

RECOMMENDATIONS OF THE GEORGIA BOARD OF REGENTS' SCIENTIFIC PANEL ON EVALUATING THE EROSION MEASUREMENT STANDARD DEFINED BY THE GEORGIA EROSION AND SEDIMENTATION ACT

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Abstract. The 1993 Senate Stormwater Control Study Committee reviewed the Georgia Erosion and Sedimentation Act of 1975 and, among other recommendations, petitioned the Lieutenant Governor to request that a scientific panel be appointed by the Board of Regents to make recommendations for a turbidity instream standard necessary to protect state waters from siltation and sedimentation.¹ This review by a scientific panel was incorporated in the 1994 amendments to the Georgia Erosion and Sedimentation Act.² At the behest of the Lieutenant Governor, the Board of Regents submitted the names of qualified individuals to James E. Kundell of the Carl Vinson Institute of Government and requested that he convene the panel and coordinate its work.³ The panel met on five occasions between May and December 1994, to consider the issues before it and to develop recommendations for the Board of Natural Resources. The report of the panel was submitted to the Board of Natural Resources in January 1995.⁴ This paper presents the recommendations of the panel.

EFFECTS OF EROSION AND SEDIMENTATION

The quality of stream and river ecosystems is affected by sedimentation and turbidity. Communities that live in aquatic environments depend upon water of a minimum quality for their survival. Similarly, instream and offstream uses require water of high quality. The known and suspected adverse effects of erosion and sedimentation on aquatic systems discussed below provide the basis for setting standards for water quality and for establishing guidelines on erosion and sedimentation control.

Aquatic Communities

Aquatic communities are sensitive to sediment generated from land disturbing activities. Some aquatic ecosystems, such as trout streams, are highly sensitive to sediment. Sediment affects aquatic communities in many ways, including a myriad of direct effects such as loss of spawning sites, abrasion, light absorption and gill clogging, as well as indirect effects such as depletion of oxygen due to oxidation of organic sediment deposits.

An important direct effect of increased turbidity is the increased absorption and scattering of light in water, resulting in a reduction in the light available to aquatic plants and animals. Photosynthetic activity is dependent on the ability of light to penetrate the water column. Increased organic matter inflows from soil erosion, coupled with decreasing light penetration, increases the respiratory burden of the water, thus lowering the photosynthesis/respiration (P/R) ratio. This reduction in the P/R ratio may lead to the development of a heterotrophic system, even in large rivers (Cole, 1988). Turbidity also increases stream temperature by absorbing larger amounts of radiant energy.

Increased suspended silt and clays severely depress both filtering and assimilation rates of *Daphnia pulex*, even at concentrations as low as 10 NTU (McCabe and O'Brien, 1983). Reductions of freshwater zooplankton adversely affect planktivorous fish communities. While sources of organic sediment may provide a food source for zooplankton (Arruda et al., 1983) or a nutrient source for phytoplankton (Lind et al., 1992), the increased total concentration adversely affected zooplankton ingestion and incorporation rates (Arruda et al., 1983). Cuker and Hudson (1992) showed that montmorillonite clays are more effective than kaolinite clays in reducing crustacean zooplankton densities, due to the increased adherence to *Daphnia* which hinders feeding, molting and swimming. Also, montmorillonite causes more light absorption (Cuker et al., 1990).

Offshore marine benthic communities, such as live-bottom areas off the coast of Georgia and South Carolina, are damaged when suspended sediment concentrations from dredging and dredge tailings disposal exceeds 100 mg/L or when the turbidity exceeds 15 NTU (Porter, 1993). Sediments can smother sea grass and live-bottom beds as well as cause algal blooms and resultant eutrophication of enclosed bays.

