STANDARD SPECIFICATIONS & BEST MANAGEMENT PRACTICES FOR DISTURBED LANDS REMEDIATION

Big River Unit, Mendocino Headlands State Park
Mendocino County, California

Prepared by the California Department of Conservation
California Geological Survey
in Collaboration with the
California Department of Parks and Recreation
February 2006

STANDARD SPECIFICATIONS & BEST MANAGEMENT PRACTICES FOR DISTURBED LANDS REMEDIATION

Big River Unit, Mendocino Headlands State Park
Mendocino County, California

Compiled by the
California Department of Conservation
California Geological Survey
In Collaboration with
California State Parks

February 2006

PROFESSIONAL GEOLOGIST
M.G. SMELSER
No. 2192
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

STANDARD SPECIFICATIONS &
BEST MANAGEMENT PRACTICES FOR
DISTURBED LANDS REMEDIATION

TABLE OF CONTENTS

STANDARD SPECIFICATIONS &
BEST MANAGEMENT PRACTICES FOR
DISTURBED LANDS REMEDIATION

TABLE OF CONTENTS
(continued)

STANDARD SPECIFICATIONS &
BEST MANAGEMENT PRACTICES FOR
DISTURBED LANDS REMEDIATION

Big River Unit, Mendocino Headlands State Park
Mendocino County, California
February 2006

SECTION 1: INTRODUCTION

1.01 Acknowledgements

The following specifications and practices were adopted from two California Department of Parks and Recreation publications (Merrill and Casaday, 2001, and 2002). Secondary sources of information include: unpublished specifications developed by Redwood National and State Parks (Terri Sprighter, 2004, personal communication); Low-Volume Roads Engineering published by the U.S. Department of Agriculture and Virginia Polytechnic Institute (Keller and Sherar, 2003); Standard Specifications published by the California Department of Transportation (1999); and the Handbook for Forest and Ranch Roads (Weaver and Hagens, 1994). In addition, pertinent pages from the California Salmonid Stream Habitat Restoration Manual (Flosi and others, 1998) are included as Appendix A. This compilation of specifications and practices is considered "a work in progress" evolving to meet the specific needs of the Big River Unit of the Mendocino Headlands State Park as remediation and restoration efforts proceed.

1.02 General Description of the Remediation Work

The California Department of Parks and Recreation (DPR) is removing roads, watercourse crossings, landings, and skid roads to reduce future erosion and restore natural landforms and watershed systems within the Big River Unit of Mendocino Headlands State Park. The primary goal of the work is to obliterate elements of hydrologic disturbance caused by road construction and to rehabilitate the disturbed lands to a condition similar to what existed prior to disturbance. Secondary goals include minimization of erosion and sediment delivery to watercourses and stewardship of essential access roads. Contract work for these efforts may include excavating road fill from stream channels, pulling back side-cast road fill, decompacting roads, retrieving and removing debris (culverts, cable, concrete foundations, etc.) from logging and other activities, and restoring the natural configuration of the land (ridges, stream valleys and swales) along roadway corridors. Trees and logs encountered during excavations shall be spread over finished surfaces as mulch. The finished surfaces of all areas disturbed by the equipment shall be left in a manner suitable for transplanting and re-establishment of native vegetation.

Project area terrain is typically steep, irregular, and vegetated with dense shrubs and redwood forests of variable ages. The work requires heavy earthmoving equipment to be used on steep terrain and in difficult working conditions.

Equipment will be required to push fill material up steep inclines as well as shape and finish steep slopes. Such work will require the equipment to traverse, move around, and sit on steep slopes while performing the work. Access to some work sites, or portions of work sites, will require operator skill and dexterity to minimize access impacts over steep irregular ground. Large quantities of vegetation shall be removed before and during excavation, stockpiled, then spread over finished surfaces according to the post-excavation erosion control guidelines. Operator planning and forethought will be necessary to manage vegetation and excavated material efficiently.

