place for the relocation of stripped material as well as sound and sightline barriers. The design and construction of berms is site specific and bench heights, bench widths and slopes will vary with circumstances. *General* design and construction parameters for berm construction include the following:

- Maximum slope of 3:1
- Installation of a 20-feet wide bench for each 20 feet in overall berm height
- Segregation and storage of top soil for final cover
- Ideally 6-inches to 12-inches of topsoil or other soil suitable to establish vegetation will be applied as the last lift.

Maintenance

- Routine inspection and monitoring of the berm construction process

TYPICAL BERM CONSTRUCTION DETAIL



Surface Roughening (Su)

Soil roughening is means of dressing soils on slopes leaving the surface soil in a roughened condition to provide temporary soil stabilization and augment future erosion and sediment control practices such as temporary (Ds1) or permanent seeding (Ds2). Surface roughening also reduces runoff velocity and facilitates infiltration.

Surface Roughening

Typical Applications

- Critical slopes (slopes equal to or greater than 3:1) that subsequently will be vegetated. Note: soil roughening should not be applied to slopes that are to be matted (Mb).

Design/Installation Guidance

The method of surface roughening will in part be determined by steepness of slope and whether slope will need to be mowed. Applicable methods of roughening include:

- Grading "stair steps" into steep cut slopes
- Cutting furrows along steep fill slopes
- Furrows, discing and harrowing along moderate cut or fill slope

- Roughening with tracked equipment should typically be avoided particularly on soils with high clay content. Use of this equipment can lead to soil compaction and decrease in water infiltration.

Downdrain Structure (Dn1) and (Dn2)

Downdrains are designed to transport water from one elevation (top of berm or slope benches) to another by routing water through pipe or culvert, thereby avoiding direct contact with the face of the slope and subsequent erosion. The downdrain discharges at beyond the toe of the slope. Velocity at terminal end of pipe can be attenuated by use of additional erosion control structures (outlet protection or other energy dissipating structures) prior to discharge. Downdrain structures can be temporary (Dn1) or permanent (Dn2). For the majority aggregate mining application downdrains will be temporary and will be removed once the area reached final stabilization.

Downdrain Structure

Typical Applications

- Frequently used in conjunction with diversion structure (Di) to direct water to downdrain
- Overburden storage berm
- Other slopes where concentrated flow will likely result in erosion

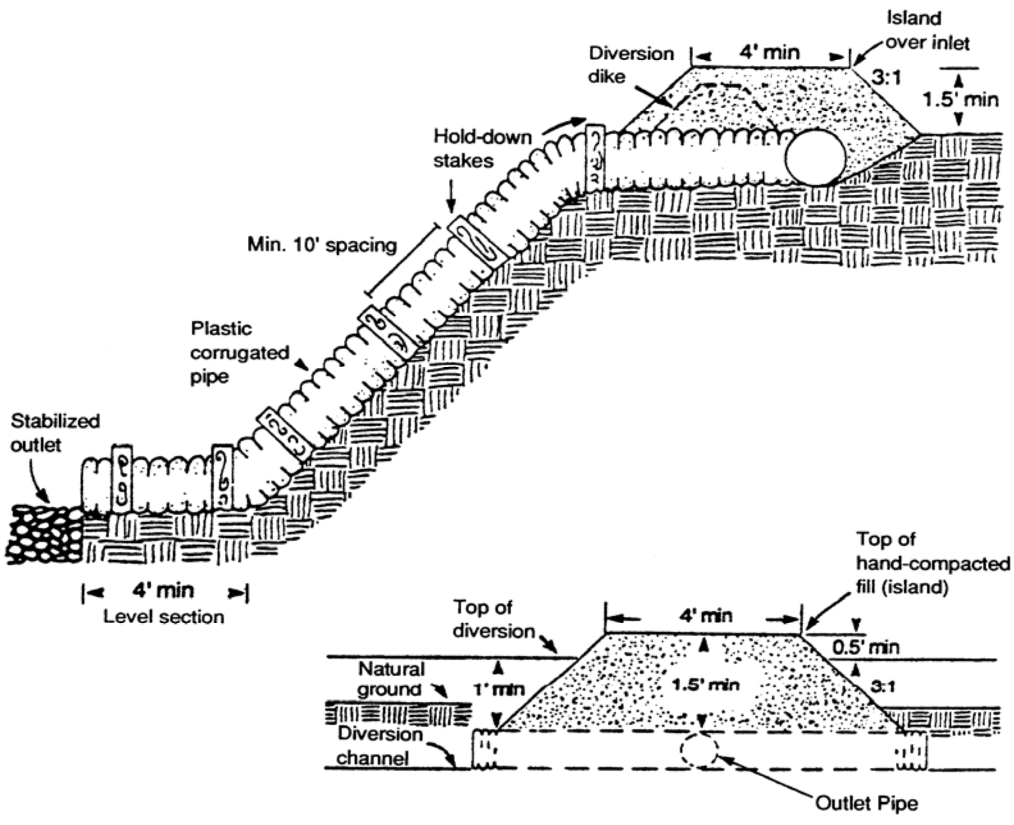
Design/Installation Guidance

- Pipe sizing guidance for temporary downdrain (Dn1)

Pipe Size Guide

Maximum Drainage Area Per Pipe (acre)	**Pipe Diameter** (inches)
0.3	10
0.5	12
1.0	18

- Pipe material for temporary downdrain non-perforated, flexible, plastic pipe
- Sizing for permanent downdrain (Dn2) – 25-yr/24-hour event
- Permanent downdrain materials pipe (plastic or metal), concrete channel
- Soil underlying downdrain should be well compacted
- Anchor downdrain at top of slope securely (recommended: 1.5 feet of soil above pipe to secure pipe)
- Extend downdrain beyond toe of slope and provide outlet protection
- Downdrain should be secured by staking to underlying soil surface at approximately 10-feet intervals



Inlet Detail

Maintenance

- Routine inspection and repair/replacement of hold-down stakes as needed
- Inspect for scour at downdrain discharge

Level Spreader (Lv)

A storm water outlet constructed of a vegetated strip graded to zero slope. This outlet device results in concentrated runoff to discharge at non-erosive velocities to undisturbed downgradient areas.

Typical Applications

- To receive relatively sediment free storm water, typically from a diversion ditch (Di).

Design/Installation Guidance

- Design level spreader for 10-year 24-hour event according to the following guidance:

Designed Q10/24 (cfs)	Minimum Length "L" (feet)
up to 10	10
11 to 20	20
21 to 30	30
31 to 40	40
41 to 50	50

- Typical minimum width 6-feet
- Minimum depth of channel 6-inches
- Flow into and out of the level spreader will be at grade of 0%. Intermediate portions of the channel (to within 15 feet of discharge) will have slope less than or equal to 1%.
- The level spreader should be constructed in native material not fill.
- Channel should be covered by temporary vegetation (Ds2), permanent vegetation (Ds3) or matting (Mb)
- Discharge from level spreader should be onto vegetated undisturbed area

Maintenance

- Routine inspection and repair of erosion as needed
- Conduct routine maintenance to vegetation (remove unwanted species, fertilize, etc.)

4.4 Operations

Water quality issues associated with crushed stone operations include the characterization, control and treatment of process water. Washing and sizing of aggregates is the principal source of process water from aggregate mining facilities. Other operations conducted on aggregate mining operations that generate process water include pit dewatering, equipment washing, oil/water separators and dust suppression.

The Clean Water Act authorizes EPA and states, when delegated the authority by EPA, to regulate the discharge of process water through the NPDES permit program. Process water discharges are generally referred to as point sources, drawing the distinction from non-point source discharges that arise from discharges due to precipitation contacting industrial operations (i.e. storm water discharge).

The principal pollutant of concern associated with process water from aggregate mining operations is TSS. To a lesser degree and geology dependent, pH can be a secondary water quality issue. While individual NPDES permit limits may vary slightly between aggregate mining facilities, typical NPDES permit limits from aggregate mining facilities for TSS are an average concentration ranging from 45 to 55 mg/l and a daily maximum of 110 mg/l. Typical NPDES limits for pH at aggregate mining facilities allow for a range of 6.0 to 9.0 standard units.

Process Water Control

There are two principal components of process water control. The first is to minimize the production of process water, by constructing water efficient processes and recycling. The second and most obvious component, diversion and directing, is to insure that all process water is collected and treated as needed prior to discharge at a NPDES permitted outfall.

Process Water Minimization

Process water minimization requires effective management of water resources while providing sufficient water to provide the washed product required by customer and avoiding non-compliance with other environmental regulations (i.e. air quality permit). Possible areas for process water minimization include:

- Design and selection of efficient dust suppression equipment including spray bars and nozzles
- Utilization of unit process enclosures and chemical additives to augment and limit water required for dust suppression
- Appropriate water application rates to customer road and haul roads
- Use of tackifiers and wetting agents on customer roads and haul roads
- Recycling/reuse of process water

Diversion and Directing

To avoid an unpermitted discharge, process water will need to be collected at the point of generation and diverted to a control discharge structure or recycle ponds. Several of the BMPs discussed in the Construction Section presented above are applicable. The principal BMPs applicable to the majority of aggregate mining facilities include:

- Diversion (Di)
- Check Dams (Cd)
- Channel Stabilization (Ch)
- Permanent Sediment Basin

Process Water Treatment

With TSS the principal water quality parameter of concern at aggregate mining facilities, sedimentation is the primary treatment process. Sedimentation can be accomplished by physical settling alone or in tandem with chemical addition.

Physical Treatment

While physical treatment includes several types of treatment processes, at aggregate mining facilities the primary physical treatment is sedimentation. Sedimentation is a physical water treatment process used to settle out suspended solids in water under the influence of gravity.

