INTEGRATED STREAMBANK PROTECTION GUIDELINES

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ABSTRACT: Washington State's Integrated Streambank Protection Guidelines provide advice for the selection and design of streambank protection techniques that protect or restore aquatic and riparian habitats. Protecting and restoring these habitats will provide essential functions for a healthy and productive natural system while at the same time prevent or minimize bank erosion damage. Too often these habitats have been ignored in favor of developing or protecting other floodplain uses and have not successfully mitigated habitat impacts. By understanding river processes, designs for streambank protection can optimize the potential to maintain fluvial integrity and provide habitat. Natural river processes should be integrated into selecting and designing bank protection projects. Integrated streambank protection requires a change in the traditional approach; bank protection measures should be selected to address site- and reach-based conditions and to avoid habitat impacts rather than automatically applying traditional methods such as riprap. This new approach allows for consideration of other methods such as roughening a bankline, directing flow away from an eroding bank, revegetation, floodplain management, landuse planning, maintaining riparian corridors, restoring oxbows/wetlands, relocating infrastructures at risk, managing meander belts, and public education. It may also lead to a recommendation of not allowing specific bank protection projects.
KEY WORDS: streambank protection, assessment, risk, habitat, mitigation, design

INTRODUCTION

The State of Washington is in the final process of developing a document entitled "Integrated Streambank Protection Guidelines" (ISPG) (Washington Department of Fish and Wildlife, 2000) for use by a wide variety of technical and laypersons. Integrated streambank protection is the recognition, assessment, and assimilation of erosion and channel processes, habitat considerations, mitigation requirements, levels/types of risk, project objectives, design criteria, and attributes of bank protection techniques. Guidance is provided on how to assess these factors and how to use the results from the assessments to select appropriate bank protection solutions. A graphical representation of the integrated streambank protection process is shown in Figure 1. There are a number of fundamental guiding principals that comprise integrated streambank protection:

- erosion is a natural process that is essential to ecological health;
- erosion is often exacerbated or caused by human activities;
- causes of erosion (not just symptoms must be solved when appropriate;
- basin, reach and meander belt management are essential to integrated streambank projects;
- habitat protection must be assimilated into streambank projects;
- mitigation sequencing must be integrated into streambank projects; and
- impacts to natural channel processes must be mitigated.

Identification of suitable bank protection treatments begins with an understanding of the specific mechanism of failure at a project site as well as the site- and reach-based causes of bank erosion. The mechanism of failure is the physical action or process within the bank and can be thought of as the problem you see on site. The site-and reach-based causes are what activates the mechanism of failure. These causes may be simple and discreet, or they may be highly dependent and difficult to separate. Table 1 lists typical mechanisms of failure and corresponding site- and reach based causes of bank erosion.

These guidelines are intended to provide a framework for the selection of techniques that promote an understanding of the erosion problem and ultimately, innovative and habitat-friendly solutions. As such, the design process advocated here is not linear. Developing effective, creative solutions requires a clear definition and understanding of why a bank is eroding. Once this is understood, the art and science of integrating this information with habitat considerations, mitigation requirements, levels/types of risk, project objectives, and design criteria can result in the selection of appropriate, habitat-friendly bank protection treatments.

