GEOLOGIC CONTROLS ON EROSION, SEDIMENTATION OF STREAMS, AND POTENTIAL FOR GROUNDWATER CONTAMINATION IN SOUTHWESTERN GEORGIA

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Abstract. The Georgia Geologic Survey (GGS) has mapped 29 7.5 minute quadrangles in the Upper Coastal Plain of southwestern Georgia during the past eight years as part of the U.S. Geological Survey's STATEMAP program. Exposed sediments in these quadrangles consist of Upper Cretaceous to Tertiary sand, sandstone, clay, and limestone. Two geological rock units, the Eocene-age Claiborne Group and the Cretaceous Providence Formation consist mainly of sand or soft sandstone that are easily eroded when exposed to concentrated storm runoff. Runoff from highway culverts, poor irrigation or logging practices can lead to significant and rapid erosion of the soft sands. Clear-cutting and stripping or burning of fragile ground cover in sandy terrain significantly inhibits regeneration of the ground cover that protects the sand from erosion. Erosion may threaten agricultural fields and infrastructures such as roads, railroads, pipelines and power lines. Sedimentation or silting up of streams by sand eroded from the surrounding terrain reduces the depth and velocity of normal stream flow and adversely affects stream ecology. Gullies resulting from this erosion tend to collect a variety of trash. As the Providence Formation and Claiborne Group are both important local and regional aquifers in the southwestern Coastal Plain of Georgia, trash may leak chemicals into these aquifers and have a detrimental effect on domestic, agricultural, and public water supplies.

GEOLOGIC SETTING AND CONTROLS ON EROSION

The Georgia Geologic Survey (GGS) has mapped 29 7.5 minute quadrangles in the Upper Coastal Plain of southwestern Georgia during the past eight years as part of the U.S. Geological Survey's STATEMAP program (Figure 1). Exposed sediments in these quadrangles consist of Upper Cretaceous to Tertiary sands, sandstones, clays, and limestones (Cocker, 2004, 2005, 2006a and b).

The STATEMAP map area contains two stratigraphic units, the Upper Cretaceous Providence Formation and the Eocene Claiborne Group, which consist mainly of soft, easily erodable sand and sandstone. Above and below each of these sandy units are more resistant units containing clay, limestone or more indurated sandstone. Spectacular erosion of the Providence Formation, mainly during the early 1900's, led to development of Providence Canyon State Park and highly dissected terrain in surrounding areas. This paper will examine erosion and sedimentation associated with the Claiborne Group, as it is less widely known as and may pose a greater geological hazard than the Providence Formation.

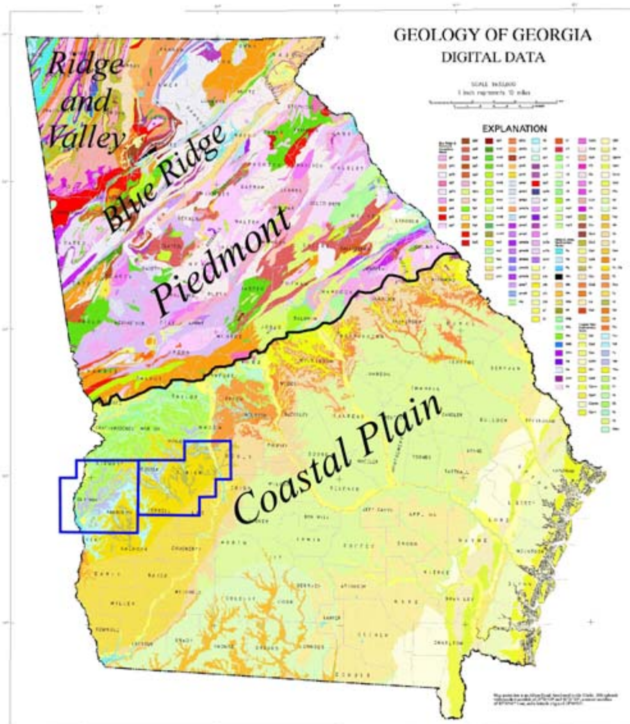

Figure-1 Location of STATEMAP map area (in blue outlined boxes).

The Claiborne Group is a shallow marine to nearshore, white, yellow, to reddish brown, locally crossbedded, fine-grained sand and sandstone. Thin, less than 3 feet thick, clay beds are locally present. This unit weathers rapidly to a fine, white to light brown sand. In much of the map area (Fig. 2), the Claiborne Group is overlain by the more resistant, Miocene Altamaha Formation (Fig. 3) and is protected from erosion. Breaching of the Altamaha caprock leads to rapid erosion of the underlying Claiborne Group (Fig. 4). A considerable volume of sand (estimated to be about 22,500 cubic yards) has been removed from the gullied area shown in Fig. 3 and dumped into downslope streams. The aggregate effect of gully erosion contributes a vastly larger amount of sediment to streams in the area. An estimate of the number of erosion gullies or their size is difficult because many of these gullies have