The solids present in process water generated at the majority of aggregate mining facilities tend to readily settle. Since grain size, shape and density are important factors in the sedimentation process, the silts and sands present in aggregate mining process water readily undergo sedimentation, assuming that the sediment pond is appropriately designed and maintained (see permanent sediment pond design below).

Physical/Chemical Treatment

In certain conditions unaided settling may not be adequate to achieve the effluent TSS concentrations required. This may be due to improper sediment pond design or the presence of a higher clay content resulting in colloidal suspension. In these situations chemical addition can result in flocculation in increasing the settling rate. Unstable colloidal suspensions form flocs as the particles aggregate due to interparticle attractions. This can be accomplished by a number of different methods:

- Removal of the electrostatic barrier that prevents aggregation of the particles. This can be accomplished by the addition of salt to a suspension or changing the pH of a suspension to effectively neutralize the surface charge of the particles in suspension.
- Addition of a charged polymer flocculant. Polymer flocculants can bridge individual colloidal particles by attractive electrostatic interactions.
- Addition of nonadsorbed polymers called depletants that cause aggregation due to entropic effects.

Permanent Pond Design

Sedimentation – Basin Design Theory

Aggregate mining operations typically require the construction of permanent sediment ponds. The ponds are used for a variety of purposes including fresh water storage, recycling and process water treatment. These ponds are intended to be in service for several years and differ in their design considerations from the temporary sediment ponds described above.

Sedimentation is the separation of suspended particles that are heavier than water by gravitational settling. It is the most widely used water treatment process in use at aggregate mining facilities. On the basis of the solids concentration and the tendency of the particles to interact, four types of settling can occur.

- Type 1 Settling – Discrete particle settling

- Type 2 Settling – Dilute suspension of particles that coalesce or flocculate. By coalescing particles increase in mass and settle faster

- Type 3 Settling – Suspension of intermediate concentration, where a distinct solids-liquid interface forms and the mass settles as a unit.

- Type 4 Settling – High concentration of solids such that a “structure” forms and settling occurs due to compression from further addition of solids.

For the typical aggregate mining process water, Type 1 settling is generally the objective for sediment pond design.

With TSS being the principal water quality issue, effective water quality pond design should consider the settling velocity of the particles to be removed. In the design of sediment basins the usual procedure is to select a particle with a terminal velocity (V_c) and to design the basin so that all particles that have a terminal velocity equal to or greater than V_c will be removed. Therefore the rate at which clarified water is produced is :

$$Q = A\ V_c \text{ (equation 1)}$$

Where
Q = flow rate
A = surface area of the sediment basin

Simple manipulation of equation 1 yields the following

$$V_c = Q/A \text{ (equation 2)}$$

Equation 2 indicates that the overflow rate or surface loading rate, a common basis of design, is equivalent to the settling velocity. Equation 2 also indicates that Type 1 settling is independent of basin depth.

Since process water generated at aggregate mining operations results in the need for continuous flow sedimentation, as opposed to batch flow and treatment, the length of the basin and the time a unit volume of water is in the basin should be such that all particles with the design velocity (V_c) will settle to the bottom of the basin. This required time is referred to as the detention time. The design velocity, detention time, and basin depth are related as follows:

$$V_c = \text{ Basin Depth/Detention Time (equation 3)}$$

The attached figure summarizes Type 1 settling. As indicated in the figure, particles with terminal settling velocities less than V_c will not settle in the designed detention time. Making the assumption that particles of various sizes are evenly distributed over the entire depth of the basin inlet, the sediment removal efficiency can be determined by the following:

$$X_r = V_p / V_c$$

Where
X_r = Rate of removal
V_p = Particle settling velocity
V_c = Overflow rate

In a typical process wastewater a wide range of particle size gradation is likely. To determine the removal efficiency for a given settling time, it is necessary to consider the entire range of settling velocities present in the system. Once the characteristics of the process water are known a settling velocity curve analyses can be constructed as shown in the attached figure.

Under certain site conditions process water from aggregate mining operations requires the use of chemical (flocculant) addition to achieve the required removal rate. The extent to which adding flocculant increases solids removal is dependent upon opportunity for contact, which varies with the overflow rate, the depth of basin, sediment concentration and the range of particle size. To determine design settling velocity, lab scale settling experiments should be conducted and the design settling velocity and detention times adjusted accordingly.

In actual practice design factors should be included to allow for the effect turbulence, short-circuiting and scour.

Scour
Scouring occurs when inflow velocities to a sediment pond are sufficient to re-introduce previously sediment to suspension. The critical velocity is given by the following:

$$V_H = \{8k(s-1)gd/f\}^{1/2}$$

Where:
V= horizontal velocity that will just produce scour
s = density of particles
d = diameter of particles
k = constant (depends on type of material being scoured. Values range from 0.04 for sand to 0.06 for clays)
f = Darcy-Weisbach friction factor (values range from 0.02 to 0.03)
g = gravity

Turbulence
The discussion of Type 1 Settling above assumes laminar flow. This ideal flow condition is obviously never possible with turbulence potentially introduced by a variety of factors including inlet or outlet conditions or by poor pond design. To adjust for turbulent flow equation 1 above can be rewritten to include a factor for turbulent flow.

$$A = QK_t / V_c \text{ (equation 1)}$$

Where
Q = Flow
A = surface area of the sediment basin
V_c = Overflow rate
K_t = Turbulence factor

While a number of numerical models have been developed to estimate K_t, they are beyond the scope of this manual. The frequent used value for K_t of 1.2 has been compared to the more complex estimates. Assessment of this value has demonstrated that using this value tends to under estimate removal rates of smaller sediment sizes and over estimate removal rates of larger particle sizes.

Short-Circuiting
Short-circuiting occurs when a preferential flow path is present that results in fluid residing in the pond for a period less than the designed detention time.

Sediment Pond Design Practical Considerations
The above discussion addresses the major considerations for the proper design of permanent sediment ponds. The following discussion provides some additional description and practical considerations for sediment ponds.

Flow Rates/Drainage Area
In evaluating flow rates it is important to consider all potential flow to the pond, both process water and storm water runoff. For ponds that are likely to receive storm water runoff from a large area, assessment of site-specific hydrology for peak flows is recommended. Utilizing these procedure will insure that outlet structures are sufficiently sized.

Basin Capacity
Good basin design should allow for a minimum of 67 cubic yards per acre of total contributing drainage area. One half of this design volume shall be in permanent pool (wet storage) and the remaining half as drawdown volume. Permanent pool volume is measured from the low point of the basin to an elevation corresponding to one-half of the total storage volume. The volume of the drawdown area is measured from the elevation of permanent pool to the crest of the principal spillway.

Basin Shape
Development of basin area has been described above. To improve sediment trapping efficiency by reducing short circuiting and decreasing flow velocity through the pond, the effective length should be a minimum of twice the effective width. Baffles can be incorporated where surface area will not allow these physical dimensions.

Impoundment Structure
The material used for the impoundment structure should be from approved borrow areas. Ideally these soils will have been geotechnically assessed for use and will be free of cap rock, vegetative matter and other perishable or objectionable material. Placement of the material should be done in accordance with specific recommendations of a qualified engineer. Typically soil will be placed in 6-inch to 12-inch lifts with appropriate moisture content to achieve standard proctor compaction. Routine field assessment of compaction should be conducted.

The impoundment structure should be fitted with a cutoff trench excavated along the centerline of the impoundment structure and a minimum depth of two feet. The cutoff trench should extend up both abutting sides to the crest elevation of the principal spillway. The cutoff trench should be wide enough to effectively compact, but a minimum of 4-feet wide. The material used for the cutoff trench should be sufficiently impermeable (1x10^{-5}cm/sec or better) and placed to achieve standard proctor compaction.

The minimum width of the impoundment structure is summarized in the following table. Slopes of the impoundment structure should be 2.5:1 or flatter and minimum top width as follows:

Impoundment Height	Minimum Top Width
<10 feet	8 feet
>10 and <15 feet	10 feet
>15 feet	Per Engineers Specification

Impoundment Design Criteria

*Impoundment structures in excess of 25 feet in height and/or maximum storage of greater than 100 acre-feet that have the potential for loss of life in the event of failure will be subject to the Georgia Safe Dams Act (O.C.G.A. § 12-5-370, et seq.).

Impoundments structures that will be left in place for several years have the potential for internal erosion of the foundation or embankment caused by water seepage. Generally this erosion starts at the downstream toe and works back toward the basin, forming channels or pipes under the dam. The channels or pipes follow paths of maximum permeability and may not develop for many years. Resistance of the embankment or foundation to piping depends on the plasticity of the soil, gradation, and the degree of compactness. These factors are the reasons for selecting suitable soil for the impoundment structure and placing it using good construction techniques.

Seepage can be avoided or controlled by vertically extending the cutoff trench described above and/or lengthening the path of the seepage within the dam by the use of toe drains or chimney drains. The lengthening of the flow path decreases the hydraulic gradient of the water flow, thereby decreasing the water velocity and its potential for erosion. Internal drains should be considered for impoundment structures in excess of 15 feet that will likely be in service for several years. Toe drains are typically installed on the final one third to one half of the downstream side of the impoundment. Chimney drains extend vertically into the impoundment structure, ideally intercepting seepage and directing it for discharge downstream of the toe of the impoundment structure.

Immediately upon completion, the impoundment structure should be vegetated with temporary and/or permanent seeding.

Spillways
The impoundment should be fitted with a principal spillway and separate emergency spillway.

Basic design criteria - Principal Spillway

- Peak flow capacity - 100-year 24 hour event
- Crest of inlet to be set to full storage elevation corresponding to half the storage requirement
- Inlet should be fitted with anti-vortex and trash rack
- Calculate buoyant forces and anchor base accordingly

Basic design criteria - Emergency Spillway

- Peak flow capacity - 100-year 24 hour event
- Inlet to be set at elevation corresponding to the full storage requirement and at least 1-foot below the height of the impoundment
- The spillway should have a control section of at least 20-feet
- Lining of emergency spillway should be consistent with calculated maximum velocity.

