CONSTRUCTION CONSIDERATIONS APPENDIX

Construction issues can significantly influence both the feasibility and design of a stream rehabilitation project. The constructability of stream rehabilitation or restoration proposals is a primary design criterion during project scoping. *Constructability* refers to the technical and financial feasibility of an overall stream rehabilitation proposal and its constituent treatments or techniques. The selection of construction methods will therefore be determined by affordability, availability of equipment, access to work sites and regulatory constraints.

This appendix is intended to provide a broad overview of construction considerations. Because site-specific conditions and project-specific criteria influence construction approaches significantly, a comprehensive discussion of construction techniques is beyond the scope of this appendix. However, careful consideration of the topics listed here should assist stream restoration and rehabilitation practitioners to develop a comprehensive work plan for accomplishing project goals with respect to construction issues.

1 SITE LIMITATIONS

Site limitations such as terrain, location of utilities, land ownership, infrastructure, sensitive landscapes, stockpiling/disposal and access are constructability issues that may influence many design components. For this reason, site limitations should be considered during all phases of design and implementation and are best addressed by preparing a construction-sequencing plan, an outline of the major tasks and their sequential order of construction. Developing a conceptual construction-sequencing plan early in the design process will help identify and resolve many aspects of constructability that are dictated by site limitations.

1.1 Site Access

While some types of stream restoration or rehabilitation projects can be constructed solely with hand labor, the construction of most projects will require heavy equipment at the project site. Site-access considerations include ingress and egress for construction staging, access to the stream and any planned stockpile areas (e.g., construction and waste materials), and dewatering and sediment-control systems.

Construction Considerations Figure 1.
Heavy equipment access for a log cribwall construction on Beaver Creek.
Source: Inter-Fluve, Inc.

- use an existing access point,
- construct an access point,
- construct a temporary construction platform adjacent to the stream,
- create an in-channel access point during low-flow conditions or where the channel has been dewatered such that the work area is dry (e.g., exposed gravel bar), or
- use a spider excavator, a floating platform or heavy equipment as construction access within a wetted channel.

Construction Considerations Figure 2.
Spider Excavator placing rocks and logs in Whatcom Creek.
Source: Inter-Fluve, Inc.

Access through a riparian area should be carefully marked to minimize impacts and to aid in the subsequent restoration efforts. Mitigation for construction activities will be necessary. See

Chapter 4, *Developing A Restoration Strategy* for more information about mitigation.

1.2 Access Roads

Temporary access roads may need to be constructed to transport materials and equipment to the site. Access roads must be designed and built according to the needs of the equipment, taking into account road grade, equipment size and weight distribution, and vegetation and habitat character. In particular, the need for equipment to maintain traction will drive important design decisions if ground conditions at the site are slippery, steep or soft. Street-legal dump trucks in particular are limited in their ability to travel on unpaved roads. Many types of equipment are able to travel on softer roads, causing less damage to soils because their weight is better distributed. Excavators, tracked dump trucks and other vehicles can be outfitted with extra wide tracks to reduce weight impacts and soil compaction.

In relatively non-sensitive areas (e.g., meadows, pastures, woody riparian areas), access roads can be constructed by placing road gravel on geotextile materials laid directly on the ground surface. Some of the plastic products on the market (PVC, PVE, etc.) can be used to reinforce low-load-bearing soils. This approach is appropriate when access roads will be used frequently for hauling materials or equipment or for refueling operations.

Access can also be achieved using temporary mats (e.g., linked tires, cabled ties, landing mats) to “walk” equipment across sensitive areas on a limited interval basis. This assumes little or no materials will be transported in or out of the site for the duration of the project, and whatever equipment is needed can be housed and maintained at the site.

Scheduling construction for times when the ground is either dry or frozen can also reduce impacts associated with access roads. Snow-covered, frozen soils can often be traveled with wide-track equipment with no impact to underlying vegetation or soils. Similarly, dry conditions reduce many impacts associated with soil compaction and soft soils.

In summary, the following circumstances should be considered in designing and timing construction access to the site:

- refueling location and frequency,
- sensitivity of landscape soils and vegetation,
- size and character of equipment,
- frequency of ingress/egress, and
- season and soil moisture.

1.3 Construction Platform

Construction of most bank-protection projects will require some degree of heavy-equipment mobility along and near the bank. Construction of bank protection can be conducted from the channel, from the bank or from a temporary platform. Site limitations may determine where construction is conducted.