Increased turbidity, suspended sediment concentrations, and bedload sediments can have deleterious effects on fish communities. Turbidity directly affects the reaction distance of trout during feeding, thus reducing the feeding efficiency (Barrett et al., 1992). Also, studies by the Fish and Wildlife Service, U.S. Department of the Interior, to develop Habitat Suitability Index Models demonstrate the adverse effects of sediment. Bluegill sunfish habitat was reduced by half at

TSS concentrations averaging 150 mg/L for an average monthly flow. Channel catfish are similarly affected at 200 mg/L and largemouth bass at 100 mg/L (Stuber et al., 1982). Creek chub are adversely affected at 90 JTU, while green sunfish are adversely affected at 180 JTU within pools or littoral areas. Brook trout are adversely affected if the percent fines less than 3 mm exceed 15 percent in spawning areas and 35 percent in riffle-run areas. Except for brook trout, these species are all sediment-tolerant species and none of these studies considered effects of turbidity on eggs, larvae, or juveniles, which are likely to be more sensitive life history stages.

The fish fauna of Georgia's freshwaters includes species that are sediment-tolerant, but many of the most unique species are much more sensitive to sediment. The darters of Georgia are probably more sensitive to bottom sediment than salmonids (e.g. trout, salmon), which are sensitive primarily as eggs and juveniles. Studies from the Conasauga river illustrate the sensitivity of Georgia fish fauna to sediments. There is a gradient of species loss in the Conasauga from the state line downstream. At the state line, the fish fauna is diverse and includes 6 species that are state listed as endangered, 3 of which are also federally endangered species [*Cyprinella caerulea* (blue shiner), *Noturus munitrus* (freckle belly madtom), *Percina shumardi* (river darter), *Percina antesella* (amber darter), *Percina jenkinsi* (Conasauga log perch), *Percina lenticula* (freckled darter)]. Suspended sediments at this site are always less than 10 NTU. When the Conasauga crosses Highway 76, all but 2 of those species have been eliminated from the community. Over a 3-year period of monthly grab samples, turbidity exceeded 25 NTU only 9 times and maximum measured turbidity was 96 NTU; yet 4 species had been lost from the community. Further downstream at Tilton, none of the endangered species are present. At that site, monthly turbidities exceeded 25 NTU 14 times in 3 years and the maximum measured turbidity was 240 NTU.

The influence of sediments on benthic invertebrate communities include such direct effects as gill clogging, loss of habitat, abrasion, smothering, and scouring of food (periphyton) from rocks. The benthic habitat consists of spacing between stones in the substrate. Clogging of the spacing between stones by sediment reduces the benthic habitat, which reduces the number and diversity of benthic organisms, which, in turn, reduces the food source for higher trophic levels.

Deposition of organic sediments can increase the sediment oxygen demand (SOD), thus resulting in anaerobic conditions in rivers and streams. Similar to the biochemical oxygen demand (BOD), increasing SOD concentrations can result in substantial degradation of the aquatic resource. Accumulations of organic sediments may interact with elevated BOD concentrations to yield stream segments that fail to provide suitable habitat for desired species, or to meet desired water quality standards. Lake eutrophication can

result when suspended sediments transport nutrients that induce enhanced algae production.

Sediments can also serve as a carrier to many metals and toxic compounds, such as lead, cadmium, zinc, copper, aluminum, iron, manganese, chromium and nickel (see e.g., Novotny and Chesters, 1989). One study of Lake Lanier determined that in excess of 60 percent of the annual discharge of phosphorus and trace metals to the lake were contributed by suspended sediments (Faye, et al., 1980). Transport of metals and toxic organic compounds (e.g., PCBs, lawn herbicides and pesticides) from urban environments into aquatic systems can result in substantial degradation of the aquatic environment due to uptake and subsequent concentration within the food chain. Toxicity effects can be both acute and chronic. Additional reviews of the effects of sediment on aquatic systems can be found in Sylvester et al. (1994). Winger (1994) also provides an excellent bibliographic summary of sediment publications.

Instream Uses

Rivers and streams are used for many purposes, a few of which are noted in this section. Erosion and sedimentation rarely increase the value of natural resources, the Little Grand Canyon at Providence Canyon State Park in Stewart County, Georgia, being one possible exception due to the picturesque nature of erosion at this site. Turbidity may affect recreational uses in several ways. It may decrease the aesthetic attraction of the resource, and it may introduce risks when diving into water containing hazards, such as rocks or other obstructions, that can not be readily observed due to cloudy water. Suspended sediments may adversely affect recreation by transporting hazardous microorganisms or toxic compounds on the sediment surface which are ingested accidentally during recreational activities. Bed sediments may decrease recreational aesthetics by covering sand beaches with less-desirable, finer materials such as clays and organic mucks.