The size of excavations associated with this work can range from less than one hundred cubic yards to tens of thousands of cubic yards in volume. In general, stream crossings shall be excavated to original width, depth, alignment and gradient to expose natural channel armor and buried topsoil. Sidecast fill material shall be excavated along road benches to expose buried topsoil. Excavated material shall be end-hauled to more distant fillsites. The type of material to be excavated can vary from fine-grained soil material to large concentrations and quantities of rock, boulders, rootwads, and sections of old growth trees. Additionally, ground conditions and material to be excavated can vary from dry to completely saturated. These variations in excavated material and ground conditions are inherent to the nature of this work.

To ensure that state park restoration goals are met, DPR will provide a full-time Project Inspector (PI) to oversee the construction work. The PI may adjust specifications and excavation designs as excavations proceed. Contractors and equipment operators must be able to accurately interpret written and verbal excavation details as stated in the contract or given by the PI. They must be able to visualize and plan all aspects of work required at each site to ensure that access is not cut off inadvertently or prematurely. Skill in operation and coordination of heavy equipment is necessary for cost-effective restoration of these state park lands. Adverse impacts to park resources (e.g. old growth trees, natural ground surface, water quality, vegetation, wildlife habitat, etc.) must be minimized in accomplishing the required work.

The Contractor shall not initiate any earth moving work or vegetation manipulation unless the Project Inspector is present at the worksite. By monitoring excavations as they progress, the Project Inspector shall assist the contractor in adjusting the excavation grade and alignment to achieve a topographic match, and also shall determine the suitability of the grade achieved. Indicators of original (natural) grade may include: original topsoil or channel features (small woody debris and rock) bedrock outcrops, or naturally introduced large woody debris. These boundary conditions exist naturally in a stream channel or its valley prior to road building and functioned as natural control for the channel forming processes. It is extremely important not to remove or disturb these natural grade indicators.

SECTION 2: DEFINITIONS AND TERMS

aggrade - the filling of a stream channel with sediment. This usually happens when the supply of sediment is greater than the stream is transporting. Compare to "degrade" and "graded stream."

alignment - the area affected by a road or trail including the fill slopes, road bench, and cut bank. Also a linear representation of features on a map such as a stream channel.

curvilinear - a curving line. Refers to a meandering trail that curves around boulders and trees following contours across the land at a flat or oblique angle.

cutbench - the portion of a roadway that has been cut into bedrock or native soil. Compare with embankment.

decommissioning - the treatment of a road to eliminate diversion potential during periods of nonuse. A road is typically decommissioned when the road will not be used for a period of time but may be used some time in the future. Decommissioning includes the removal of stream crossing fill and partially recontouring or outsloping road segments between crossings.

degrade - refers to the erosion of a stream channel. This usually happens when the supply of sediment is less than the amount the stream is transporting. Compare to "aggrade" and "graded stream." Also refers to poor water quality or a disturbed watershed function.

ditch memory - subsurface water flow along a former drainage ditch after road removal is completed. This often occurs when ditches have not been ripped. Also see memory.

ditch relief culvert - see road cross drain

diversion potential - the potential for water to divert down a roadway if a stream crossing becomes plugged. Stream crossings with diversion potential have a high likelihood of contributing massive volumes of sediment to streams if the diversion causes gullies or landslides. Diversion potential is reduced by construction of a fail-safe crossing (critical dip with rock armor) or by complete stream crossing removal.

drain lens - buried angular rock wrapped in filter fabric used to drain subsurface water from springs or seeps.

duff - partially decayed organic material composed of needles, leaves, and twigs on the forest floor .

endhauling - the transportation of excavated material to a stable storage location using a dump truck.

energy dissipater - material such as rock riprap or a structure made of logs, metal pipe, or poured concrete that is used to reduce the energy of flowing water below culvert outlets or dips

embankment - fill excavated from the cutbench and used to construct the outboard road bench. This is often referred to as the fill slope or outboard fill material.

