CONDUCTING RAPID FLUVIAL GEOMORPIC ASSESSMENTS BASED ON THE CHANNEL EVOLUTION MODEL: A CASE STUDY IN GRIFFIN, GEORGIA

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Abstract. A variety of fluvial geomorphic assessment methods, such as TMDL development, biological habitat quality assessment, and overall channel characterization, have been developed and are being adopted by organizations for use in assessing stream conditions for a variety of purposes. This paper first summarizes available stream geomorphic assessment methods, detailing their strengths and weaknesses. Then we describe an actual project conducted by Tetra Tech in Griffin, Georgia to show how assessment methods were selected to suit a particular application and how the results were presented to maximize usefulness to the client. The stream channel stability study was conducted on Shoal Creek for the City of Griffin, Georgia, Public Works and Stormwater Department. The focus of the study was to qualitatively assess the potential availability of sediment from channel sources so that the findings could be used to address downstream sedimentation issues. Time and funding constraints led to choosing a qualitative rapid geomorphic assessment method whereby channel evolution and other easily observable field data were collected for the entire watershed. Assessed reaches were then classified by degree of channel stability with results presented as a set of correlated maps, data tables, photographs, and reach narratives. This data set enabled stormwater management decision makers for the City of Griffin to prioritize the specific erosion hot spots for mitigation.

INTRODUCTION

Proper selection of assessment techniques is important for returning data that is truly useful in addressing sedimentation concerns. Studies that are designed with most of the resources spent assessing the condition of a watershed using only existing desktop data sources such as soil surveys, geologic maps, topographic maps, land use maps, and aerial photos result in generalized and often out-of-date descriptions of the watershed. Due to its higher cost, field work is often limited to windshield surveys of the watershed or short streamwalks oriented around road crossings. As a consequence, the resulting deliverables contain little information based on recent direct observations of the watershed, and thus are often not useful for decision making. Where determined suitable, Rapid Geomorphic Assessment (RGA) is a very useful, low cost methodology for gathering up-to-date data describing specific locations in the watershed, and thus better enables decision makers to make specific plans on watershed management. The project described in this paper serves as a case study of the techniques used to conduct such an RGA in a particular watershed as well as the appropriate presentation of the results.

BACKGROUND OF EXISTING STREAM GEOMORPHIC ASSESSMENT PROTOCOLS

Stream geomorphic assessments are being conducted via a variety of protocols including Rosgen's (1996), Montgomery-Buffington (1998), and Channel Evolution Model (CEM) (Simon, 1994). Such geomorphic assessment methods typically have several phases where the primary activities for each phase are desktop studies, qualitative field studies, and quantitative field studies.

- Phase 1--The Desktop Phase: this phase entails data collection and interpretation of topo maps, soil maps, land use maps, and aerial photos. Paper maps or GIS datasets may be used depending on data availability and the scale of the watershed being studied. The data is used to make interpretations of channel planform, gradient, valley width, vegetated riparian zone width, development in the watershed, spatial distribution of erodable soils, etc.
- Phase 2--The Qualitative Field Study Phase: this phase is often called "Rapid Geomorphic Assessment," and entails field truthing the data sets and maps. Field personnel are used to gather qualitative site-specific data, such as approximate bank heights and riparian vegetation condition, as well as locate natural grade controls, channel constrictions, and specific areas of local erosion, such as mass wasting stream banks and scour

exacerbated by large woody debris jams. Field data can thus be used to update and add detail to the base set of maps.

- Phase 3--The Quantitative Field Phase: this phase entails conducting reach scale measurements. This may include surveying cross sections and gradients, collecting bed and bank material samples for lab analysis. Data is used to determine bankfull heights, bankfull discharges, and degree of incision. This data can also be used as input to models such as the Hec-Ras or CONCEPTS to estimate discharge, sediment loading, and potential bank erodability.

Each of the phases have their strengths and weaknesses which need to be weighed when deciding which methods will return the most useful results at the lowest cost. Additionally, each of these assessment methods can be conducted with a broad range of effort depending on the needs of the project because not all information defined for each method is needed in order to make a useful assessment. Therefore, picking out the appropriate phase(s) to conduct as well as the salient data types for each phase is essential in meeting the goals of any study most efficiently and effectively.

PROS AND CONS OF ASSESSMENT TECHNIQUES

Phase 1 Type Assessment

Strengths

- This methodology requires the lowest cost per square mile for watersheds ranging from hundreds to thousands of square miles.
- Personnel do not need to be on site.
- Preliminary stream characterizations can be made such as, which reaches are likely to be generating sediment, transporting sediment, and aggrading sediment.
- Aerial photos are useful for locating historical upland sediment sources, and stream channel erosion hotspots, such as mass wasted banks of larger channels.