Sediment Pond Maintenance
The impoundment structure should be inspected on a routine basis to ensure that it is structurally sound. Damage due to erosion or construction should be repaired and the damaged section re-stabilized.

The emergency spillway should be routinely inspected to insure lining is well protected and erosion resistant.

- Debris collected around principal spillway should be routinely removed

- Sediment should be removed from the basin when the volume of the permanent pool is reduced by one-half.

- Removed solids should be initially placed upslope of the sediment pond to dewater. After dewatering removed sediments should be moved to permanent disposal area (fill area or berm) and stabilized.

Miscellaneous Process Waters

In addition to the principal process water generated by aggregate mining operations, i.e., sediment laden wash waters, some facilities may generate small quantities of hydrocarbon-contaminated water. This process water, typically generated at facility maintenance locations, is generated from the routine maintenance and pressure washing of site equipment. The typical treatment process employed by aggregate mining operations for the collection and treatment of this process water is an oil/water separator. In practice, all facilities generally collect and dispose of the oil fraction by using the services of a waste oil vendor. The water fraction of this treatment process should not be overlooked and allowed to discharge unmonitored at an unpermitted discharge point. The discharge of the water fraction should occur only at a permitted NPDES discharge point.

Oil/water separators are typically "in-line" devices used to remove oils and greases from the waste stream. The separators generally operate by employing physical separation methods including gravity separation and flotation, according to Stokes Law. The performance of gravity separation systems is a function of the relatively low water solubility of petroleum products in water and their different specific gravities. Solids, if present in the waste stream, will generally collect at the bottom of the separator holding tank and can be periodically removed when the tank is drained for maintenance. Small quantities of dirt and grit will not harm the operations of the separator; however, they will eventually need to be removed. If large quantities of solid particles are expected, it is wise to provide a grit removal chamber before the separator.

Gravity separator performance and efficiency can be enhanced by coalescence, i.e., increasing the size of the oil droplets.

While oil/water separators are simple unit processes, several factors should be considered in the selection and design of oil the system including:

- Flow rate and conditions
- Degree of separation required - effluent quality
- Amount and type of oil in the water
- Amount of emulsified oil
- Minimum temperature (generally ambient)

Since the size of the oil droplets formed in the separator is the principal factor affecting separator performance, anything that decreases the average droplet size in the inlet of a separator will decrease the performance of the separator. The type of equipment that Decreasing droplet size caused by shear in the inlet stream. This can be caused by pumps, valves, small or rough piping and undue amounts of pipe fittings in the inlet pipe.

Soaps and detergents can cause emulsions that are very difficult to remove. Without careful attention to the amount and type of soaps and detergents used it is likely that a system will not operate satisfactorily. The degree of emulsification of the oil is difficult to assess, but steps can be taken to discourage the formation of emulsions and encourage the breakup of emulsions that are inadvertently created. It may be necessary to substitute quick-break detergents for conventional detergents that are also emulsion causing. Quick-break detergents are detergents designed to remove the oil (or grease) from the item to be cleaned and then to quickly dissociate again from the oil, leaving the oil as free hydrocarbon droplets in the water.

4.5. Reclamation

The permitted mine land use plan will identify reclamation activities to be conducted. An effective mine land use plan will specify reclamation methods that are technically effective, cost efficient and employ tested engineering practices. The general reclamation objectives applicabe to all of mining facilities include:

- Returning the mine to a condition that will not pose a hazard to public health and environment
- Create conditions that result in stabilized self-sustaining vegetative cover
- Return the site to a condition that will support wildlife habitat.
- Enhance the visual appearance of the former mine areas

Reclamation plans will be site specific but will generally include the following:

- The removal of all mine facilities (processing plant, buildings, utilities)
- A grading plan that will create land surfaces that promote drainage and minimize potential for ponding of water and erosion
- Establish stable slopes
- Call for the placement of suitable soil for establishment and sustainability of vegetative cover
- Monitor the performance during and after reclamation to ensure objectives are achieved.

Through proper planning and implementation of the reclamation plan, reclaimed aggregate mining operations can be valuable economic, aesthetic, and environmental resources. The following section describes the regulatory requirements and typical activities undertaken during mine reclamation.

Before Reclamation

After Reclamation

Regulatory Requirements – Georgia Surface Mining Act

The reclamation plan prepared as part of the Mining Land Use Plan will define the reclamation actions to be taken at the end of the active aggregate mine life span. This plan will be reviewed and approved by the GAEPD prior to implementation. Prior to facility bond releasing, a report of reclamation activities will be provided to GAEPD. The reclamation plan, therefore will include GAEPD requirements but will likely also address issues relevant to the operator including long term liability and potential future land use.

Section 391-3-3-.06 of the rules promulgated under the Georgia Surface Mining Act defines the requirement for mine reclamation for all facilities holding surface mine permits. The rule states:

> "Following the removal or disposal of all structures, equipment, stockpiles, mining refuse and all other materials associated with surface mining, the affected land will be reclaimed in accordance with the provisions of the mining operator's approved Mining Land use Plan. All lands, except those specifically exempted by the Division in the operators Mining Land Use Plan, will have a neat, clean appearance and contain a high quality, permanent vegetative cover."

The rule provides few details regarding aggregate mine site reclamation. The GAEPD uses the reclamation plan included in the Mining Land Use Plan as the mechanism to regulate and approve site-specific reclamation. Given the typical life span of an aggregate mine facility the initial reclamation plan will be subject to change in subsequent mine amendments and will be reflective of current GAEPD policies and initiatives.

The current Application for Surface Mining Permits ("Blue Form") provides more detail on the requirements for reclamation. The performance from the "Blue Form" criteria for reclamation includes the following:

> "Reclamation shall be concurrent with mining activity as lands become available."

> "Reclamation objectives as shown on Surface Mining Land Use Plan will be achieved unless Operator submits an amendment."

> "Following the removal or disposal of all structures, equipment, stockpiles, mining refuse, and all other materials associated with surface mining, the Operator will reclaim all affected land in accordance with the provisions of this Plan. All lands except those specifically exempted in this Plan will have a neat, clean appearance and contain a high quality permanent vegetative cover."

> "Vegetative Stabilization (planting) Requirement: The Operator will provide a high quality, enduring vegetative ground cover of properly planted and nurtured perennial vegetative species suited for the specific planting zone involved. The perennial vegetative species shall provide a complete, thorough stabilization by providing root mass and cover for the total disturbed area. If forest land is the reclamation objective, a vegetative ground cover will also be provided prior to or concurrent with tree seeding or the planting of tree seedlings."

> "Structural Stabilization: Permanent structural control measures, i.e. stone riprap, ditches, berms, paved chutes, or piped down drains, etc, shall be

utilized to convey concentrated storm flows down slopes to stable outlets. These measures are necessary in areas where concentrated stormflow velocities may cause erosion."

"The Operator shall grade all peaks, ridges, and valleys resulting from surface mining and backfill all pits and trenches resulting from same in a manner to minimize any hazardous effects of mining adjacent to any State or county maintained public road."

"All affected lands requiring backfilling as stated in the Reclamation Objective of this Plan shall be backfilled utilizing overburden, spoil material, and/or borrow from affected (permitted) land unless approval from the Division is obtained to utilize other materials. Sound engineering principles shall be applied to ensure that affected lands, as reclaimed, meet the intended use."

"Immediate erosion control measures shall be applied to protect the topsoil cover until an adequate vegetative cover is established."

"All highwalls occurring in unconsolidated materials shall be reduced by grading to blend in with the existing original site topography. Highwalls occurring in consolidated material shall be reduced as much as may be practicable. A constructed bench with reverse slope to the wall shall be provided at the top of highwalls which are to remain. Any remaining highwalls of fifty (50) feet or greater shall be fenced or bermed at the top beyond the initial bench. Such fencing or berm shall be sufficient to provide an adequate degree of protection or warning to foot traffic."

"All affected land, unless otherwise specified in this Plan, shall be graded into a rolling topography and blended in with the existing landscape. All graded areas shall be free of debris, stockpiled materials, boulders, etc. that would interfere with the intended use and/or maintenance of the area."

"Constructed slopes shall not exceed three horizontal to one vertical (3:1) except where may be approved otherwise in this Plan. Fill and cut slopes shall be designed and constructed to prohibit slumping or shear failures. Prior to final grading, all slopes will be blended in with the original existing topography. Slope grades shall be uniform. Mechanical or vegetative or both stabilization measures shall be employed as soon as practical to prevent erosion."

"Overburden, spoil or refuse, when used as backfill material, for berm or other construction, shall be segregated as necessary, emplaced and compacted in accordance with sound engineering practices to provide for the purpose intended. Refuse does not include any material which may be classified as solid waste under provisions of the Georgia Comprehensive Solid Waste

Management Act.”

“All new landform structures created with the use of overburden (spoil) or refuse materials shall be constructed in a manner to protect against failure, subsidence and/or erosion and will be permanently stabilized upon completion of construction.”

“When lakes/ponds are proposed, the minimum acceptable design criteria shall meet or exceed that criteria in: Agriculture Handbook Number 590, Ponds - Planning, Design, Construction published by the United States Department of Agriculture, Soil Conservation Service, latest issue. When the dam structure proposed is 35 feet or higher, other acceptable design criteria shall be used.”

“Water shall be of a quality suitable for the intended use. The lake/pond shall have a safe access and be free of underwater hazards. All above water portions of the lake/pond site development shall be revegetated with an enduring permanent vegetative cover.”