Near-bank construction platform. Traditionally, the majority of operations are conducted in the bank and in near-bank areas. This requires either a sizeable bank-reconstruction area (which may facilitate conducting construction activities entirely within the bank-treatment footprint), or it results in considerable impact to near-bank environments. In the latter case, remediation of near-bank environments is required.

Construction Considerations Figure 3.
Construction platform for a major streambank reconstruction on the Little Miami River in Ohio**.**
Source: Inter-Fluve, Inc.

Between-bank construction platform. When site restrictions require that construction must occur within the channel banks, there are a number of options. Of particular note, the channel can be partially or completely dewatered. Dewatering a channel will require protocols for cleaning equipment, refueling equipment and handling fluid spills. Advantages of this type of operating platform include minimizing impacts to near bank areas during construction and enabling detailed manipulation of the channel bed and bank toe for habitat enhancement without the interference of flowing water during construction.

Temporary construction platform. An alternative to dewatering for between-bank construction is a temporary fill platform within the channel, constructed from large rock (with a small rock work surface). Temporary platforms can also be constructed within the channel on temporary pilings. A third alternative is to operate equipment positioned on a barge within the channel. This is particularly appropriate for dredging and excavation activities.

1.4 Utilities

Utilities are often found near or within a project site. Careful review of the site will reveal most utilities present, including power lines, railroad tracks, pipelines, buried cables, sewers and other common utilities. All utilities owners should be contacted to evaluate hidden utilities and to identify or establish protocols for working near or within utilities' rights-of-way. Urban project locations with many site limitations may require the temporary or permanent relocation of utilities to accomplish project objectives.

1.5 Stockpile and Disposal

Any significant movement of materials on-site, off-site or within the site will require a stockpile area for temporary storage of construction or waste materials. Stockpiling of construction materials (e.g., gravel, rock, soil, fabric, wood materials) and disposal of waste materials (e.g., excavated bank materials, vegetation, trash) should be considered during the construction sequencing. Careful consideration of stockpile size and location will facilitate construction, reduce cost and limit damage to sensitive areas. The location of stockpiles can significantly increase or decrease cost if it increases or decreases cycle time for construction operations.

Construction Considerations Figure 4.
Stockpiling logs and soils on Beaver Creek.
Source: Inter-Fluve, Inc.

2 CONSTRUCTION PERIOD

The timing of construction will often be determined by regulatory mandates intended to reduce water-quality impacts to critical fish life cycles such as migration and spawning. The timing for construction projects that affect state waters varies throughout the state, depending upon the species present in the watercourse. Contact the Washington Department of Fish and Wildlife's Area Habitat Biologist for information on work windows (see Appendix B, *Washington Department of Fish and Wildlife Contact Information*). Once the allowable construction window has been identified for your project, additional factors such as hydrologic, precipitation and revegetation considerations will assist in determining the most appropriate time to operate within the established work window.

2.1 Hydrology and Precipitation

Hydrologic analyses that can be helpful in determining an appropriate time for construction include analyses of seasonal variations in average and extreme flows. From the standpoint of feasibility and cost-effectiveness, construction should occur when average seasonal flows are low and the likelihood of high-flow events is at its lowest. This will vary geographically, depending upon the dominant hydrologic character of a watershed. Further information on methods for determining hydrologic character and approaches to hydrologic analyses are available in Appendix D, *Hydrology*.

Hydrologic analyses should also be conducted to determine the appropriate method and design for dewatering. Dewatering systems must be designed not only to handle average flows, but also to handle anticipated high flows associated with storms or other hydrologic events during the construction period. In scenarios where it is impractical or impossible to design a dewatering system that can handle storm flows, it is important to determine the extent to which the dewatering systems will be inundated during such flow events and for how long. Before proceeding with construction of a bank-protection project, the potential consequences of inundation due to high seasonal flows should be estimated and the risk of such occurrences calculated using hydrologic statistics. These analyses can be conducted for any stream using daily gauge data. They are further discussed in Appendix D.

2.2 Revegetation

Successful revegetation is largely determined by the timing of revegetation efforts. Ideally, revegetation components of a bank-protection project will be conducted to maximize the potential for survival of the plant materials installed and to enhance their ability to grow quickly. Furthermore, the success of many bioengineered techniques will require that vegetative cover be maximized in the least amount of time possible following construction. This requires minimizing the period of dormancy of installed materials between installation and the following growing season and ensuring ideal moisture conditions, which are often specific to species and plant forms installed, following construction. Detrimental moisture conditions may include either drought or inundation. For further discussion of planting considerations, refer to Appendix H, Planting Considerations and Erosion-Control Fabrics.