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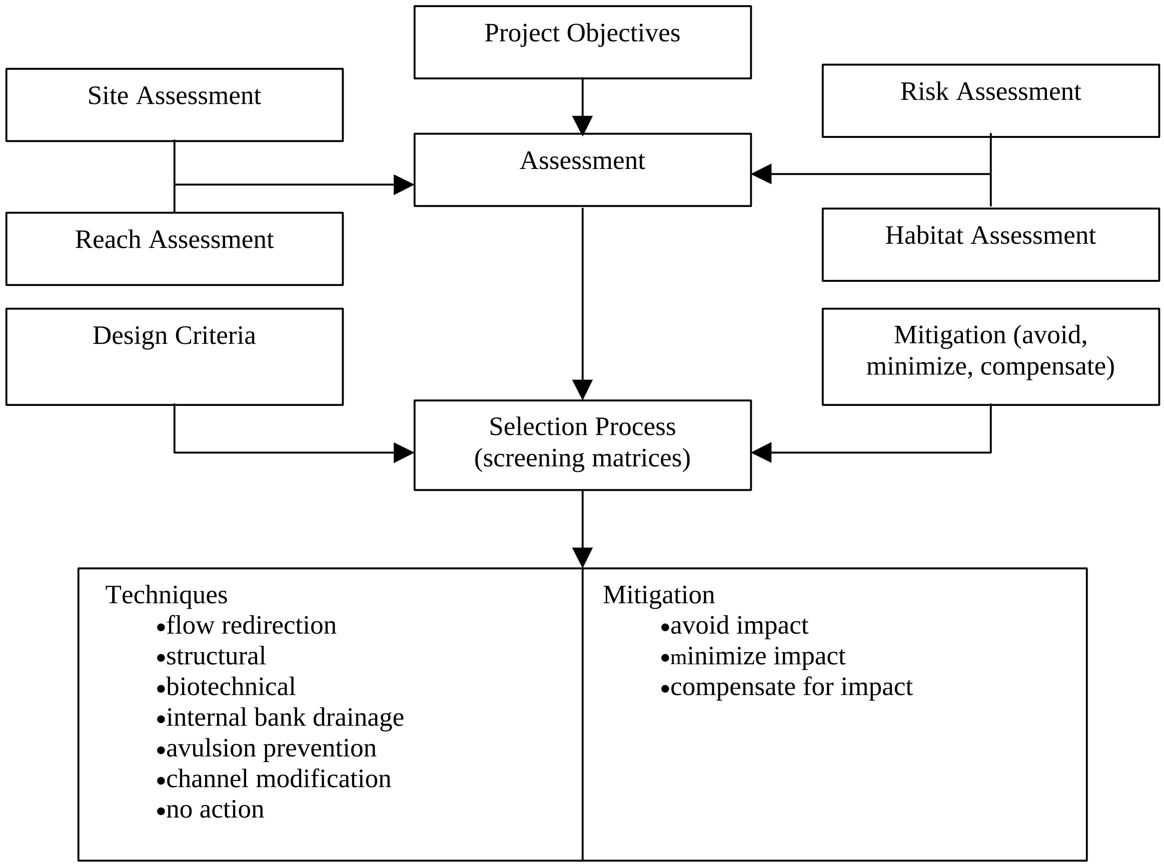

FIGURE 1. Integrated Streambank Protection Process, (ISPG)

SITE AND REACH ASSESSMENTS

Identifying suitable bank protection alternatives begins with an understanding of the specific mechanism(s) of failure as well as the site- and reach-based causes of erosion. Correctly identifying the mechanism(s) and cause(s) of failure is critical to selecting appropriate bank protection solutions. There are five types of mechanism of failure: general bank erosion, scour, mass failure, subsurface entrainment, and avulsion. The cause(s) of failure can be divided into site- or reach-based causes. At times, these causes may be difficult to ascertain, nevertheless the single cause or combined causes can be identified with careful evaluation. Often, the reach-based causes generate site-based causes. Table 1 lists the mechanisms of failure and site- and reach-based causes. The mechanisms and causes listed in the table may be natural or human caused or exacerbated.

A site and reach assessment should identify existing habitat conditions and the habitat potential, respectively. During site and reach assessments, it is important to recognize that bank erosion is a natural process where essential habitat functions are often created. For example, an overhanging bank with exposed plant roots provides cover habitat. Considering habitat creation (or conversely, impacts to habitat) resulting from bank erosion is a critical component of site and reach assessments.