“Under provisions of the Georgia Safe Dams Act, no permit shall be required to be obtained by the Operator if a dam is constructed with or incidental to "surface mining" as defined in the Georgia Surface Mining Act. If the dam so constructed is classified by the Director as a Category I dam the Operator shall, upon the completion of the mining activity in connection with which such dam was constructed, either drain and reclaim the impoundment formed by such dam or stabilize such impoundment as a lake. If the impoundment is reclaimed as a lake and the dam which created the impoundment remains in place as a Category I dam, then, before such lake is deemed acceptable reclamation and the Operator is released from his obligations under the Georgia Surface Mining Act, as amended, the Operator will obtain a permit for such dam under the Safe Dams Act.”

“Any proposal for the construction of wetlands as a reclamation objective shall be consistent with accepted practices utilizing the best available technology (BAT) and include the best management practices (BMP's) to attain the desired result. The proposal shall be attached to and be a part of this Plan subject to approval by the Division.”

“The operator shall file a final reclamation report and request for release upon completion of reclamation responsibilities on affected acreage. A report may be filed on reclamation activities which partially completes the operator’s full responsibilities for total acreage affected. Said report and request shall be on forms as provided by the Division.”

Facility-Specific Requirements

As listed above, GAEPD reclamation requirements are generally directed toward long-term surface stabilization and the resulting control of erosion. In addition, GAEPD requirements include general safety concerns including limiting public access to the highwall and removal of dams that do not meet current requirements of the Safe Dams Act, as needed.

In addition to the GAEPD's requirements, the operator's may have expanded reclamation objectives. Reclamation objectives for the operator could include one or more of the following:

- Long-term liability protection
- Future economic benefits from the sale or re-development of the reclaimed mine site
- The restoration or enhancement of previously affected habitat for plants and animals consistent with pre-mining conditions
- Adaptive reuse of the reclaimed mine site for future agricultural, recreational, or green space

Sequencing of Reclamation Activities

The primary objective of reclamation is to provide a sustainable land surface by providing a self-sustaining vegetative cover. To accomplish this objective many of the BMPs discussed in the active operations section of this manual will also be employed during reclamation. Since reclamation generally requires the removal of all structures, equipment, stockpiles, mining refuse, and all other materials associated with surface mining additional activities will be required. Following are the general reclamation activities in the order in which they are typically conducted.

Demolition/Removal of Structures

All structures including stone processing equipment, buildings, tanks, and tenant structures will be need to be inventoried and arrangements made for their demolition, removal and offsite disposal. In preparation for general demolition of site structures the following should be considered:

- The GAEPD requires that all structures be inspected for the presence of asbestos containing material (ACM). All confirmed material must be removed by a licensed asbestos contractor prior to general demolition.

- Regulated material including fuels, lubricants and waste oil should be characterized and appropriately disposed. Bulk containers holding regulated materials should be emptied of their contents and appropriately disposed or relocated for reuse. Underground storage tanks must be closed in accordance with GAEPD regulations and in most instances USTs should not be re-used at another location.

- Soil in the vicinity where regulated materials were used, including tenant sites, should be characterized for residual impact. Impacted soil above applicable regulatory limits should be excavated and appropriately disposed of or otherwise remediated.

Initial Site Preparation

In most instances, the aggregate mine facility will need preparatory work before mine reclamation efforts can begin. Preparatory work may include, but is not limited to the following:

- Clearing and grubbing to remove stumps, roots, boulders and other surface objects designated to be removed in the reclamation plan. Disposal of debris should be consistent with the type of debris encountered.
- Identification and marking of all vegetation and objects designated to remain.
- Coarse grading to remove rills and ruts as well to shape final contours as detailed in the reclamation plan.
- Construction of water control structures to protect reclaimed areas from erosion and to prevent sediment transport offsite.

Final Site Preparation

The principal objective for most reclamation projects will be the establishment of permanent vegetation. The vegetative cover will provide protection from erosion by reducing velocity of raindrops and the subsequent erosive energy of surface water runoff, while promoting deep-rooted growth helping to bind soil and increase infiltration. If appropriately planned and installed, erosion and sediment control for reclamation can be completed with relatively low cost and with little or no long-term maintenance. To achieve this objective adequate soil coverage along with the selection and installation of appropriate vegetation is required.

Final Soil Cover

Once all structures and unsuitable soil have been removed and site grading has been completed, the surface of the site is typically covered with topsoil to provide a quality medium to establish vegetation. Ideally sufficient topsoil or other suitable soil will be available onsite. When possible topsoil should be stockpiled and stored onsite during the active life of the quarry for later use. While salvaged topsoil quality is best when immediately placed, due to retention of soil microbes and degree of porosity, stockpiled topsoil quality can be enhanced by minimizing exposure to and keeping the stockpile vegetated. Ideally stockpiled topsoil will not be disturbed again until used for final reclamation. During the placement of topsoil the following should be considered:

- Avoid compaction and excessive disturbance after placement. Compaction results in loss of pore spaces in the soil and an increase in bulk density, which have adverse affects on plant rooting and nutrient transport.
- Maintain optimum soil moisture as excessive moisture or dryness can have adverse affects on topsoil quality and, subsequently, on vegetation success. Soils that are too wet become compacted and soils that are too dry turn to powder and are difficult to handle.
- When the stockpiled soils are laid over the regraded areas, it is recommended that 6-12 inches of topsoil be used to ensure successful plant growth. Because roots will extend into the graded overburden, it is also important to prepare the overburden to a depth of at least one foot.

Establishment of Vegetation

After all other reclamation activities have been completed and final soil layer applied vegetation activities can be initiated. Successful establishment of vegetation is the primary goal of the reclamation process, since the engineered controls (i.e. structural erosion control measures) are generally only designed to function until vegetation is established. The vegetation process typically includes the following:

- Selection of the appropriate plant species based on the physical location (i.e. climate range), purpose, and chemical/physical properties of the material in which the plants will be rooted;
- Preparing seed bed by tilling or surface roughing
- Seeding or planting of live stakes
- Mulching and/or chemical stabilization
- Fertilizing
- Maintenance

Table 6-4.1 and Table 6-5.2 in the Georgia Manual for Erosion and Sediment Control in Georgia provides species recommendations, planting schedule, and application rates for temporary vegetative cover and permanent vegetative cover, respectively.

APPENDIX A
Erosion and Sediment Control Inspection Checklist

Sample Water Quality Management Inspection Checklist

(Water Quality Management Inspection Checklists Are Site Specific - For Illustrative Purposes Only)

Facility Name	
Date:	
Inspector:	

Permit Information

	Y/N	N/A
Copy of Permitted Mine Plans Onsite Drainage Patterns Evident Final Slopes on Berms and Graded Areas Evident Undisturbed and Buffer Areas Depicted Principal Structural BMPs Depicted		
Copy of NPDES Permit Onsite Location of Outfalls Identified Name of Receiving Stream		
SWPPP Plan Onsite BMPs Identified and Described Stormwater Outfalls Identified		
SPCC Plan Onsite		

Non Sediment Pollution Control

	Y/N	N/A
Pressure washing conducted in designated area		
Does oil/water separator appear to be operating correctly		
Is any excessive oil staining present		
Is standing water present in petroleum containment areas Is sheen present on standing water		
Are all containers in excess of 55-gallons provided with secondary containment		

Sediment Control-General Site Conditions

	Y/N	N/A
Have structural measures been constructed per facility plans and permits		
Are all facility perimeter controls installed and stabilized per plans and permits		
Are stockpiles staged away from watercourses		
Is runoff from stockpiles areas directed to a sediment control structure		
Evidence of offsite tracking at facility entrances		

Evidence of sediment directed to receiving stream		
Is material dredged from sediment ponds present If so is it scheduled for permanent placement		

Sediment Control – Vegetative Measures

	Y/N	N/A
Are any slopes or berms at final grade Has soil been prepared for seeding Has seed been applied and mulched Rainfall or applied water adequate		
Are areas of site reclaimed Is vegetation providing adequate stabilization Is excessive erosion present		
Have temporary structures no longer needed in reclaimed areas removed		
Are temporary vegetative measures employed on actively worked areas (i.e. temporary seeding, mulching, surface roughening)		

Sediment Control – Structural Measures

	Y/N	N/A
Are stormwater conveyance channels/ditches adequately stabilized with the designed channel lining Is excessive erosion or scour evident along channel/ditch		
Is rip rap placed at all stormwater outfall pipes Is excessive scour evident at point of discharge		
Are check dams present within channels or ditches If present is accumulated sediment less than one-half check dam height		
Is silt fence present at the facility Is silt fence trenched into ground Gaps, tears or sagging evident Ends of fence brought upslope Level of accumulated sediment less than 50%		
Is there sediment pond(s) present at the facility Are all industrial process waters directed to sediment pond Are all concentrated stormwater flows directed to sediment pond Are sediment pond banks stabilized		

Is trash rack free of debris Emergency spillway free of debris Impoundment structure stabilized Seeps or leaks present on downslope face of impoundment Sediment cleanout level marked on riser Good visible water quality (i.e. no sheen, odor, excessive floating debris) Rip rap present at pond outlet Headwall conditions are satisfactory		

APPENDIX B
Regulatory Contacts

STATE

Main Office
Georgia Environmental Protection Division
Georgia Department of Natural Resources
2 Martin Luther King Jr. Drive, Suite 1152 East Tower
Atlanta, GA 30334
Telephone: 404.657.5947
www.georgiaepd.org

Land Protection Branch
4244 International Parkway, Suite 104
Atlanta, GA 30354
Phone: 404.362.2537 Fax: 404.362.2693

Area of Interest - surface mining permits, surface mining compliance

Watershed Protection Branch
4220 International Parkway, Suite 101
Atlanta, GA 30354
Phone: 404.675.6232 Fax: 404.675.6247