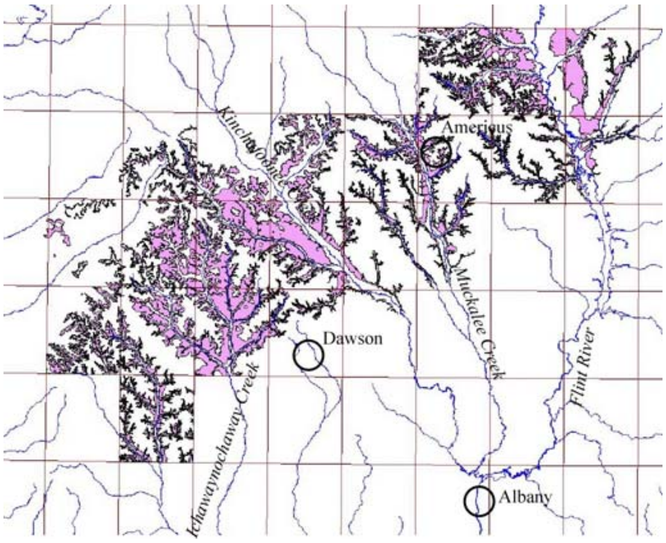

Figure-2 Location map of the Claiborne Group relative to major streams and cities, presently mapped distribution of the Claiborne Group is in light blue. Rectangles are 7.5 minute quadrangles

Figure-3 Extreme erosion and downcutting into soft Claiborne Group sandstone (lighter material) after breaching of the more resistant Altamaha sandstone (dark red sandstone on top), a road culvert concentrated storm runoff and caused the development of this canyon. Mass-wasting with down-dropped blocks of the Altamaha Formation occurs due to slope failure. Refrigerator at bottom of cayon for scale.

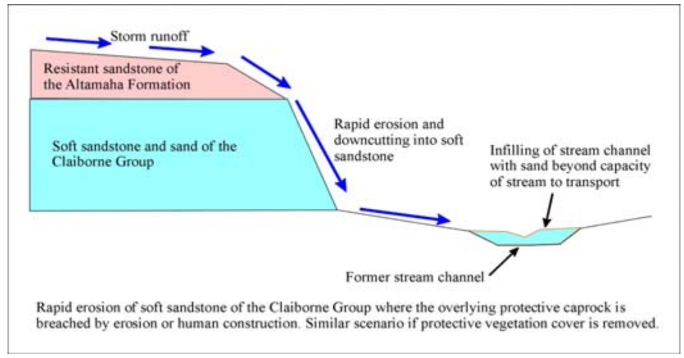

Figure-4 Model of erosion where caprock has been breached

Figure-5 Drainage above culvert pictured in Fig. 6 Entrance to north end of culvert is just above grassy area in this picture.

developed or grown since publication of the early 1970's vintage topographic maps.

In places where culverts are sited under roads to channel storm runoff to the downslope side of a road, exceptionally rapid erosion may develop. This type of dramatic erosion poses immediate and longer term hazards to infrastructure and people that depend on them. The immediate threat is a precipitous drop off that may be only a few feet from the road or the road may fail due to abnormal loading, e.g. logging trucks. As shown in Figures 6 and 7, a drop off of about 20 feet is less than 6 feet from the paved road. In one locality, erosion from one year to the next, erosion was so rapid that the sediments supporting an entire section of culvert were removed and the culvert now lies at the base of the gully. The head of that gully now lies about 10 feet from a major highway.

A longer term threat is a more gradual weakening of the roadbed and probably eventual collapse. The road in Fig. 8, exhibits cracks that are concentrically arranged over a culvert that heads another erosion gully. Considerable logging has occurred along this road during the past year, and these cracks are relatively new according to the road supervisor of this county.

Other circumstances observed during the field geologic mapping that contribute to erosion of Claiborne Group sand include road grading activity, clear-cutting of forest vegetation and groundcover, and malfunction or breakage of irrigation systems. Roads that descend into a valley to cross streams serve as artificial channelways for storm runoff. Gullying can occur along the shoulder drainage ways or in the roadbed. Road grading to repair the erosion typically moves large volumes of sand further downhill. Some of clear-cutting of forests involves complete stripping of all vegetation and erosion gullies may be started before the cleared area is revegetated. The gully shown in Fig. 6 may have begun in this manner and did continue to grow after the area was reforested. Several acres of prime farmland near Parrott were lost when an irrigation system broke and water eroded through the overlying Altamaha Formation and gullied the underlying Claiborne Group sand.

Sand removed by gully erosion eventually ends up in stream valleys, and most of these streams do not have the hydraulic capacity to transport the large amounts of sand. Stream channels fill with sandy sediments, become shallower and wider. The stream valleys are now mostly wide, flat-bottomed swamps (Fig. 10). The once healthy stream ecosystem is altered to one that is more acidic, reducing and warmer.