erosion control - activities that prevent soil from being detached and moved down slope including, but not limited to, road removal, revegetation, mulching with brush, out sloping, and compaction of unstable fill.

erosion prevention - cost-effective techniques used to prevent erosion before it happens.

fail safe crossing - a stream crossing that has been constructed in a way that has no potential for diversion. The ultimate fail safe crossing would include an oversized culvert, road approaches that slope upward in both directions, a critical dip that drains back into the stream, energy dissipaters, brush rack, and a headwall.

fall line - an imaginary line on a sloped surface that follows the steepest angle. You can think of the fall-line as the line that would be made by a ball rolling down the slope.

fill - material used to construct roads and related structures. Fill can include soil, rock, and large organic debris.

full recontouring - the treatment of a road that completely eliminates (obliterates) the road from the landscape. Full recontouring is accomplished by recovering all available fill and burying the cutbank until the surrounding terrain is fully matched. This type of treatment is also referred to as road removal or road obliteration. See obliteration.

geomorphology - the study of the earth's surface and the processes that shape it. Geomorphology is closely related to geology.

geomorphologist - a person who studies geomorphology.

grade - the natural, proposed, or planned ground surface. Usually grade is set to match the surrounding topography.

graded stream - a stream that, over a long period of time can move as much sediment as is supplied to it. Compare to "aggrade" and "degrade."

gradient - the measurement of the angle along the length of a road or a stream. This term is often confused with grade (see grade).

gully - a steeply sided channel caused by concentrated surface runoff erosion. Gullies can usually be identified by their location away from natural stream valleys.

Humboldt crossing - a stream crossing constructed with logs set parallel to the stream channel and covered with fill.

hydrology - the science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rock, and in the atmosphere. This term is often confused with hydrogeology, which is the science of groundwater.

inboard - refers to the upslope side of a road, trail or other feature.

inboard ditch - a drainage ditch cut along the inboard side of the roadbed to intercept drainage from the slope above or small streams. Inboard ditches usually direct their water through a culvert that crosses under the road.

large woody debris (LWD) – also known as large organic debris (LOD), refers to logs and stumps found in stream channels, road fills, etc., having a diameter greater than 12 inches and a length greater than 6 feet.

legacy road - a road originally constructed for another purpose that remains in use. Many of today's park roads were originally constructed as logging roads but now serve as backcountry access roads.

mass wasting - a general term that includes many types of massive, gravity-driven earth movements. These include rock slides, debris slides, debris flows, and earthflows, etc.

meander - a series of gentle curves in a stream, road, or trail.

memory - a subsurface zone where water will preferentially flow due the presence of a gully or inboard ditch buried in recontoured fill. Also see ditch memory.

mulch – the accumulation of organic topsoil, leaves, twigs, duff, brush, and trees that is created during the brushing efforts and that will be placed upon the finished slopes to minimize erosion and promote revegetation.

natural boundary feature – any landscape or vegetative elements that existed prior to road construction that are uncovered during the remediation effort which can be used as a guide to restoring the landscape to a pre-disturbance condition. Examples of these features include stream gravels, “A” horizon soil layers, or buried tree stumps.

obliteration - to completely remove the road feature from the landscape. This is accomplished by full recontouring. See full recontouring.

outboard - refers to the downslope side of a road, trail or other feature.

operator - the person operating heavy equipment or other machines.

outsloping - the treatment of a road to eliminate diversion potential along the roadbed during road reengineering. Outsloping includes excavation of some of the road fill along the outboard edge of the road and placing it against the cutbank to eliminate the inboard ditch and provide drainage toward the outside of the road. Outsloped roads are commonly graded and covered with compacted road base to harden the surface.

partial recontouring - similar to outsloping, this term is reserved for roads that are to be removed or decommissioned. The partial recontour often has a steeper cross slope on the former roadbed to ensure proper drainage. Partially recontoured roads are not matched at the top of the cutbank like fully recontoured roads.

permeability - a measure of the rate at which water can pass through soil.