Areas of Interest – Individual NPDES, Stormwater NPDES, TMDL

FEDERAL

Industrial Stormwater Program
US EPA Headquarters / Office of Water / Office of Wastewater Management / Water Permits Division
1200 Pennsylvania Ave NW
Washington, DC 20460
Phone: (202) 564-0577
Fax: (202) 564-6431
http://cfpub1.epa.gov/npdes/home.cfm

US EPA, Region 04 / Water Management Division
Atlanta Federal Center
61 Forsyth St SW
Atlanta, GA 30303-3104
Phone: (404) 562-9303
Fax: (404) 562-8692

Individual NPDES
US EPA Headquarters / Office of Water / Office of Wastewater Management / Water Permits Division
1200 Pennsylvania Ave NW
Washington, DC 20460
Phone: (202) 564-8311
Fax: (202) 564-9544
URL:http://cfpub.epa.gov/npdes/index.cfm

US EPA, Region 04
Atlanta Federal Center
61 Forsyth St SW
Atlanta, GA 30303-3104
Phone: (404) 562-9444
Fax: (404) 562-9728

SPCC
U.S. EPA Office of Emergency Management
Ariel Rios Building (5104A)
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460
(202) 564-8600 (phone)

U.S. EPA - Region 4
61 Forsyth Street
Atanta, GA 30365-3415
(404) 562-9900
(800) 241-1754

Army Corps of Engineers
Main Office
US Army Corpos of Engineers
441 G. Street, NW
Washington, DC 20314-1000

http://www.hq.usace.army.mil/hq_exec/index.asp

Savannah District Office
P.O. Box 889
Savannah, GA 31402-0889
912-652-5222
http://www.sas.usace.army.mil/

APPENDIX C
Glossary of Erosion and Sediment Control Terms

APPENDIX F

Glossary

The list of terms that follows is representative of those used by soil scientists, engineers, developers,conservationist planners, etc. The terms are not necessarily used in the text, nonetheless they are in common use in conservation matters.

AASHTO CLASSIFICATION (soil engineering) — The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway Transportation Officials.

ACID SOIL — A soil with a preponderance of hydrogen ions, and probably of aluminum in proportion to hydroxyl ions. Specifically, soil with a pH value less than 7.0. For most practical purposes, a soil with a pH less than 6.6, the values obtained vary greatly with the method used consequently there is no unanimous agreement on what constitutes an acid soil. The term is usually applied to the surface layer or to the root zone unless specified otherwise.

ACRE-FOOT — The volume of water that will cover 1 acre to a depth of 1 foot.

AGGRADATION — The process of building up a surface by deposition. This is a long-term or geologic trend in sedimentation.

ALKALINE SOIL — A soil that has a pH greater than 7.0, particularly above 7.3, throughout most or all of the root zone, although the term is commonly applied to only the surface layer or horizon of a soil.

ALLUVIAL — Pertaining to material that is transported and deposited by running water.

ALLUVIAL LAND — Areas of unconsolidated alluvium, generally stratified and varying widely in texture, recently deposited by streams, and subject to frequent flooding. A miscellaneous land type.

ALLUVIAL SOILS - An axonal great soil group of soils, developed from transported and recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil forming processes.

ALLUVIUM — A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay, and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

ANGLE OF REPOSE — Angle between the horizontal and the maximum slope that a soil assumes through natural processes.

ANTECEDENT SOIL WATER — Degree of wetness of a soil prior to irrigation or at the beginning of a runoff period, expressed as an index or as total inches soil water.

ANTI-SEEP COLLAR — A device constructed around a pipe or other conduit and placed through a dam, levee, or dike for the purpose of reducing seepage losses and piping failures.

ANTI-VORTEX DEVICE — A facility placed at the entrance to a pipe conduit structure such as a drop inlet spillway or hood inlet spillway to prevent air from entering the structure when the pipe is flowing full.

APRON (soil engineering) — A floor or lining to protect a surface from erosion. An example is the pavement below chutes, spillways, or at the toes of dams.

AUXILIARY SPILLWAY — A dam spillway built to carry runoff in excess of that carried by the principal spillway. See *Emergency Spillway*.

BACKFILL — The material used to refill a ditch or other excavation, or the process of doing so.

BEDROCK — The solid rock underlying soils and the regolith in depths ranging from zero (where exposed by erosion) to several hundred feet.

BEDLOAD — The sediment that moves by sliding, rolling, or bounding on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both but at velocities less than the surrounding flow.

BEST MANAGEMENT PRACTICES (BMP) — A collection of structural practices and vegetative measures which, when properly designed, installed and maintained, will provide effective erosion and sedimentation control for all rainfall events up to and including a 25-year, 24-hour rainfall event.

BLINDING MATERIAL — Material placed on top and around a closed drain to improve the flow of water to the drain and to prevent displacement during backfilling of the trench.

BLIND INLET — Inlet to a drain in which entrance of water is by percolation rather than open flow channels.

BORROW AREA — A source of earth fill material used in the construction of embankments or other earthfill structures.

BOTTOM LANDS — A term often used to define lowlands adjacent to streams.

BOX-CUT — The initial cut driven in a property where no open side exists, resulting in a highwall on both sides at the cut.

BRUSH MATTING

(1) A matting of branches placed on badly eroded land to conserve moisture and reduce erosion while trees or other vegetative covers are being established.
(2) A matting of mesh wire and brush used to retard streambank erosion.

CHANNEL — A natural stream that conveys water; a ditch or channel excavated for the flow of water. See Watercourse.

CHANNEL IMPROVEMENT — The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity. Sometimes used to connote channel stabilization.

CHANNEL SLOPE — Natural or excavated sides (banks) of a watercourse.

CHANNEL STABILIZATION — Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

CHANNEL STORAGE — Water temporarily stored in channels while enroute to an outlet.

COLLOID — In soil, organic or inorganic matter having very small particle size and a correspondingly large surface area per unit of mass. Most colloidal particles are too small to be seen with the ordinary compound microscope.

COMPACTION — In soil engineering, the process by which the silt grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per cubic foot.

CONDUIT — Any channel intended for the conveyance of water, whether open or closed.

CONSERVATION — The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

CONSERVATION DISTRICT — A public organization created under state enabling law as a special purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries, usually a subdivision of state government with a local governing body.Often called a soil conservation district or a soil and water conservation district.

CONTOUR

(1) An imaginary line on the surface of the earth connecting points of the same elevation.

(2) A line drawn on a map connecting points of the same elevation.

COVER CROP — A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of permanent vegetation.

CRADLE — A device, usually concrete, used to support a pipe conduit or barrel.

CREEP (SOIL) — Slow mass movement of soil and soil material down relatively steep slopes, primarily under the influence of gravity but facilitated by saturation with water and by alternate freezing and thawing.

CRITICAL AREA — A severely eroded sediment producing area that requires special management to establish and maintain vegetation to stabilize soil conditions.

CUT — A portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below the original ground surface to the excavated surface. Syn. *Excavation.*

CUT-AND-FILL — Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

CUTOFF — A wall, collar or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

DAM — A barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or for retention or soil, rock, or other debris.

DEBRIS — The loose material arising from the disintegration of rocks and vegetative material; transportable by streams, ice or floods.

DEBRIS DAM — A barrier built across a stream channel to retain rock, sand, gravel, silt, or other material.

DEBRIS GUARD — A screen or grate at the intake of a channel, drainage, or pump structure for the purpose of stopping debris.

DEGRADATION — To wear down by erosion, especially through stream action.

DESIGN HIGHWATER — The elevation of the water surface as determined by the flow conditions of the design floods.

DESIGN LIFE — The period of time for which a facility is expected to perform its intended function.

DESILTING AREA — An area of grass, shrubs, or other vegetation used for inducing deposition of silt and other debris from flowing water; located above a stock tank, pond, field, or other area needing protection from sediment accumulation. See *Filter Strip.*

DETENTION DAM — A dam constructed for the purpose of temporary storage of streamflow or surface runoff and for releasing the stored water at controlled rates.

DIKE (engineering) — An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee. (geology) A tabular body of igneous rock that cuts across the structure of adjacent rocks or cuts massive rocks.

DISCHARGE (hydraulics) — Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.

DISCHARGE COEFFICIENT (hydraulics) — The ratio of actual rate of flow to the theoretical rate of flow through orifices, weirs, or other hydraulic structures.

DISCHARGE FORMULA (hydraulics) — A formula to calculate rate of flow of fluid in a conduit or through an opening. For steady flow discharge, Q =

AV,wherein Q is rate of flow, A is cross-sectional area and V is mean velocity. Common units are cubic feet per second, square feet, and feet per second, respectively. To calculate the mean velocity, V for uniform flow in pipes or open channels see Manning's Formula.

DISPERSION, SOIL — The breaking down of soil aggregates into individual particles, resulting in single-grain structure. Ease of dispersion is an important factor influencing the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodible it is.

DIVERSION — A channel with or without a supporting ridge on the lower side constructed across the top or bottom of a slope for the purpose of intercepting surface runoff.

DIVERISION DAM — A barrier built to divert part or all of the water from a stream into a different course.

DRAIN

(1) A buried pipe or other conduit (closed drain).
(2) A ditch (open drain) for carrying off surplus surface water of groundwater.
(3) To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or by internal flow.
(4) To lose water (from the soil) by percolation.

DRAINAGE

(1) The removal of excess surface water or groundwater from land by means of surface or subsurface drains.
(2) Soil characteristics that affect natural drainage.

DRAINAGE, SOIL — As a natural condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation; for example, in well-drained soils the water is removed readily but not rapidly; in poorly drained soils the root zone is waterlogged for long periods unless artificially drained, and the roots of ordinary crop plants cannot get enough oxygen: in excessively drained soils the water is removed so completely that most crop plants suffer from lack of water. Strictly speaking, excessively drained soils are a result of excessive runoff due to steep slopes or low available water holding capacity due to small amounts of silt and clay in the soil material. The following classes are used to describe soil drainage:

Well drained — excess water drains away rapidly and no mottling occurs within 36 inches of the surface.