Weaknesses

- Data sets are essentially out-of-date where the analysis needs are most critical, i.e. areas undergoing land use change.
- Details of stream features such as channel width, depth from floodplain, and gradient, are nearly always too fine to be usefully represented by the readily available GIS data sets (10 to 30 meter grid).
- Key features on small channels, such as natural bedrock grade controls, bed material grain size, bank material grain size, degree of incision cannot be discerned.

Phase 2 Type Assessment

Strengths

- The present actual conditions of stream channels are observed by field personnel.
- Reach level characterizations can be made. Each reach observed can be ranked according to its sediment generating/transporting/aggrading state.
- Details that offer explanations to downstream sedimentation issues, such as active channel incision, active bank mass wasting, unmapped channelized reaches, and active stream side construction can be detected and mapped using GPS.
- Material characteristics such as grain sizes bed material, parent material, and alluvial bank material can be determined.
- Photos of stream features can be taken for further assessment in the office, comparison to other reaches, and as an historical record.

Weaknesses

- There is an added cost of putting personnel in the field. Typically, two persons are needed for safety concerns.
- Additional time must be spent getting permission to access private property.
- Some areas may be inaccessible due to private property or extreme topography.
- There are practical limits to the area that can be assessed. In the authors' experience, trained field staff can cover 1 square mile of watershed and 2.5 miles of channel per day.
- Unexpected delays can be encountered due to floods and extreme field conditions such as deep water, numerous large woody debris jams, and dense briers and poison ivy along the riparian zone.

Phase 3 Type Assessment

Strengths

- This methodology returns specific quantitative data that can be used to calculate flows, bed and bank material erodability, stream power, and bankfull depths and discharges.

Weaknesses

- In general, the same weaknesses apply here as for Phase 2 type assessments.
- This methodology involves the highest cost per stream mile assessed. Two trained field staff can typically cover only ¼ mile per day.

THE CASE STUDY

The Public Works and Utilities Department (PWUD) for The City of Griffin, Georgia (Griffin is located 30 miles south of Atlanta), already involved in a long-term water quality contract with Tetra Tech, asked if Tetra Tech could design and conduct a low cost study to determine the potential sources of sediment contributing to the sedimentation of a downstream reservoir. The 40-acre impoundment, managed by the Griffin Country Club, is located at the downstream end of the 4.1 square mile Shoal Creek Watershed. Originally, the Country Club had a sediment management program implemented that was designed around lake dredging every 12 months. However, the actual sedimentation rate necessitated the need to dredge every 2 months. The City, in cooperation with the Army Corp of Engineers and Tetra Tech, later completed a watershed characterization of Shoal Creek, but since it was primarily a GIS-based study, it could only implicate general areas of the watershed as having a potential to contribute sediment. Thus, it could not give specific locations where City Engineers could physically go to mitigate the sediment sources, which in turn could have lessened the need for dredging the lake.

It was agreed that a detailed field assessment was needed to locate the actual and specific sediment sources. However, available funding and time limited the study to the use of one person for 10 days. Since the land in the watershed was essentially 100% built out, it was felt that stream channel erosion was potentially the dominant sediment source. Therefore, the initial plan was to design a stream walk where some level of geomorphic assessment would be conducted to document the state of Shoal Creek and its tributaries. Secondary goals included noting potential upland sources of sediment during the time spent in the watershed.

STUDY DESIGN

From the available geomorphic assessment techniques a combination of portions of Phase 1 and Phase 2 type data collection were decided upon. Stream and road maps were necessary for planning the daily field work portion and for presenting the results. Qualitative field data included types that could be collected in less than 15 minutes per site. This time constraint was necessary to insure that the field personnel had sufficient time to walk the entire 10 miles of channels in 4 days. From previous similar projects, an RGA stream walk assessment rate was estimated at 2.5 miles per day. A 15 minute assessment plus a 5 minute walk between sites equals 24 sites per 8 hour day with the sites spaced every 500 feet.

In this case, part of doing the RGA involved doing a CEM channel classification because portions of Shoal Creek had been channelized. The streams that have been channelized in alluvial materials often exhibit clearly one of the evolutionary stages (Simon, 1994). The CEM thus indicates the direction of channel stability, i.e. presently stable, becoming more unstable, or becoming more stable. The CEM evaluation can be made based on a few qualitative observations in several minutes. These observations include the percent bank coverage of woody vegetation, occurrences of mass wasting, bed material, percent of bed and bank toes aggrading sediment, and degree of channel incision. The complete data set collected in this case included:

- Latitude and longitude (from GPS).
- Location features such as road crossings, manhole cover ID numbers, power line crossings.
- Approximate bank heights.
- Bank vegetation.
- Bed state (Qualitative assessment of incising, stable, or aggrading).
- Bank state (Qualitative assessment of widening by scour, mass wasting, or stable).
- Channel evolution model stage (based on woody bank vegetation density, bank state and bed state).
- Channel cross section sketches.
- Planform sketches.
- Photographs of bank profiles and bed material.