Project Inspector (PI) – a State of California certified engineering geologist (or his/her designee) authorized by the Department of Parks and Recreation to manage and inspect the remediation construction activities on a full-time basis.

rill - a small erosional feature similar to a gully in morphology but less than 1 square foot in cross-sectional area. Rills often form on soft bare soil or road surfaces. Compare with gully.

ripping - decompaction of the soil by means of rippers mounted on the rear of a dozer.

roadbed - the surface of the road where driving takes place. The roadbed extends from the inboard ditch or cutbank to the outboard slope break or berm.

road cross drain - a drainage structure which utilizes a culvert to direct water from an inside ditch to an area beyond the outer edge of the road fill.

roadway - the corridor including the cutbank, the inboard ditch, the roadbed, and the embankment.

rolling dip – a shallow dip designed to convey water off of the road surface while allowing vehicles to pass at reduced speed. Rolling dips shall be located where stable landscape features exist that can carry runoff without causing erosion.

runoff - rainwater flowing on the surface of the ground. Runoff can be generated by rain falling on saturated ground or from heavy rain that cannot soak in fast enough.

scarify (scarification) –removal of organic soil material and the subsequent mechanical decompaction, or breaking up, of the substrate (see also ripping).

sediment - silt, sand, clay, and gravel that is moved by water and deposited at some location.

sediment control - activities that filter dirt out of water, including silt fence and sediment retention basins.

slope angle - the angle of the hill slope measured in degrees along the fall line.

soil - clay, silt, sand, organic material, air, water, and weathered rock mixed in various proportions. Soil consists of horizons or layers that display different amounts of weathering and fertility.

spoils – soil and organic material that is excavated from stream crossings or road embankments that is used for recontouring or can be end-hauled to a stable storage location.

stream crossing - a constructed road section across a natural stream. There are many types of crossings such as bridges, culverts, Humboldt (see definition), and fill crossings.

surfacing – rock aggregate or paving that is placed on the road surface to reduce erosion and weather-proof a road for winter use.

through-cut – a portion of a road that has cutbanks on both sides with drainage flowing down the road or inside ditch.

topography - the shape and relief of the earth's surface.

topsoil - the uppermost layer of decayed organic matter, seeds, soil, and microorganisms.

trash rack – a structure located upstream of a culvert inlet designed to trap floating debris to prevent the culvert from becoming plugged.

watercourse crossing – synonymous with stream crossing

SECTION 3: PROJECT LAYOUT, PROFESSIONAL RESPONSIBILITIES & SCHEDULE

3.01 Reference Points

Reference points (RP) are located at select points within the project area and are shown on the Plan Sheets. Reference points are typically half-inch diameter rebar stakes that are highlighted with fluorescent orange flagging. The stakes are approximately 3 feet long and are typically embedded 2.5 feet into the ground. These reference points were established as the end points of a fiberglass measuring tape that was used in the initial mapping and characterization of the road alignment. Consequently, each stake corresponds to “straight-line distance from the previous stake. Each RP is identified with a number that is the slope-distance (in feet) that particular stake is away from a designated “starting” stake. The Reference points are used for detailed surveys and are necessary for construction staking. **Therefore, these reference points must not be disturbed without approval of the PI.**

3.02 Stations

All work is laid out using the Reference Points and the engineering "station" method. A station is a 100-foot interval, measured along the centerline of the traveled roadway or a specified project area. A station stake with flagging (or wire flag) is installed on the cutslopes along the road every 100 feet starting at the beginning of the road and labeled with its station number. For example, the point on the road that is 600 feet from the beginning has a stake on the inside edge of the road labeled "6+00". Locations between station stakes are identified such as "6+34". This is found 34 feet up station of the 6+00 stake or 634 feet from the beginning of the road. "Up station" means in the direction of the higher station numbers; "down station" means in the direction of lower station numbers.