Some plant materials must be installed during construction, while others may be installed months after construction to enhance survival and success. For instance, seed must be placed under geotextile fabrics during construction. Similarly, some techniques that incorporate cuttings or other dormant materials may be integral to the structure of the protection measure. However, many plant materials, such as cuttings, tubelings and rooted stock can be planted following construction, during ideal soil-moisture conditions to improve survival rates.

Construction Considerations Figure 5. Installing rooted willow cuttings during fabric encased soil lift construction. Source: Inter-Fluve, Inc.

2.3 EROSION AND SEDIMENT CONTROL

Erosion control includes all measures to check the migration of soil materials from a construction area into areas where moving water can carry them away. Sediment control includes all measures to reduce turbidity associated with construction activities. The success of erosion and sediment-control methods greatly depends upon weather patterns during the season of construction, dewatering methods applied and the character of the hydrograph at the project site. The period of construction will determine the method of erosion and sediment control required. Careful consideration should be given to inundation levels and flow durations derived from hydrologic statistics (see Appendix D).

Erosion control includes both the prevention of soil loss through soil cover and the trapping of soils eroded by surface flow. Erosion-control mechanisms must be effective during precipitation events and/or during inundation by stream flow. In areas that are above anticipated inundation levels, the potential for soil loss through erosion can be reduced by applying mulch (e.g., straw, wood chips and other organic materials), hydroseeding, or adding biodegradable, chemical or synthetic soil stabilizers. Areas that may become inundated by flowing water during high-flow events should be protected by geotextile fabric (see Appendix H). The Washington State Department of Ecology has guidance on erosion-control techniques in the *Stormwater Management Manual for Western Washington*[1].

In addition to preventing soil loss, eroded soils must be trapped before reaching the stream. This is best accomplished using standard silt-barrier approaches, such as straw bales or a silt fence. The design and specification of silt barriers must include inspection and maintenance schedules, as well as a schedule for removal. Silt barriers require cleaning when they reach 50 percent of capacity.

Sediment control is intended to minimize the input of sediment associated with constructing bank treatments. However, it is unrealistic in most circumstances to expect complete control of sediment inputs, because the installation process for most sediment-control systems itself generates some turbidity. While there are a variety of sediment filters available that are advertised as having moving-water applications, these are impractical and ineffective for controlling sediment except on very small streams. Dewatering the site or isolating the construction area from moving water can largely control sediment input.

3 DEWATERING

Dewatering a streambank construction area may be essential for constructability and to provide a required degree of sediment control for water-quality protection. The design and implementation of dewatering systems is often underemphasized. At a minimum, dewatering systems must be able to divert one-year flows anticipated during the period of construction. A one-year flow is the greatest flow that has a 100-percent chance of occurring every year during the construction period. This magnitude of return flow will need some qualification based on the period of construction. For instance, during the summer period, the one-year flow may be appropriate; but, during the winter, preparation for a greater-magnitude flow event will likely be required. The possibility of inundation should be planned for in the design of dewatering systems. The probability of a dewatering system being overwhelmed by storm flows can be determined using standard hydrologic analyses. When available, the analyses should be based on data sets derived from peak flows covering the construction window for period of record. The risk of inundation, based on a probability of occurrence for a particular flow level, can then be used to gauge the relative costs associated with inundation. The cost of inundation may include lost work, lost time, damage to equipment and sediment influx in the stream.

Dewatering can be accomplished on small streams by diverting flow around a project. On larger streams, cofferdams can be used. Flows can be diverted with pumps or passive systems such as side channels, canals or tubes. Flow diversion requires careful consideration of the backwater effects on diversions; pump capacities, diversion-channel capacities and outfall protection. Diversion outfalls require temporary erosion-protection measures to prevent scour at the point of return flow from the diversion channel or pipe. Additionally, pumps require screens designed to Washington State[2][2] and National Marine Fisheries Service specifications to prevent loss of fish. Any diversion will similarly require a recovery plan for fish left behind when the water is gone. Fish can be recovered manually from remnant pools and transferred by bucket to downstream reaches.

Construction Considerations Figure 6. Dewatering an urban stormwater channel in preparation for stream restoration. The Menomenee River is diverted through a pipe, with coffers at each end defining the work area. Note track hoe on temporary in-channel pad.
Source: Inter-Fluve, Inc.