Figure 6. Rapid and significant erosion at south end of culvert across county road in Fig. 5. Note four-foot segment of culvert that has broken off and tires for scale. Another segment lies beneath large block of sediment just behind visible section of culvert.

Figure-7 Top of gully shown in Fig. 6 lies within six feet of county road.

Figure 8. Concentric cracks signifying initial road failure are centered over a culvert at the head of an erosion gully.

EFFECTS ON AQUIFERS

Initially, items such as tires (Fig. 6) and relatively inert chunks of concrete may be placed in these gullies in an attempt to stem the erosion. Eventually, these actions foster further accumulation of other types of trash (Fig. 11), including old appliances (Fig. 3), cars, construction material, dead game animals, discarded cans of petroleum products, pesticides and herbicides. Over time, heavy metals, herbicides and pesticides may leach from the trash and enter and have an adverse effect on domestic, agricultural and public water supplies.

Another effect of erosion is to remove an entire portion of the Claiborne aquifer down to the underlying aquiclude. The redult would be the interruption of the normal flow of ground water.

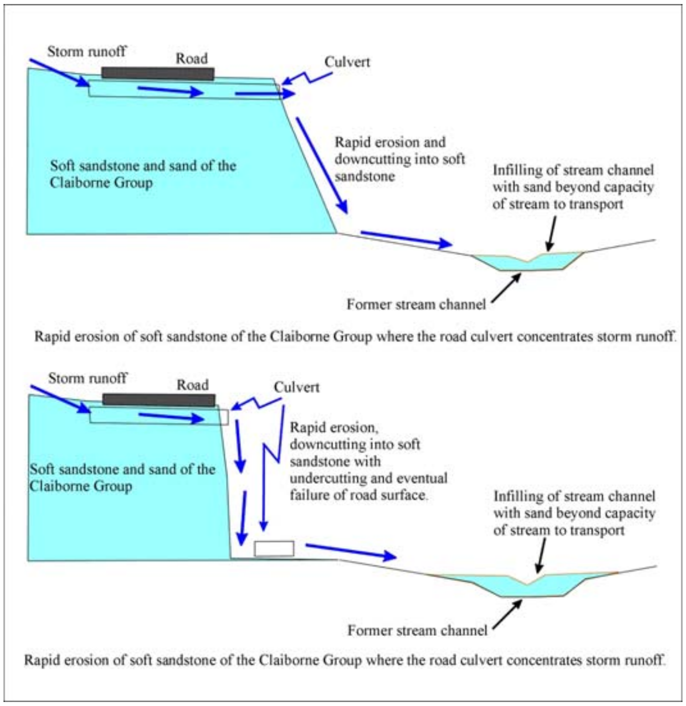

Figure 9. Model of erosion associated with a road storm culvert.

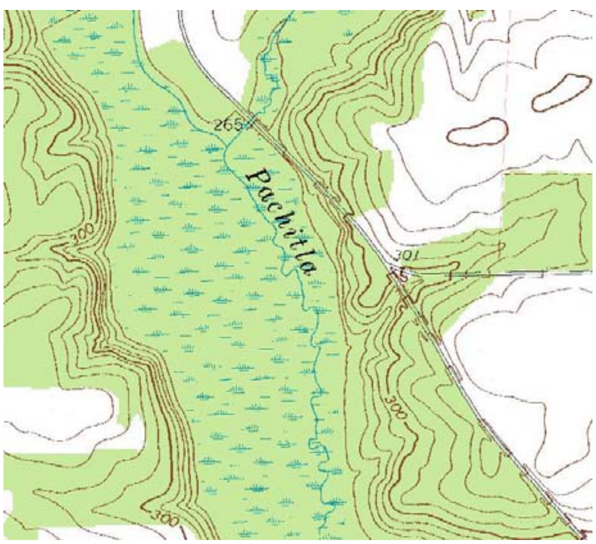

Figure 10. Segment of Pachitla Creek in Randolph County. Stream valley choked with sandy sediments eroded from gullies developed in the adjacent hillsides. Location of Figures 5, 6 and 7 are just to the right of the "h" in Pachitla.

SUMMARY

Both the Providence Formation and Claiborne Group are sandy units that host important aquifers. Both are highly susceptible to erosion where a protective surface cover has been removed or surface runoff is channeled. Erosion of the sand promotes sandy sedimentation in relatively small streams that do not have the hydraulic capacity to move the sand. This leads to an overall degradation of the fluvial ecosystem. Erosion gullies can rapidly threaten public safety and infrastructure facilities. In addition, gullies collect trash that may contaminate the very aquifers in which the gullies are developed.

Suggested actions would include filling of these gullies with non-erodable material such as rip-rap, and proactive education of land owners and local officials regarding the potential hazards as well as better land-use practices.

Figure 11. Trash begins to accumulate within these erosion gullies.

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