3.03 Limits of Grading

Limits of Grading are established for each remediation project and define the maximum area anticipated to be impacted by the proposed grading. These areas are depicted on the Plan Sheets and are delineated for compliance with various environmental regulations and requirements. **The Limits of Grading do not represent areas of unrestrained access for earthmoving equipment and support vehicles**. More specifically, any necessary staging areas, parking areas, or equipment access ramps required for the remediation work are to be contained within the Limits of Grading and each such area shall be approved in writing on the Plan Sheets by the PI and DPR. The Limits of Grading are marked by single stakes with fluorescent pink flagging or wire flags.

3.04 Parking Areas, Heavy Equipment Staging Areas, and Access Ramps

Parking areas for two-wheel drive vehicles as well as staging areas and access ramps (or short roads) for heavy equipment shall be located within the Limits of Grading for each project area. Each such area shall be approved in writing on the Plan Sheets by the PI and DPR, and will be flagged on the jobsite by the PI.

3.05 Photo Point Locations

Photo points are locations that have been used to photo-document the restoration site. They are identified by stakes with yellow flagging, and are located out of the way of any anticipated equipment work. They must not be disturbed.

3.06 Plan Sheets

Plan Sheets list and detail the tasks specified in specific contracts. Technical information and specifications for the work at each work site are specified in the Plan Sheets with written explanations. **The Plan Sheets shall take precedence over the Standard Specifications described herein.** The work specified at a particular station is printed in abbreviated form. Estimated volumes, road dimensions, culvert diameters and lengths, fillsite locations, and special instructions are also listed as they apply.

3.07 Responsibilities of the Project Inspector

An engineering geologist certified by the State of California (or his/her designee) shall be designated by DPR as the Project Inspector and authorized to provide full-time construction inspection for the length of the project. The Project Inspector works closely with the equipment operator to maintain a professional work environment and to maximize the quality and quantity of work accomplished. The inspector shall have five primary responsibilities.

a. The inspector is responsible for making sure all reference marks, grade stakes, photo point locations, station markers, watercourses, culverts, and project boundaries are accurately flagged prior to the commencement of construction activities. Additionally, the inspector explains the proposed design to the heavy equipment operators and makes on-site design modifications as the project proceeds. The inspector oversees the day-to-day heavy equipment operations and assists the operators in understanding the design specifications. This requires maintaining frequent and professional dialogue with the operator. However, the inspector shall refrain from telling equipment operators how to conduct the excavation and grading. Instead, the inspector shall remain focused on the design of the finished product.

b. The inspector is responsible for protecting the natural, cultural, and capital resources of the property owner, whether it be public or private land. The inspector shall exercise the authority given to him/her by the property owner and permitting agencies to halt operations if equipment work poses a threat to any resources outside the work area.

c. The inspector keeps detailed records of the project's progress. This includes equipment operating time, operator's time on the job, time spent on individual tasks such as brushing or recontouring, and other topics of interest. On some jobs, inspectors shall keep track of equipment production for many different phases of the project to better analyze the overall job effectiveness. The inspector shall document work efforts such as bucket loads of soil moved per hour, time spent positioning equipment, and equipment efficiency.

d. The inspector is responsible for preparing an "as-built" report that describes each phase of the construction phase and includes appropriate tables, maps, and figures.

e. The inspector is responsible for maintaining clear and professional communication with the equipment operator(s) throughout the length of the project.