Moderately well drained — water is removed from the soil somewhat slowly, resulting in small but significant periods of wetness. Mottling occurs between 8 and 18 inches.

Somewhat poorly drained - water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Mottling occurs between 0 to 18 inches.

Poorly drained — water is removed so slowly that the soil is wet for a large part of the time. Mottling occurs between 0 to 8 inches.

Very poorly drained — water is removed so slowly that the water table remains at or near the surface for the greater part of the time. There may also be periods of surface ponding. The soil has a black to gray surface layer with mottles up to the surface.

DRAWDOWN — Lowering of the water surface (in open channel flow), water table, or piezometric surface (in groundwater flow) resulting from a withdrawal of water.

DROP-INLET SPILLWAY — An overfall structure in which the water drops through a vertical riser connected to a discharge conduit.

DROP SPILLWAY — An overfall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

DROP STRUCTURE — A structure for dropping water to a lower level and dissipating its surplus energy; a fall. A drop may be vertical or inclined.

EARTH DAM — Dam constructed of compacted soil material.

EMBANKMENT — A man-made deposit of soil, rock, or other material used to form an impoundment.

EMERGENCY SPILLWAY — A spillway used to carry runoff exceeding a given design flood. Syn. *Auxiliary Spillway.*

ENERGY DISSIPATOR — A device used to reduce the energy of flowing water.

ERODIBLE (geology and soils) — Susceptible to erosion.

EROSION

(1) The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.
(2) Detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of water erosion:

ACCELERATED EROSION — Erosion much more rapid than normal, or geologic erosion, primarily as a result of the influence of the activities of man, or in some cases, of other animals or natural catastrophes that expose base surfaces, for example, fires.

GEOLOGIC EROSION — The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc. See *Natural Erosion.*

GULLY EROSION — The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.

NATURAL EROSION — Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. See *Geological Erosion.*

NORMAL EROSION — The gradual erosion of land used by man which does not greatly exceed natural erosion. See **Natural Erosion.**

RILL EROSION — An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See *Rill.*

SHEET EROSION — The removal of fairly uniform layer of soil from the land surface by runoff water.

SPLASH EROSION — The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

EROSION AND SEDIMENTATION CONTROL PLAN — A plan for the control of erosion and sediment resulting from a land-disturbing activity.

EROSION CLASSES (soil survey) — A grouping of erosion conditions based on the degree of erosion or on characteristic patterns; applied to accelerated erosion, not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion.

EROSION INDEX — An interaction term of kinetic energy times maximum 30-minute rainfall intensity that reflects the combined potential of raindrop impact and turbulence of runoff to transport dislodged soil particles from a field.

EROSIVE — Having sufficient velocity to cause erosion; refers to wind or water. Not to be confused with erodible as a quality of soil.

ESCARPMENT — A steep face or ridge of highland; the scarpenet of a mountain range is generally on that side nearest the sea.

EXISTING GRADE — The vertical location of the existing ground surface prior to cutting or filling.

FERTILIZER — Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth.

FERTILIZER ANALYSIS — The percentage composition of fertilizer, expressed in terms of nitrogen, phosphoric acid, and potash. For example, a fertilizer with a 6-12-6 analysis contains 6 percent nitrogen (N), 12 percent available phosphoric acid (P205) and 6 percent water-soluble potash (K2O). Minor elements may also be included. Recent analysis expresses the percentages in terms of the elemental fertilizer (nitrogen, phosphorus, potassium).

FILLING — The placement of any soil or other solid material either organic or inorganic on a natural ground surface or an excavation.

FILTER STRIP — A long, narrow vegetative planting used to retard or collect sediment for the protection of diversions, drainage basins or other structures.

FINAL CUT — The last cut or line of excavation made when mining a specific property or area.

FINISHED GRADE — The final grade or elevation of the ground surface forming proposed design.

FLOOD — An overflow or inundation that comes from a river or other body of water and causes or threatens damage.

FLOOD CONTROL — Methods or facilities for reducing flood flows.

FLOOD CONTROL PROJECT — A structural system installed for protection of land and improvements from floods by the construction of dikes, river embankments, channels, or dams.

FLOODGATE — A gate placed in a channel or closed conduit to keep out floodwater or tidal backwater.

FLOODPEAK — The highest value of the stage or discharge attained by a flood. The peak stage or peak discharge.

FLOODPLAIN — Nearly level land situated on either side of a channel which is subject to overflow flooding.

FLOODROUTING — Determining the changes in the rise and fall of floodwater as it proceeds downstream through a valley or reservoir.

FLOOD STAGE — The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

FLOODWATER RETARDING STRUCTURE — A structure providing for temporary storage and controlled release of floodwater.

FLOODWAY — A channel, either natural, excavated, or bounded by dikes and levees, used to carry excessive flood flows to reduce flooding; sometimes considered to be the transitional area between the active channel and the floodplain.

FLUME — A device constructed to convey water on steep grades lined with erosion resistant materials.

FRAGIPAN — A natural subsurface horizon with high bulk density relative to the solum above, seemingly cemented when dry but showing a moderate to weak brittleness when moist. The layer is low in organic matter, mottled, slowly or very slowly permeable to water, and usually shows occasional or frequent bleached cracks forming polygons. It may be found in profiles of either cultivated or virgin soils but not in calcareous material.

FREEBOARD (hydraulics) — Vertical distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures provided to prevent overtopping because of unforeseen conditions.

GAGE OR GAUGE — Device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc.

GAGING STATION — A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.

GEOTEXTILE — A term used to describe woven or non-woven fabric materials used to reinforce or separate soil and other materials.

GRADATION (geology) — The bringing of a surface or a streambed to grade by running water. As used in connection with sedimentation and fragmental products for engineering evaluation, the term gradation refers to the frequency distribution of the various sized grains that constitute a sediment, soil, or material.

GRADE

(1) The slope of a road, channel, or natural ground.
(2) The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction like paving or laying a conduit.
(3) To finish the surface of canal bed, roadbed, top of embankment, or bottom of excavation.

GRADED STREAM — A stream in which, over a period of years, the slope is delicately adjusted to provide, with available discharge and with prevailing channel characteristics, just the velocity required for transportation of the load (of sediment) supplied from the drainage basin. The graded profile is a slope of transportation. It is a phenomenon in which the element of time has a restricted connotation. Works of man are limited to his experience and of design and construction.

GRADE STABILIZATION STRUCTURE — A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further headcutting or lowering of the channel grade.

GRADIENT — Change of elevation, velocity, pressure, or other characteristics per unit length; slope.

GRADING — Altering surfaces to specified elevations, dimensions, and/or slopes; this includes stripping, cutting, filling, stockpiling and shaping or any combination thereof and shall include the land in its cut or filled condition.

GRASS — A member of the botanical family Gramineae, characterized by bladelike leaves arranged on the culm or stem in two ranks.

GRASSED WATERWAY — A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from cropland.

GULLY — A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or during the melting of snow. A gully may be dendritic, or branching, or it may be linear; rather long, narrow, and of uniform width. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lesser depth and would be smoothed by use of ordinary tillage equipment. See Erosion, *Rill*.

GULLY EROSION — See *Erosion*.

GULLY CONTROL PLANTINGS — The planting of forage, legume, or woody plant seeds, seedlings, cuttings, or transplants in gullies to establish or re-establish a vegetative cover adequate to control runoff and erosion and incidentally produce useful products.

HABITAT — The environment in which the life needs of a plant or animal organism, population or community are supplied.

HEAD (hydraulics)

(1) The height of water above any plane of reference.
(2) The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed; used in various compound terms such as pressure head, velocity head, and lost head.
(3) The internal pressure expressed in "feet" or pounds per square inch of an enclosed conduit.

HEAD GATE — Water control structure; the gate at the entrance to a conduit.

HEAD LOSS — Energy loss due to friction, eddies, changes in velocity, or direction of flow. Syn. *friction-head*.

HEADWATER

(1) The source of stream.
(2) The water upstream from a structure or point on a stream.

HOOD INLET — Entrance to a closed conduit that has been shaped to induce full flow at minimum water surface elevation.

HYDROGRAPH — A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

IMPOUNDMENT — Generally an artificial collection or storage of water, as a reservoir, pit, dugout, sump, etc. Syn. *reservoir*.

INFILTRATION — The gradual downward flow of water from the surface through soil to ground water and water table reservoirs.

INFILTRATION RATE — A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions, including the presence of an excess of water.

INLET (hydraulics)

(1) A surface connection to a closed drain.
(2) A structure at the diversion end of a conduit.
(3) The upstream end of any structure through which water may flow.

INOCULATION — The process of introducing pure or mixed cultures or micro-organisms into natural or artificial cultural media.

INTAKE
(1) The headworks of a conduit, the place of diversion.
(2) Entry of water into soil. See *Infiltration.*

INTAKE RATE — The rate of entry of water into soil. See *Infiltration Rate.*

INTENSITY — Rainfall rate usually in/hr.

INTERCEPTION (hydraulics) — The process by which precipitation is caught and held by foliage, twigs, and branches of trees, shrubs, and other vegetation. Often used for "interception loss" or the amount of water evaporated from the precipitation intercepted.

INTERCEPTION CHANNEL — A channel excavated at the top of earth cuts, at the foot of slopes or at other critical places to intercept surface flow; a catch drain. Syn. Interception Ditchs of water.

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INTERCEPTOR DRAIN — Surface or subsurface drain, or a combination of both, designed and installed to intercept flowing water.

INTERFLOW — That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface at some point downslope from its point of infiltration.

INTERMITTENT STREAM — A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. It is dry for a large part of the year, ordinarily more than 3 months.

INTERNAL SOIL DRAINAGE — The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are: none, very slow, slow, medium, rapid, and very rapid.