Suspended solids and bedload sediments can adversely affect power generation by scouring turbine blades resulting in the decreased operational lifetime of the power generating equipment, and the reduction in useable reservoir storage capacity causing a reduction in the power generation capacity. It has been estimated that the replacement cost of storage lost to sediment accumulation in U.S. reservoirs amounts to millions of dollars annually (USBR, 1977). Channel infilling due to excessive sedimentation increases dredging costs and reduces flood transport capacity under bridges and through culverts.

Other Effects

In 1990, surface water provided over 900 million gallons per day for public drinking water supplies in Georgia. Sedimentation can adversely affect drinking water supplies by filling water supply reservoirs, thereby diminishing water storage capabilities, and by increasing the treatment costs needed to meet federal and state drinking water standards.

Municipal drinking water supplies are required by the U.S. Environmental Protection Agency (EPA) to maintain monthly turbidity levels below 1 NTU and to not exceed 5 NTU as an average for two consecutive days (McCutcheon et al., 1993). The greater the turbidity levels of the raw water, the greater the cost of treating it to meet the drinking water standards.

Over 3 billion gallons of surface water per day were used for thermoelectric purposes in Georgia. Additional uses of water include rural irrigation (587 million gallons per day) and self-supplied industry (744 million gallons per day). This water must be free of sand and silt in order to prevent damage to pumps and pipelines. Sediment removal can be a significant operational cost for the utilities that require water for thermoelectric purposes or industries that require water of high quality for manufacturing processes. Increased erosion also reduces agricultural and forest soil productivity by diminishing the physical, chemical and biotic properties. Prevention of sediment loss increases production while at the same time decreasing fertilization, mulching, and maintenance costs.

A STRATEGY FOR CONTROLLING EROSION AND SEDIMENTATION

The development of a strategy for the prevention and control of erosion and sedimentation is a challenge that requires the integration of many complex systems, including biological, engineering and social. The strategy must account for the wide variety of human activities which contribute to erosion and sedimentation. It must also accurately incorporate the physics of soil mobilization and movement and the biological effects of sediment in aquatic systems. The interaction of sources and effects results in uncertainties related to storm intensity, site location, nature and size of the land-disturbing activities, location of the site in the watershed, size and flow regime of the stream, prior condition of the stream, and type of aquatic ecosystem being influenced by the soils.

Three components of an erosion and sedimentation control strategy have been identified that address divergent means for effecting a solution. Each of these components of the strategy contributes to a more integrative method for maintaining the quality of water in Georgia. The first component, cumulative effects, allows for the minimization of large scale disturbances on stream water quality. The second component focuses on assuring on-site control of erosion. The third component, runoff or effluent standards, proposes a quantitative measure of the effectiveness of prevention control methods or BMPs.

Cumulative Effects

One concern with erosion and sedimentation is the need to consider the cumulative effects they have on the aquatic integrity of Georgia's streams. Adverse cumulative effects do

not result from a single source of erosion in space or time, but rather from many sources generating sediment independently. This concept is analogous to the total maximum daily load (TMDL) concept of the assimilative capacity of streams. The key to addressing cumulative effects is the designation of nonattainment streams. The use of a nonattainment designation is intended to parallel a similar designation of nonattainment areas under the Clean Air Act. Issuing authorities can use this designation to concentrate their monitoring efforts on those stream segments that are in greatest need of restoration and mitigation. Increased inspection and enforcement efforts should focus on ensuring that a nonattainment watershed is brought back into compliance.

As discussed earlier, available research suggest that turbidity levels above 25 NTU result in the loss of species. This is true in trout as well as nontrout streams and, consequently, one level is recommended for all water use classifications that are based on the aquatic systems they support (i.e. trout, fishing). Since there is currently no designation for high-biodiversity streams, it is recommended that such a designation be created and that the turbidity standard for streams classified as such be set at 25 NTU. With additional research, it may be that turbidity levels for certain classifications should be adjusted, either upward or downward.

A strategy for controlling cumulative effects is presented as Table 1. The strategy is intended to provide a means of controlling sediment production in areas where streams have been severely degraded due to elevated releases of sediment, both from current and past sources.