MITIGATION

Bank protection projects can create substantial impacts to fish habitats. As such, every bank protection project should be evaluated with respect to potential mitigation requirements. Before designing a project, attempts should first be made to avoid impacts altogether. Where impacts cannot be avoided, they should be minimized to the extent possible. Where such impacts cannot be avoided, compensatory mitigation will be necessary. The preferred option is to: first, avoid; second, minimize; and third, compensate for impacts.

TABLE 1. Mechanisms of Failure, Site- and Reach-Based Causes

Mechanism of Failure	Site-Based Causes	Reach-Based Causes
General Bank Erosion	Reduced vegetative bank structure Tailout and backwater bars Smoothed channel Along a bend (bend scour)	Meander migration Aggradation •reduced hydrology/increased sediment supply •localized downstream constriction •reduced slope •confined channel Degradation •increased hydrology/reduced sediment supply •localized shortened channel •natural channel evolution •change in long-term watershed hydrology
Scour •Local Scour	Woody debris Bridge pier or abutments Boulder/outcropping	Not applicable
•Constriction Scour	Bridge/road approach Existing bank feature Large woody debris jam	Not applicable
•Drop/Weir Scour	Weir, ledge, or sill	Not applicable
•Jet Scour	Lateral bar Side-channel or tributary Abrupt channel bend (energy sink) Subchannels in a braided channel	Not applicable
Mass Failure	Saturated soils Increased surcharge Loss of root structure Removal of lateral/underlying support	Meander migration Aggradation •reduced hydrology/increased sediment supply •localized downstream constriction •reduced slope •confined channel Degradation •increased hydrology/reduced sediment supply •localized shortened channel •natural channel evolution •change in long-term watershed hydrology
Subsurface Entrainment	Groundwater seepage Rapid drawdown	Not applicable
Avulsion/ Floodplain Erosion	Floodplain activities Natural conditions	Aggradation Previously relocated channel Braided channel Large storm event

The first priority of regulatory agencies normally is for the project to be designed so impacts are avoided. If an impact cannot be avoided, then direct effects, such as hardening a bank, are mitigated by restoring damaged or lost ecological functions. Indirect effects are addressed by recognizing long- and short-term impacts to the reach and mitigating for them in the design or off-site. Indirect effects might include the loss of valuable future side-channel habitat and sources of spawning gravel and large woody debris. These losses in habitat arise from bank hardening practices, which prevent the channel from migrating laterally (Dillon, 1998). These impacts are most critical in undisturbed river reaches since the first bank protection project will often promulgate more bank protection projects. They are also critical in developing watersheds where landowners expect stream channels not to move.

RISK

Throughout the design process, it is important to understand and evaluate the many types and levels of risk associated with a bank protection project. A risk assessment should consider both the risk of continued bank erosion and the risk associated with the bank protection project with respect to property, habitat, and public safety. All bank protection projects contain some level of risk. For example, a bank protection project may be effective at lower flows, but may fail as a result of a larger flood. Likewise, the quality of fish cover habitat along an undercut, vegetated streambank may be at risk by the placement of bank protection techniques (Peters, 1998). Low erosion risk to property and public safety deserves bank protection treatment of comparable risk that allows the bank to continue to erode but at a more gradual, natural rate.

OBJECTIVES AND DESIGN CRITERIA

Solving a bank protection problem begins with clearly stating the objectives of a project. Objectives are typically somewhat general or qualitative. For example, objectives may be stated as “preventing further erosion of the river along the highway” or “stabilizing the streambank to reduce loss of cropland”. In fact, there are usually a number of objectives with differing levels of priority. For example, either of these objectives should often include “maintaining the aesthetic qualities of a streambank environment” or “protecting or enhancing fish habitat”.

In order to bridge objectives with selection of techniques, it is important that design criteria are established. These criteria, considering risk and cost, and stratified according to relative priority, outline the objectives of the project and provide the foundation for making design decisions about the specific sizes and components of bank protection techniques.

SELECTION OF TECHNIQUES

One of the most difficult but important aspects of the design process is moving from the site and reach assessments to the selection of an appropriate solution.