LAND — The total natural and cultural environment within which production takes place; a broader term than soil. In addition to soil, its attributes include other physical conditions, such as mineral deposits, climate, and water supply; location in relation to centers of commerce, population,and other land; the size of the individual tracts or holdings; and existing plant cover, works of improvement, and the like. Some use the terms loosely in other senses: as defined above but without the economic or cultural criteria; especially in the expression "natural land" as a synonym for "soil"; for the solid surface of the earth; and also for earthy surface formations, especially in the geomorphological expression "land form".

LAND CAPABILITY — The suitability of land for use without permanent damage. Land capability, as ordinarily used in the United States, is an expression of the effect of physical land conditions, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. Land capability involves consideration of (1) the risks of land damage from erosion and other causes and (2) the difficulties in land use owing to physical land characteristics, including climate.

LAND CAPABILITY CLASSIFICATION — A grouping of kinds of soils into special units, subclasses, and classes according to their capability for intensive use and the treatments required for sustained use. (Prepared by the Natural Resources Conservation Service, USDA.)

LAND CAPABILITY MAP — A map showing land capability units, subclasses and classes, or a soil survey map colored to show land capability classes.

LAND CAPABILITY UNIT — Capability units provide more specific and detailed information for application to specific fields on a farm or ranch than the subclass of the land capability classification. A capability unit is group of soils that are nearly alike in suitability for plant growth and responses to the same kinds of soil management.

LAND CLASSIFICATION — The arrangement of land units into various categories based on the properties of the land or its suitability for some particular purpose.

LAND-DISTURBING ACTIVITY — Any land change which may result in soil erosion from water or wind and the movement of sediments into State water or onto lands within the State, including, but not limited to, clearing, dredging, grading, excavating, transporting and filling of land.

LAND FORM — A discernible natural landscape, such as a floodplain, stream terrace, plateau, valley, etc.

LAND RECLAMATION — Making land capable of more intensive use by changing its general character, as by drainage of excessively wet land; irrigation of arid or semiarid land; or recovery of submerged land from seas, lakes, and rivers. Large-scale reclamation projects usually are carried out through collective effort. Simple improvements, such as cleaning of stumps or stones from land, should not be referred to as land reclamation.

LEACHING — The removal from the soil in solution of the more soluble materials by percolating waters.

LEGUME — A member of the legume or pulse family, Leguminosae. One of the most important and widely distributed plant families. The fruit is a "legume" or pod that opens along two sutures when ripe. Flowers are usually papilionaceous (butterflylike). Leaves are alternate, have stipules, and are usually compound. Includes many valuable food and forage species, such as the peas, beans, peanuts, clover, alfalfas, sweet clovers, lespedezas, vetches, and kudzu. Practically all legumes are nitrogen-fixing plants.

LEVEL SPREADER — A shallow channel excavation at the outlet end of a diversion with a level section for the purpose of diffusing the diversion out-flow.

LIME — Lime, from the strictly chemical standpoint, refers to only one compound, calcium oxid (CaO); however, the term ``lime" is commonly used in agriculture to include a great variety of materials which are usually composed of the oxide, hydroxide, or carbonate of calcium or of calcium and magnesium. The most commonly used forms of agriculture lime are ground limestone (carbonates), hydrated lime (hydroxides), burnt lime (oxides), marl, and oyster shells.

LIME, AGRICULTURAL — A soil amendment consisting principally of calcium carbonate, but including magnesium carbonate and perhaps other materials, used to furnish calcium and magnesium as essential elements for the growth of plants and to neutralize soil acidity.

LIMING — The application of lime to land, primarily to reduce soil acidity and supply calcium for plant growth. Dolomitic limestone supplies both calcium and magnesium. It may also improve soil structure, organic matter content, and nitrogen content of the soil by encouraging the growth of legumes and soil microorganisms. Liming an acid soil to pH value of about 6.5 is desirable for maintaining a high degree of availability of most of the nutrient elements required by plants.

LIQUEFICATION (spontaneous liquefication) — The sudden large decrease of the shearing resistance of a cohesionless soil, caused by a collapse of the structure from shock or other type of strain and associated with a sudden but temporary increase in the pore-fluid pressure. It involves a temporary transformation of the material into a fluid mass.

LIQUID LIMIT (LL) — The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.

LITTER — In forestry, a surface layer of loose organic debris in forests, consisting of freshly fallen or slightly decomposed organic materials.

LOAMY — Intermediate in texture and properties between fine-textured and coarse-textured materials.

LOOSE ROCK DAM — A dam built of rock without the use of mortar, a rubble dam. See *Rock-Fill Dam.*

MADE LAND — Areas filled with earth or earth and trash mixed, usually made by or under the control of man. A miscellaneous land type.

MANNING'S FORMULA (hydraulics) — A formula used to predict the velocity of water flow in an open channel or pipelines:

$$V = \frac{1.486 r^{2/3} S^{1/2}}{n}$$

wherein V is the mean velocity of flow in feet per second; r is the hydraulic radius; s is the slope of the energy gradient or for assumed uniform flow the slope of the channel in feet per foot; and n is the roughness coefficient or retardance factor of the channel lining.

MEAN DEPTH (hydraulics) — Average depth; cross-sectional area of a stream or channel divided by its surface or top width.

MEAN VELOCITY — Average velocity obtained by dividing the flow rate discharge by the cross-sectional area for that given cross-section.

MEASURING WEIR — A shaped notch through which water flows are measured. Common shapes are rectangular, trapezoidal, and triangular.

MECHANICAL ANALYSIS — The analytical procedure by which soil particles are separated to determine the particle size distribution.

MECHANICAL PRACTICES — Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion. See *Structural Practices.*

MONOLITHIC — Of or pertaining to a structure formed from a single mass of stone.

MOUNTAIN TOP REMOVAL — A mining method in which 100 percent of the overburden covering a mineral deposit is removed in order to recover 100 percent of the mineral. Excess spoil material is hauled to a nearby hollow to create valley fill.

MOVEABLE DAM — A moveable barrier that may be opened in whole or in part, permitting control of the flow of water through or over the dam.

MUCK SOIL
(1) An organic soil in which the organic matter is well decomposed (USA usage).
(2) A soil containing 20 to 50 percent organic matter.

MULCH — A natural or artificial layer of plant residue or other materials, such as sand or paper, on the soil surface.

NATURAL GROUND SURFACE — The ground surface in its original state before any grading, excavation or filling.

NOISE POLLUTION — The persistent intrusion of noise into the environment at a level that may be injurious to human health.

NORMAL DEPTH — Depth of flow in an open conduit during uniform flow for the given conditions. See *Uniform Flow*.

OPEN DRAIN — Natural watercourse or constructed open channel that conveys drainage water.

OUTFALL — Point where water flows from a conduit, stream, or drain.

OUTLET — Point of water disposal from a stream, river, lake, tidewater, or artificial dam.

OUTLET CHANNEL — A waterway constructed or altered primarily to carry water from man-made structures, such as terraces, tile lines, and diversions.

OVERFALL — Abrupt change in stream channel elevation; the part of a dam or weir over which the water flows.

OVERHAUL — Transportation of excavated material beyond a specified haul limit, usually expressed in cubic yard stations (1 cubic yard hauled 100 feet).

PARENT MATERIAL (soils) — The unconsolidated, more or less chemically weathered, mineral or organic matter from which the solum of soils has developed by pedogenic processes. The C horizon may or may not consist of materials similar to those from which the A and B horizons developed.

PEAK DISCHARGE — The maximum instantaneous flow from a given storm condition at a specific location.

PERCOLATION — The downward movement of water through soil, especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 of less.

PERMEABILITY — Capacity for transmitting a fluid. It is measured by the rate at which a fluid of standard viscosity can move through material in a given interval of time under a given hydraulic gradient.

PERMEABILITY, soil — The quality of soil horizon that enables water or air to move through it. The permeability of a soil may be limited by the presence of one nearly impermeable horizon even though the others are permeable.

pH — A numerical measure of the acidity or hydrogen ion activity. The neutral point is pH 7.0. All pH values below 7.0 are acid and all above are alkaline.

PIPE DROP — A circular conduit used to convey water down steep grades.

PLASTICITY INDEX (PI) — The numerical difference between the liquid limit and the plastic limit.

PLASTIC LIMIT (PL) — The water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of soil.

PLASTIC SOIL — A soil capable of being molded or deformed continuously and permanently by relatively moderate pressure.

PLUNGE POOL — A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing. These facilities may be protected by various lining materials.

POOLS — Areas of a stream where the velocity provides a favorable habitat for plankton. Silts and other loose materials that settle to the bottom of pools are favorable for burrowing forms of benthos. Syn. *riffle*.

PRINCIPAL SPILLWAY — A water conveying device generally constructed of permanent material and designed to regulate the normal water level, provide flood protection and/or reduce the frequency of operation of the emergency spillway.

PURE LIVE SEED (PLS) — A term used to express the quality of seed, even if it is not shown on the label. Expressed as a percentage of the seeds that are pure and will germinate. Determined by multiplying the percent of pure seed times the percents of germination and dividing by 100.

RATIONAL FORMULA — Q = CIA. Where ``Q" is the peak discharge measured in cubic feet per second, ``C" is the runoff coefficient reflecting the ratio of runoff to rainfall, ``I" is the rainfall intensity for the duration of the storm measured in inches per hour, and ``A" is the area contributing drainage measured in acres.

RELIEF DRAIN — A drain designed to remove water from the soil in order to lower the water table and reduce hydrostatic pressure.

RELIEF WELL — Well, pit, or bore penetrating the water table to relieve hydrostatic pressure by allowing flow from the aquifer.

RESTORATION — The process of restoring site conditions as they were before the land disturbance.

RETURN FLOW — That portion of the water diverted from a stream that finds its way back to the stream channel either as surface or underground flow.