3.08 Responsibilities of the Heavy Equipment Operator

An operator's main job is to work to reconstruct the desired landscape according to the design specifications. Based on the specifications, the operator shall develop the most efficient procedure for accomplishing the prescribed work. The operator shall have four primary responsibilities:

a. The operator is responsible for all safety related to the operation of the equipment in the difficult terrain and must take all precautions to avoid accidents. Road removal jobs are often complex, difficult, and can be extremely hazardous. The operator shall communicate with other onsite personnel about blind spots and/or the limitations of the equipment in particular situations or locations.

b. The equipment operator is responsible for determining the safest and most efficient use of equipment. It is the operator's responsibility to decide the best way to maneuver and position equipment in difficult terrain. This includes the order in which work is done and any intermediate steps that may be required to complete the project work. Operators shall consult with the inspector on strategies that increases the efficiency of the work.

c. The equipment operator shall document the number of hours worked on each project. The hour meter in the machine can be used and it shall be double-checked using a watch. Each day the operator shall confer and concur with the inspector as to the number of hours worked. The operator and the inspector shall each keep a notebook to record time worked. Depending on the contract specifications, some projects pay by the operator time, some pay by equipment time, some pay by the volume of soil moved, and some pay by a total cost estimate. Equipment time contracts require the most careful record-keeping because time for breakdowns, fueling, and maintenance is not paid. In some cases, the number of hours of equipment time can be different from the number of hours the operator works each day.

d. The equipment operator is responsible for maintaining clear and professional communication with the inspector throughout the length of the project.

3.09 Heavy Equipment Selection

Equipment selection is an essential component of remediation work because the choice of equipment affects the cost of the earthmoving. Most projects require that an excavator and bulldozer work together. The excavator primarily handles brush and retrieves fill from hard-to-reach locations. The dozer moves material along the road, shapes, and compacts. In some situations where roads are especially narrow and on very steep sideslopes, a dozer may not be usable. In other situations, two excavators may be required to keep up with a dozer that can operate at peak efficiency. In general, the largest machine that will safely fit on a road or project site while not limiting maneuverability shall be used. Limitations on the size of the machine depend primarily on the road width and the proximity to “save” trees or other valuable resources.

How the equipment is configured is also important. For dozers pushing long distances, a U-blade or semi-U blade works best. For fine shaping work or road-to-trail conversions, a 6-way blade is most efficient. Sometimes a dozer needs to be equipped with rippers, and other times it needs a winch. Excavators are usually fitted with short booms and sticks to increase lifting power and allow for more reliable rotation when working on steep slopes. A thumb on the excavator bucket is essential for picking up logs or moving boulders. All equipment shall be fitted with rollover protection structure (ROPS), and brush guards before commencing work in difficult forested terrain.

3.10 Hours of Work

The PI must be present during all equipment operations involving excavation or placement of fill. Hours of work shall be determined by the Construction Schedule. Heavy equipment work is only permitted between sunrise and sunset. In addition, noise restriction periods apply to areas located within ¼ mile of suitable nesting habitat for the marbeled murrelet during its breeding season (March 24 - September 15). In these areas, hours of work may be dictated by Threatened and Endangered Species restrictions: two hours following sunrise to two hours prior to sunset. Heavy equipment work outside of the days and hours specified in the construction schedule may be performed only with prior consent of the PI, with notification at least 48 hours in advance. Sound judgment shall be exercised in the case of bona fide emergencies, or where resource damage may result if work does not continue.

SECTION 4: GENERAL TREATMENT SPECIFICATIONS

4.01 Design and Finish Grades

Treatments are designed with TENTATIVE grades that provide the basis for estimates of volumes to be excavated. As the work progresses, final grades are determined by the PI who monitors the excavation. While monitoring the excavations, the PI may instruct the contractor to adjust the excavation's grade and alignment to preserve natural boundary conditions which may include: original topsoil, natural channel armor, bedrock outcrops, or stumps in the growth position. Any stumps in the growth position encountered during excavation shall be left in place unless removal is authorized by the PI. Snags or live trees greater than 2 feet in diameter shall not be damaged or undercut (root ball exposed) during excavation without the PI's approval. It is extremely important not to remove or disturb the natural boundary features because they are guides to the pre-disturbance landscape configuration. The limits to excavations are marked in the field, and cannot be exceeded without advanced approval from the PI. **The PI must be present during ALL excavations and placement of fill**.