The complete data set was then used during the data interpretation period to compare each site assessed and classify the degree of channel erosion taking place relative to all sites. The photographs were compiled into a photo log so that the stakeholders could appreciate the variation in channel stability without having to go into the field.

STUDY CONCLUSIONS

The total data package served its purpose in locating and classifying the severity of channel erosion. As expected, the rapid field assessment enabled the cataloging of known and unknown erosion hotspots. Correlating bank heights, woody vegetation density, and occurrences of bank mass wasting indicated that banks were stable when less than about 6 feet high. Deeper channels were subject to mass wasting. This mass wasting took place without exception where woody vegetation had been removed from the banks; a common condition in the residential parts of the city.

Unexpected discoveries included several features either of too fine a detail to be shown on the 1/24,000 topographic maps, or created since the last map update. Specific features include:

- More natural bedrock grade controls than indicated in the phase 1 report.
- An unmapped tributary.

- An unmapped gulley 18 feet deep and 500 feet long.
- A 500 foot reach on the main channel that had been relocated.
- Banks were saturated and subject to mass wasting where a beaver pond encroached on the channel.

These discovered features were critical in making interpretations about the state of the channels, such as bed incision being limited by the combination of natural bedrock and manmade grade controls (culverts and weirs). The relocated channel is the likely cause of the scoured bed and mass wasting banks immediately upstream.

The main weakness of this study as implemented was the inability in the field to assess the smaller reaches under dense brush land cover, and so approximately 20% of the watershed was not visually assessed. It was not practical, given the time constraints, to walk along channels less than about 5 feet wide under dense brush. Therefore, the following assumptions were made:

- Such channels, being densely vegetated, probably did not have large bank surfaces exposed to scouring flows.
- Such channels, having low bank heights, probably were not subject to mass wasting.

STUDY DISCUSSION AND RECOMMENDATIONS

This project was completed on time and within budget because of the careful selection of limited, but effective, qualitative field data to collect. The usefulness of this data was further enhanced through the presentation of a correlated set of maps, data tables, reach narrative, and photographs. Having such a compilation of reach conditions of the entire watershed enabled the Griffin Stormwater Utility to focus their erosion control efforts where they could gain the greatest return per dollar spent.

The qualitative data collected was useful in locating specific points of channel erosion and classifying the severity of erosion. The CEM classification provided further decision making ability by indicating whether a channel is likely to increase in eroding or become more stable. Erosion control efforts will go further if expended on reaches that are becoming more unstable. Reaches that are approaching stability will, over the short term, “heal themselves” and sediment production will be naturally mitigated. In the specific case of Shoal Creek, however, land use in the riparian zone had to be combined with the CEM results in deciding where to initially address stream channel erosion. Sanitary sewer drains, roads, commercial buildings, and residences encroached on the channel in many locations. Therefore, where erosion threatened a built structure, the CEM stage was not the primary driving factor in deciding whether to control the erosion; protection of the structure came first. However, where the riparian zone was free of built structures, the opportunity was afforded to install significant modifications to the channel and floodplain in order to control stormwater discharges that had been exacerbating channel erosion.

There are several limitations, however, to conducting such a low-cost, rapid study. Because the data collected was qualitative, it was not useful for calculating flows, erosion rates, and sediment loads. These are important parameters to know for determining if a stream is in compliance with its sediment TMDL and for quantifying sediment loads from various sources. Such data would thus have been useful to the clients in the long run, but was not feasible given the time and resource constraints.

Another potential improvement to this rapid geomorphic assessment would have been to conduct stream cross section and gradient surveys with differential GPS. This would provide quantitative information that could be used to estimate flow and stream power. Digital photographic data potentially could have been used also to conduct grain size analysis of bed material and surveying stream forms. Software has been developed that can provide a grain size analysis (equivalent to the pebble count) of bed and bartop surface material from digital photos. Other software has been developed that can provide dimensions and distances between features in digital photos (It is based on stereo digital photos with an object of a known size in the images).

A potential improvement to the presentation of the data would have been to provide an interactive digital map. Being able to click the mouse on an assessment point that would open a list of the photos and data collected at that location could be a powerful tool for local planners.

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