RILL — A small intermittent watercourse with steep sides, usually only a few inches deep and thus no obstacle to tillage operations.

RILL EROSION — See *Erosion.*

RIPRAP — Broken rock, cobbles, or boulders place on earth surfaces, such as the face of a dam or the bank of a stream for protection against the action of water (waves); also applied to brush or pole mattresses, or brush and stone, or other similar materials used for soil erosion control.

RISER — The inlet portions of drop inlet spillway that extend vertically from the pipe conduit barrel to the water surface.

RIVER BASIN — A major water resource region. The United States has been divided into 20 river basin areas.

ROCK-FILL DAM — A dam composed of loose rock usually dumped in place, often with the upstream part constructed of handplaced or derrick-placed rock and faced with rolled earth or with an impervious surface of concrete, timber, or steel.

RUNOFF (hydraulics) — That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include runoff, groundwater runoff, or seepage.

SCARIFY — To abrade, scratch, or modify the surface; for example, to scratch the impervious seed coat of hard seed or to break the surface of the soil with a narrow-bladed implement.

SCREENING — The use of any vegetative planting, fencing, ornamental wall of masonry, or other architectural treatment, earthen embankment, or a combination of any of these which will effectively hide from view any undesirable areas from the main traveled way.

SEDIMENT — Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice, as a product of erosion.

SEDIMENT BASIN — A depression formed from the construction of a barrier or dam built at a suitable location to retain sediment and debris.

SEDIMENT DISCHARGE — The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

SEDIMENT LOAD — See Sediment Discharge.

SEDIMENT POOL — The reservoir space allotted to the accumulation of submerged sediment during the life of the structure.

SEEDBED — The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

SEEPAGE

(1) Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring where the water emerges from a localized spot.

(2) (percolation) The slow movement of gravitational water through the soil.

SHEET FLOW — Water, usually storm runoff, flowing in a thin layer over the ground surface; also called overland flow.

SHRINK-SWELL POTENTIAL - Susceptibility to volume change due to loss or gain in moisture content.

SHRINKAGE INDEX (SI) — The numerical difference between the plastic and shrinkage limits.

SHRINKAGE LIMIT (SL) — The maximum water content at which a reduction in water content will not cause a decrease in the volume of the soil mass. This defines the arbitrary limit between the solid and semi-solid states.

SIDE SLOPE —Generic term used to describe slope of earth-moving operations, generally stated in horizontal to vertical ratio.

SILT

(1) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter.

(2) A soil textural class.

SILTING — See *Sediment.*

SILT LOAM — A soil textural class containing a large amount of silt and small quantities of sand and clay.

SILTY CLAY — A soil textural class containing a relatively large amount of silt and clay and a small amount of sand.

SILTY CLAY LOAM — A soil textural class containing a relatively large amount of silt, a lesser quantity of clay, and a still smaller quantity of sand.

SLOPE — The degree of deviation of a surface from horizontal, measured in a numerical ratio, percent, or degrees. Expressed as a ratio or percentage, the first number is the vertical distance (rise) and the second is the horizontal distance (run), as 2:1 or 200 percent. Expressed in degrees, it is the angle of the slope from the horizontal plane with a 90l slope being vertical (maximum) and 45l being a 1:1 slope.

SLOPE CHARACTERISTICS — Slopes may be characterized as concave (decrease in steepness in lower portion), uniform, or convex (increase in steepness at base). Erosion is strongly affected by shape, ranked in order of increasing erodibility from concave to uniform to convex.

SOIL — The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

SOIL AMENDMENT — Any material, such as lime, gypsum, sawdust, or synthetic conditioner, that is worked into the soil to make it more amenable to plant growth.

SOIL HORIZON — A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics, such as color, structure, texture consistence, kinds and numbers of organisms present, degree of alkalinity, etc.

SOIL PROFILE — A vertical section of the soil from the surface through all horizons, including C horizons.

SPILLWAY — An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.

SPOIL — Soil or rock material excavated from a canal, ditch, basin, or similar construction.

STABILIZATION — The process of establishing an enduring soil cover of vegetation and/or mulch or other ground cover in combination with installing temporary or permanent structures for the purpose of reducing to a minimum the transport of sediment by wind, water, ice or gravity.

STABILIZED GRADE — The slope of a channel at which neither erosion nor deposition occurs.

STAGE (hydraulics) — The variable water surface or the water surface elevation above any chosen datum. See *Gaging Station.*

STATE SOIL AND WATER CONSERVATION COMMISSION — The state agency established by soil and water conservation district enabling legislation to assist with the administration of the provisions of that law.

STORM DRAIN OUTLET PROTECTION STRUCTURE — A device used to dissipate the energy of flowing water. Generally constructed of concrete or rock in the form of a partially depressed or partially submerged vessel and may utilize baffles to dissipate velocities.

STORM FREQUENCY — An expression or measure of how often a hydrologic event of a given size or magnitude should on an average occur, based on a reasonable sample.

STREAMBANKS — The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

STREAM GAGING — The quantitative determination of stream flow using gages, current meters, weirs, or other measuring instruments at selected locations. See *Gaging Station.*

STREAM LOAD — Quantity of solid and dissolved material carried by a stream. See *Sediment Load.*

STRUCTURAL PRACTICES — Soil and water conservation measures, other than vegetation, utilizing the mechanical properties of matter for the purpose of either changing the surface of the land or storing, regulating, or disposing of runoff to prevent excessive sediment loss. Including but not limited to riprap, sediment basins, dikes, level spreaders, waterways or outlets, diversions, grade stabilization structures, sediment traps, land grading, etc. See *Mechanical Practices.*

SUBSOIL — The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when ``soil" was conceived only as the plowed soil and that under it as the ``subsoil".

SUBWATERSHED — A watershed subdivision of unspecified size that forms a convenient natural unit.

TERRACE — An embankment or combination of an embankment and channel across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down from the soil.

TILE, DRAIN — Pipe made of burned clay, concrete, or similar material, in short lengths, usually laid with open joints to collect and carry excess water from the soil.

TILE DRAINAGE — Land drainage by means of a series of tile lines laid at a specified depth and grade.

TILTH — A soil's physical condition as related to its ease to work (till).

TOE (engineering) — Terminal edge or edges of a structure.

TOE DRAIN — Interceptor drain located near the downstream toe of a structure.

TOPSOIL — Earthy material used as top-dressing for house lots, grounds for large buildings, gardens, road cuts, or similar areas. It has favorable characteristics for production of desired kinds of vegetation or can be made favorable.

TRASH RACK — A structural device used to prevent debris from entering a spillway or other hydraulic structure.

UNIFIED SOIL CLASSIFICATION SYSTEM (engineering) — A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.

UNIFORM FLOW — A state of steady flow when the mean velocity and cross-sectional area are equal at all sections of a reach.

UNIVERSAL SOIL LOSS EQUATION — An equation used for the design of water erosion control systems: A = RKLSCP wherein A = average annual soil loss in tons per acre per year; R = rainfall factor; K = soil erodibility factor; L = length of slope; S = percent of slope; C = cropping and management factor; and P = conservation practice factor.

VEGETATIVE MEASURES — Stabilization of erosive or sediment-producing areas by covering the soil with:

(a) Permanent seeding, producing long-term vegetative cover, or

(b) Short-term seeding, producing temporary vegetative cover, or

(c) Sodding, producing areas covered with a turf of perennial sod-forming grass.

WATER CLASSIFICATION — separation of water of an area into classes according to usage, such as domestic consumption, fisheries, recreation, industrial, agricultural, navigation, waste disposal, etc.

WATER CONSERVATION — The physical control, protection, management, and use of water resources in such a way as to maintain crop, grazing, and forest lands; vegetal cover; wildlife; and wildlife habitat for maximum sustained benefits to people, agriculture, industry, commerce, and other segments of the national economy.

WATER CONTROL (soil and water conservation) The physical control of water by such measures as conservation practices on the land, channel improvement, and installation of structures for water retardation and sediment detention (does not refer to legal control or water rights as defined).

WATER CUSHION — Pool of water maintained to absorb the impact of water flowing from an overfall structure.

WATER DEMAND — Water requirements for a particular purpose, such as irrigation, power, municipal supply, plant transpiration, or storage.

WATER DISPOSAL SYSTEM — The complete system for removing excess water from land with minimum erosion. For sloping land, it may include a terrace system, terrace outlet channels, dams and grassed waterways. For level land, it may include surface drains or both surface and subsurface drains.

WATER QUALITY STANDARDS — Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonates, pH total dissolved salts, etc.

WATER RESOURCES — The supply of groundwater and surface water in a given area.

WATERCOURSE — Any natural or artificial watercourse, stream, river, creek, channel, ditch, canal, conduit, drain, waterway, gully, ravine, or wash in which water flows either continuously or intermittently and which has a definite channel, bed and banks, and including any area adjacent thereto subject to inundation by reason of overflow or floodwater.

WATERSHED AREA — All land and water within the confines of a drainage divide or a water problem area consisting in whole or in part of land needing drainage or irrigation.

WATERSHED LAG — Time from center of mass of effective rainfall to peak of hydrograph.

WATERSHED MANAGEMENT — Use, regulation, and treatment of water and land resources of a watershed to accomplish stated objectives.

WATERSHED PLANNING — Formulation of a plan to use and treat water and land resources.

WATERWAY — An natural course or constructed channel for the flow of water. See *Grassed Waterway.*

WEIR — Device for measuring or regulating the flow of water.

WEIR NOTCH — The opening in a weir for the passage of water.

WETTING AGENT — A chemical that reduces the surface tension of water and enables it to soak into porous material more readily.

This glossary was compiled from definitions supplied by the Natural Resources Conservation Service, Soil and Water Conservation Society of America, Resource Conservation Glossary, and other state and federal publications.

APPENDIX D
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