4.02 Definition of Fill

"Fill" is defined as all materials (organic and inorganic) excavated or removed. The price (Lump Sum or per cubic yard Unit Price) for all treatments shall include the excavation of fill, transport of fill to the disposal site, shaping of fill, removal and spreading of organic material, removal and disposal of culverts or other debris (where applicable), and any other costs associated with excavating the fill.

4.03 Fillsites for Road Recontouring

Fillsites are typically defined by the remaining road bench (following fill excavation) and the adjacent cut bank height. It is the contractor's responsibility to meet the intent of landform restoration by allocating the appropriate quantities of excavated fill to the various fillsites listed in the plan sheets. Fill material shall be shaped to re-create or mimic the pre-road construction landforms (ridges, swales, etc.).

Fill shall be placed onto a road, landing, or skid trail against the existing cutslopes, and these surfaces shall be adequately scarified prior to the placement of the fill. Fill shall be placed and compacted against cutslopes in such a manner that shall prevent concentration, containment, or diversion of surface runoff, and the fill shall not exceed existing cutslope height. Fill material shall be placed in 6-inch lifts and compacted with the tractor. Fill material shall be placed and compacted such that surface runoff cannot enter the seam between the cutslope and the emplaced fill. The finished grade shall be a free draining surface. All berms, tracks, ruts, and other surface irregularities shall be smoothed. Fillsites shall not trap or pond surface water, and must create free draining surface flow. Brush, trees and other organic debris (including but not limited to logs and rootwads) encountered or removed during excavation and clearing of fillsite areas are to be distributed over the finished surface in accordance with the post-excavation erosion control guidelines.

The fillsite volumes referred to in the plan sheets were estimated from ground. Natural conditions may cause actual fillsite volumes to vary from designed volumes. Fillsite volumes may change due to variations in excavation volumes of adjacent bid items because of changes in grades that are made as excavations proceed. **The PI must be present during all excavations and placement of fill**.

Fillsites are an integral part of any bid item that requires excavation. Some fillsites may be used to store fill from several different bid items. No bid item shall be considered finished (for payment purposes) until all fill is excavated, placed in a suitable fillsite, and shaped to fillsite specifications. All fillsites down-station of excavation work shall be filled to capacity before access to them is cut off, unless otherwise authorized by the PI.

4.04 Standing Trees and Stumps

Standing trees, snags and stumps greater than 2 feet in diameter at breast height that are in the growth position shall not be damaged or undercut (excavated below the original ground surface) unless authorized by PI. This includes stumps that may be uncovered during all types of excavations. The Contractor shall confine contract operations to within the areas designated by the plan sheets. The Contractor shall not remove, deface, injure, or destroy trees, shrubs, or other natural features or any improvements outside of the work area unless specifically authorized by the PI. If trees are removed, the boles can be re-planted along the margins of the grading project.

4.05 Cross-Road Drain (XRD)

A cross-road drain is a deeply cut ditch, excavated across a road surface, which drains the road bed and inboard ditch to the outboard edge of the road. Cross road drains are more substantial and deeper than conventional waterbars and are steeper and more abrupt than rolling dips. Properly constructed XRDs shall be deep enough to prevent vehicular access. Cross road drains are not a restoration treatment but are typically a winterizing treatment to reduce erosion on untreated segments of roads.

Each XRD shall be free draining for its entire length and shall have a uniform grade. The depth of the XRD at its inlet shall coincide with the depth of the existing inboard ditch; the depth at the outboard edge of the road (OBR) shall be deep enough to allow free draining of the XRD. On roads with a grade, each XRD shall be constructed diagonally across the road and the slope of the XRD (from inboard ditch to outboard energy dissipater) shall be a minimum 2 percent steeper than the road grade. This will help prevent sediment from building up in the XRD. On level roads and at low spots, the drains may be constructed perpendicular to the road.