Three screening matrices were developed to assist the user in the selection of bank protection treatments that:

- perform adequately to meet bank protection objectives;
- are appropriate with respect to mechanism(s) of failure and site-and reach-based cause(s);
- are considered with an understanding of the potential impacts to habitat caused by each technique; and
- are selected in order of priority that first avoid, second minimize, and lastly compensate for habitat impacts.

These matrices act progressively as selective screens, or filters, of bank protection techniques. These matrices are:

- Screening Treatments Based on Site Identified Mechanism of Failure
- Screening Treatments Based on Reach Identified Causes
- Screening Treatments Based on Habitat Protection and Mitigation

Within each matrix, bank protection techniques are listed. Each technique is rated such that the applicability of each technique can be considered. This consideration results in accepting or rejecting a technique within the matrix. With each subsequent matrix, techniques are progressively “screened out”, leaving a suite of feasible techniques. Throughout the process of identifying a technique, the question should always be posed whether the best course of action might involve none at all.

BANK PROTECTION TECHNIQUES

Information about streambank protection techniques applicable within the State of Washington is provided in these guidelines. The techniques have been divided into seven functional groups as shown in Table 2. For each technique, the following information is provided in the guidelines:

- Description of the technique;
- Application (typical application, variations, emergency, site and reach limitations);
- Effects;
- Design;
- Habitat considerations (mitigation requirements for the technique or mitigation benefits provided by the technique);
- Risk (risk to habitat, adjacent properties, and reliability/uncertainty of the technique);
- Construction considerations (material required, timing considerations, cost);
- Operation and maintenance needs;
- Monitoring considerations by case studies;
- Examples (typical drawings, site example, description, photographs); and
- References.

TABLE 2. List of bank protection techniques organized by functional group.

In-Stream Flow Redirection Techniques	Structural Bank Protection Techniques	Biotechnical Bank Protection Techniques	Internal Bank Drainage Techniques	Avulsion and Chute Cutoff Prevention Techniques	Channel Modification Techniques	No Action
•groins •buried groins •barbs •engineered debris jam •drop structure •porous weir	•anchor points •roughness tress •riprap •log toe •rock toe •cribwalls •ballast •manufactured retention system	•woody plantings •herbaceous cover •soil reinforcement •riparian buffer •coir and straw logs •bank reshaping •buffer management	•chimney drain •collector drains	•floodplain roughness •headcut prevention (grade control) •floodplain flow spreader •construct overflow channels	Separate guidelines are currently being developed for channel modification techniques.	

CONCLUSIONS

Integrated bank protection is the assimilation of three factors; cause of bank failure, habitat, and risk; into the planning and design of a streambank protection project. It is crucial to assess these factors at the onset, otherwise a bank protection project will not likely achieve ecological and structural success. Many bank protection projects have been constructed with consideration of no more than one of these factors, the risk of erosion. The ISPG provides guidance on: assessing site- and reach-based processes that may be triggering erosion; identifying project objectives and design considerations; identifying existing and potential habitat conditions; and assessing risk. One of the most difficult but important aspects of integrated bank protection is moving from the assessment and identification of project objectives/design criteria to the selection of an appropriate bank protection solution. Three screening matrices were developed to progressively screen-out techniques, leaving a suite of favorable techniques. Mitigation is a crucial component to the selection of bank protection treatment. Techniques must first be selected that avoid impacts to habitat. Only after exhausting the practicality of applying techniques that avoid impacts, can other habitat impacting techniques be selected. These impacts must be mitigated. Detailed design information for bank protection techniques is provided in the guidelines.

ACKNOWLEDGEMENTS

The Washington Departments of Fish and Wildlife, Ecology, and Transportation and the Washington Salmon Recovery Funding Board jointly funded the Integrated Streambank Protection Guidelines document. Several authors jointly wrote this document from the Washington Department of Fish and Wildlife and Inter-Fluve, Inc. The primary authors are:
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