3.1 Cofferdam Isolation

An alternative to diverting a channel is to use a cofferdam, which isolates the project site from the water in the channel (see variant of this technique in **Construction Considerations Figure 6** above). A cofferdam is an impermeable structure installed parallel to a streambank that allows water on the landward side of the structure to be pumped out, leaving the area contained by the structure free of water. **Construction Considerations Figure M-1** shows an example of a cofferdam. Cofferdams can be created using jersey barriers, hay bales and impermeable curtains or water-filled tubes. The use of a cofferdam may confine the channel, raising water-surface elevations. Application of cofferdams will, therefore, require careful modeling of the impact on water-surface elevations during all anticipated flows.

Commercially available cofferdam systems can be applied on larger river systems. These systems can often withstand overtopping during large events. Design of coffer-dam dewatering systems should consider the infiltration rate of seepage flow from the riverbed and from banks and will require additional and constant pumping systems to address the infiltration flow. In-flow will likely be extremely turbid due to construction activities. Therefore, a sediment detention and settling basin will be required for water pumped from within the dewatered construction area.

3.2 Partial Isolation - Working in Wet

An alternative to dewatering solely for the purpose of sediment control is the use of partial isolation (see **Construction Considerations Figure M-2**). Partial isolation is still applicable even when dewatering is not necessary for installation purposes. This method minimizes the continued release of sediments that would occur with flowing water. For this reason, work can occur in standing (versus flowing) water behind a barrier. Sediment will be released, but in smaller quantities. When the barrier is removed, sediment will be released. However, it will be distributed as a single pulse rather than a continuous stream and will result in substantially less sediment input than would otherwise occur under flowing water conditions. Water-quality impacts will need to be carefully considered before applying this approach; they may even prevent the use of this approach.

4 HEAVY EQUIPMENT

There is a wealth of heavy-equipment types available for construction projects. The equipment used can play a big role in progress rates and efficiency and, consequently, cost. A rule of thumb is to use the largest, most appropriate equipment available, given site limitations, to maximize efficiency in moving and installing materials. However, this general rule must take into account site-specific limitations (e.g., turning radii and material size) and the need to perform detail work. Most standard types of equipment, including excavators, loaders, dozers and trucks are available in a range of sizes from miniature (Bobcat or smaller) to extremely large (e.g., mine-operations equipment).

Construction Considerations Figure 7.
A track hoe excavator manipulating a large root wad and bole.
Source: Inter-Fluve, Inc.

Landscape sensitivity may also be a consideration for equipment selection. While large equipment weighs more, many models essential for bank-protection work, including excavators, dozers, loaders and even dump trucks can be equipped with tracks rather than wheels. Tracks are able to distribute a vehicle's weight more evenly across a larger area than wheels can. Consequently, for the same piece of equipment, the weight per square inch of track is less in comparison to rubber tires.

Some projects will require specialized equipment that most contractors do not own or have at their ready disposal. When specialized equipment is required, progress rates are often slowed, resulting in an increase in per-hour operational costs. Consequently, construction costs may be increased by both hourly rates and slowed progress. For example, a street-legal dump truck can typically haul eight to 12 cubic yards of material. In ideal conditions, which include dry, flat ground, a tracked truck has a capacity of six cubic yards of dry fill. However, in most conditions where a tracked truck is necessary, a typical load is less than four cubic yards of relatively dry material and considerably less if the material is wet.

Specialized equipment for bank-protection applications includes:

Spider Excavator. A spider excavator is an articulated-arm excavator that operates on four independent legs rather than two tracks. It can *crawl* and perch on relatively steep slopes, and it can "walk" across channels with minimal impact. It can often access areas that traditional, tracked equipment cannot (see **Construction Considerations Figure 2**).

Bobcats: Bobcat is a brand of small earth-moving equipment that can run on four rubber tires or on tracks and has the ability to use a number of different tools for a variety of applications. Bobcats can be outfitted with loaders, dozer blades, hoes, drills and numerous other tools. They are ideal for moving and installing materials within small areas.

Helicopters. Helicopters can be used to import materials to remote areas. They can be practical and cost-effective for any imported earth materials, including wood, large boulders, fabric or artificial materials.

Construction Considerations *Figure 8:* A Chinook helicopter is used to transport and locate large woody debris in a sensitive stream site not easily reached by conventional heavy equipment. Source: Inter-Fluve, Inc.

Horses. Horses can also be used for transporting materials and as a substitute for heavy equipment in many remote or access-limited areas.

5 REFERENCES

[1] Washington State department of Ecology. 2001. Stormwater Management Manual for Western Washington. Publication Nos. 99-11 through 99-15. Olympia, WA.

[2] Bates, K. M. and B. Nordlum. 2001. Draft Fish Protection Screen Guidelines for Washington State. Washington Department of Fish and Wildlife, Olympia, WA.