Erosion Control Plan, BMPs and On-site Inspection

Turbidity and sedimentation levels in Georgia streams may frequently fail to meet acceptable limits due to several factors.

- Activities causing turbidity and sedimentation problems may not be covered by the Erosion and Sedimentation Act.
- Erosion control plans, required under the Act, may not incorporate appropriate safeguards (e.g., BMPs) to prevent sediments from leaving the site.
- BMPs may be insufficient to protect water quality.
- BMPs identified in the plan may be inappropriately installed.
- BMPs might be inadequately maintained.

The 1993 Senate Stormwater Control Study Committee reviewed the Erosion and Sedimentation Act and recommended steps to remove exemptions, to increase enforcement, and to assure that those activities that did not require a permit under the Act were still required to meet the intent of the Act. These recommendations were enacted by the General Assembly during the 1994 legislative session.

The adequacy of erosion control plans, the rigor embodied in the BMPs, and the appropriate installation and maintenance

nance of BMPs dictate that individuals charged with these responsibilities understand what they are suppose to do and why it is important. Consequently, education is a critical component of an effective erosion control program. Educational efforts designed to inform those involved in land-disturbing activities about erosion prevention and control requirements and methodologies are essential if erosion is to be controlled.

In addition to educational efforts, the design of erosion control plans should focus on preventing the mobilization of soil. It is more difficult and generally more expensive to control the movement of soil after it has been mobilized than it is to prevent soil movement in the first place. Methods such as maintaining natural vegetation through the use of buffer strips and staging development to keep areas vegetated until they must be disturbed are very important. Additionally, mulching and revegetating the site with temporary or permanent plant cover effectively reduce erosion. The certification process for those developing plans should stress the importance of preventing erosion as a first step and of controlling it as a less preferable means of keeping soils on the land and out of Georgia's waterways. In addition, educational and technical assistance efforts designed to assist those involved in land-disturbing activities should stress erosion prevention.

On-site inspections are required to determine the adequacy of the erosion prevention and control measures. Implementing authorities should inspect sites to determine if BMPs have been installed consistent with the erosion control plan and to discern if the BMPs are being maintained correctly. If not, enforcement actions should be taken. On-site evidence of erosion should be proof that erosion control measures are not effectively controlling erosion. The presence of rills, gullies or other evidence of sediments being carried to a stream should be used as indicators that BMPs are not satisfactorily controlling erosion. Excessive soil loss from a site can be quantified by measuring the volume of sediment loss in the rills and gullies. Visual identification of rills and gullies and deposition of soils in streams should be sufficient for inspectors to call for corrective actions.

Runoff or Effluent Limits

To avoid the problems associated with attempting to measure the impact of a specific site on the turbidity of a stream, the panel proposes that a runoff or effluent limits be set. The monitoring location in this approach should be the primary channelized outflow from the site. If a retention pond is used, the point of discharge can be used as the monitoring point. Because most of the sediment is transported in channelized flow, monitoring points should be located downstream of major rills or gullies.

Science does not tell us what effluent limit(s) should be set for Georgia because there are too many variables involved. Limits must be set on a site-specific basis reflecting the variables associated with that site and a computation of discharge levels that would meet instream turbidity require

Table 1. Cumulative Effects Strategy

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- Step 1: Establish designated uses for stream segments: For each stream segment, the water use classification should be determined based on the aquatic communities and instream and diversion uses of the water. In addition to current designations, the panel recommends that a new water use classification be adopted for those streams supporting highly diverse biotic communities (e.g., high-biodiversity streams) and a survey of streams be conducted to determine stream stretches that qualify for such a designation.
- Step 2: Establish turbidity standards for each designated use class: The panel proposes that 25 NTU be adopted as the standard for determining attainment status for stream segments whose classification is based on the aquatic communities they support (i.e. trout, high-biodiversity, and fishing).
- Step 3: Identify nonattainment segments: The intent of setting an instream turbidity standard is to establish a level that maintains the long-term viability of streams and the uses and biotic communities they support. Streams should be regularly monitored and those segments that do not meet their use standards should be designated as nonattainment streams. EPD should develop a monitoring protocol for instream turbidity for all stream segments. Due to the temporal nature of storm events and the resultant levels of turbidity, the determination of attainment status should be based on an instantaneous measurement (grab sample). Exceeding the maximum 25 NTU level should result in the stream segment being designated as a nonattainment stream. This standard would not apply for storms exceeding the 10 year precipitation event. The designation should be dropped once EPD has determined that turbidity levels have improved sufficiently.
- Step 4: Focus inspections and enforcement efforts on non-attainment streams: Failure to meet the use classification standard should trigger active intervention by the implementing authority through increased monitoring, inspection and enforcement actions and possibly restrictions on new land-disturbing activities within the watershed until it is in compliance (i.e., similar to a moratorium on wastewater hookups where there is inadequate treatment capacity).
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ments. It is then the responsibility of the person developing the erosion control plan to determine what mix of BMPs would best meet that effluent or discharge standard at that site.

Focused research is required to evaluate the appropriateness of BMPs and to determine what techniques should be required, and how the standards should be adjusted to reflect both the capability of reducing stream sedimentation and effects of the sedimentation.

CONCLUSIONS AND RECOMMENDATIONS

Georgia has a long history of land-disturbing activities that have caused soils to be conveyed from the land where they belong to aquatic systems where they do not belong. Inappropriate forest harvesting techniques, "dust bowl" agricultural practices, and improper construction activities have resulted in stream sedimentation that is deleterious to aquatic resources. The sediment resulting from past land abuses is slowly being carried to the sea. Because the sediment has taken hundreds of years to build up in our waterbodies, it will take a long time for them to be removed. The use of BMPs by agricultural and forestry operations greatly reduces erosion and sedimentation from farm and forest lands. Effective use of BMPs is also the best way to prevent and control erosion from construction sites. The fewer sediments entering streams, the faster the streams will be restored to their natural condition. In addition, preventing soils from entering streams results in a significant decrease in nutrients, metals and organic pollutants which are attached to the soil particles from polluting our waterways.

Most states use the National Academies of Science and Engineering 1972 review of sedimentation for the basis of establishing their sediment standards. Many changes have occurred since the early 1970s that are of sufficient magnitude to warrant taking another look at the aquatic effects of sediment. It is recommended that the National Academies of Science and Engineering revisit the issue of sedimentation and conduct a timely review of recent research. The review will be a significant undertaking and the results, if the review is undertaken, will not be available for several years. Despite time and resource constraints, a review of existing literature was performed by the panel to evaluate alternative sediment control strategies. The recommendations presented here are based on the most up-to-date research findings available to the panel.

An erosion and sedimentation control strategy is proposed that consists of three interrelated components. First, instream standards should be adopted for stream segments based on their use classification. Initially, the panel recommends setting the standard for those streams classified on the basis of the aquatic community they support at 25 NTU, recognizing that with additional research and information, some may need adjustment. Although benefits would result from reducing the NTU standard for streams classified for drinking water and recreation to 25 NTU, the panel is not recommending that these changes be made. Those streams that do not meet their specific standard should be designated

as nonattainment streams and inspection and enforcement efforts should be concentrated in these watersheds to bring them back into attainment. Second, the focus for controlling erosion and sedimentation should be on the design, construction and maintenance of BMPs. On-site inspection of BMPs and indications of erosion should determine whether efforts are adequate to prevent and control erosion or if corrective measures should be taken. Third, effluent or runoff limits should be set on a watershed and site-specific basis.

In response to the charge given it by the Georgia General Assembly, the panel makes the following recommendations:

- Education is a critical component of an effective erosion prevention and control program. Educational and technical assistance should be used to assist those involved in land-disturbing activities. The technical assistance should stress erosion prevention as the preferred approach and erosion control as a less preferred alternative.
- Erosion control plans should stress the prevention of sediment mobilization as the preferred approach. The certification process for those developing erosion control plans should stress the importance of erosion prevention, as well as effective control strategies.
- An enforceable limit should be established for site discharge effluent. Sites that exceed the limit should be deemed to be in violation of the rules. Enforcement action should be taken for these sites. The limit should be established at a level that does not penalize those who have used the best available methods for erosion prevention, but does punish those that flagrantly disregard sediment control practices. Due to the variability associated with construction sites and the watersheds in which they are located, the effluent limits should be established on a site-specific basis taking into consideration the instream turbidity standards and overall land-disturbing activities occurring within the watershed.
- There are no current turbidity standards for high-biodiversity streams. It is recommended that a high-biodiversity classification be added. A stream survey should be conducted to determine stream segments which qualify for designation as high-biodiversity streams.
- A maximum instream standard of 25 NTU should be adopted for each water use class which is based on the biotic community it supports (i.e. trout, high-biodiversity, fishing), with allowance for precipitation in excess of the 10 year event. Stream segments which exceed the standard for the water use classification should be declared nonattainment segments. Such a designation should result in increased enforcement and monitoring. Additional measures to reduce sedimentation in these stream segments may require limitations on land-disturbing activities. The implementation of building restrictions on slopes or near streams may also be required in nonattainment areas.

- Additional effort is necessary to determine how the strategy proposed by the panel can best be achieved. Consequently, the panel recommends that the Lieutenant Governor call on the State Soil and Water Conservation Commission and the Environmental Protection Division to appoint a committee composed of those with expertise in erosion prevention and control techniques, to determine how best to meet the recommended levels.
- Because more than 20 years have elapsed since the National Academies of Science and Engineering reviewed research on the effects of turbidity and sedimentation on aquatic systems and how best to abate them, the National Academy of Science and the National Academy of Engineering should undertake a review of the research conducted over the past two decades and make appropriate recommendations based upon this review.
- Although a review by the National Academies is timely and called for, the Georgia Environmental Technology Consortium of the Georgia Research Alliance should pursue identification of funding sources to support a multiuniversity research effort to analyze Georgia-specific unknowns relating to erosion and sedimentation. Other sources of funding should also be sought to support research on the relationship between sediments and aquatic systems and water uses and on the analysis of methods to monitor, control and prevent erosion and sedimentation; and on methods of stream restoration to rehabilitate streams subjected to erosion and sedimentation in the past.

The charge of the panel was to determine an instream standard protective of state waters. Based on current research and understanding, the panel recommends a 25 NTU instream standard for those streams classified based on the aquatic communities they support (i.e. trout, high-biodiversity, fishing). Other water use classifications (i.e. drinking water, recreation) are based on other factors such as the federal Safe Drinking Water Act requirements and on health consideration for human contact with recreation waters. Although the 25 NTU level would be more stringent than what currently exists, the panel is not recommending such changes. The 25 NTU figure was determined with careful consideration of existing research findings. It is evident that aquatic systems are adversely affected by higher turbidity levels. With additional research, however, this figure may be adjusted upward or downward for various use classifications. It should be stressed, however, that this figure is not comparable to the 50 NTU or 100 NTU figures included in the Erosion and Sedimentation Act. Those figures compared runoff from a disturbed site to upstream levels, whereas the proposed figure is an instream standard measured at the end of an EPD designated stream segment.

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End Notes

1. Interim Report of the the Senate Stormwater Study committee Created by Senate Resolution 252, Georgia Senate Research Office, Atlanta, GA, 1993.
2. Senate Bill 608, 1994 Session of the Georgia General Assembly.
3. Members of the panel: Dr. Michael Bruce Beck, The University of Georgia; Dr. Thomas N. Debo, Georgia Institute of Technology; Mr. Bruce K. Ferguson, The University of Georgia; Dr. Byron J. Freeman, The University of Georgia; Ms. Kathryn J. Hatcher, The University of Georgia; Dr. James Kundell, The University of Georgia; Dr. Harold McGinnis, Kennesaw State College; Dr. Judy Meyer, The University of Georgia; Dr. Wade L. Nutter, The University of Georgia; Dr. Gabor Patonay, Georgia State University; Dr. Todd C. Rasmussen, The University of Georgia; Dr. Lewis F. Rogers, Gainesville College; Dr. F. Michael Saunders, Georgia Institute of Technology; Dr. Terry W. Sturm, Georgia Institute of Technology; Dr. Malcolm E. Sumner, The University of Georgia; and Dr. William Ernest Tollner, The University of Georgia.
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