Spoil from the ditch excavation shall be placed and smoothed on the downhill side of the XRD. The road surface on the uphill side of the XRD also shall be smooth and free draining into the XRD. Unless otherwise stated, work must not disturb or alter the existing inboard ditches, which shall be left free draining to each XRD. Generally, the inboard ditch on the downhill side of the trench shall be plugged with excavated material to prevent bypassing flow. On level roads, or where the XRD is at a low spot in the road, the inboard ditches on both sides of the XRD shall remain open, so that runoff can enter the XRD from either direction. Energy dissipaters (item 4.08 below) shall be constructed at the outlet of all XRD's unless directed otherwise by the PI.

4.06 Rolling Dip

A rolling dip (RD) is a shallow, rounded dip in the road where road grade reverses for a short distance and surface runoff is directed through the dip to the outboard edge of the road. Rolling dips are drainage facilities constructed to remain effective while allowing the passage of motor vehicles at reduced road speeds. Rolling dips are usually constructed at stream crossings or swales, although they can also be constructed on road reaches. Rolling dips convey water from the inboard ditch and culvert inlet area, across and off of the road surface, and back into the natural watershed in the event the culvert or other drainage structure fails. Rolling dips are used to prevent stream diversions or to disperse road runoff on roads that are to remain drivable.

Each RD shall be free draining for its entire length and shall have a uniform grade. The depth of the RD shall coincide with the depth of the existing inboard ditch at its inlet, and deep enough on the outboard side to be free draining. On roads with a grade, each RD should be constructed diagonally across the road. On level roads and at low spots, the dips may be constructed perpendicular to the road. The "outslope" of the RD should be steeper than the original road grade if possible, so that the water drains efficiently across the road. This will help prevent sediment from building up in the dip.

Spoil from this excavation shall be placed and smoothed on the downhill side of the RD. The road surface on the uphill side of the RD shall be smooth and free draining into the RD. Unless otherwise stated, work must not disturb or alter the existing inboard ditches, which shall be left free draining to each RD. Generally, the inboard ditch on the downhill side of the RD shall be plugged with excavated material to prevent bypassing flow. On level roads, or where the RD is at a low spot in the road, the inboard ditches on both sides of the RD should remain open, so that runoff can enter the RD from either direction.

A "rocked" rolling dip is a rolling dip that has been surfaced with coarse angular rock layer at least 4 inches thick. The rock shall be sufficiently large to resist transport by concentrated runoff or streamflow. Energy dissipaters (item 4.08 below) shall be constructed at the outlet of all RD's unless directed otherwise by the PI.

4.07 Erosion Control Blanket

Erosion control blankets (ECBs) are constructed from a variety of degradable organic or synthetic fibers (e.g., straw or coconut) that are structurally bound within nettings or meshes (Gray and Sotir, 1996). ECBs are manufactured in many different weights and strengths for a variety of applications, and the design life of the various blankets ranges from one season to "permanent". The blankets must be anchored at the top of the slope in a shallow trench and then stapled in intimate contact with the ground surface. For the proposed work at Big River, ECBs shall be of a type and strength equivalent to that of the SC 150 ECB manufactured by North American Green. These blankets have a design life of 2 years are designed for graded slopes up to 1:1 (horizontal:vertical), and can be certified "phyto-sanitary" meaning that the blankets have been fumigated and contain no fertile seeds of weeds and/or exotic plants. The ECBs are to installed, anchored, and stapled exactly as per the manufactures design specifications.

4.08 Energy Dissipater

Energy dissipaters are constructed at the outlets of culverts, cross-drains, or other water conveyance structures to reduce the energy of flowing water. For the proposed work at Big River, these structures shall be rip-rap aprons composed of two layers of angular, ringing-hard (when hit with a hammer) rock, embedded a minimum of 1 foot into the ground and separated from the soil with a non-woven type filter fabric (e.g., Mirafi 140N or equivalent). The rip-rap apron shall be a minimum of 6 feet long and 6 feet wide.

SECTION 5: CONSTRUCTION SPECIFICATIONS

5.01 Brushing

a. The excavator and dozer shall prepare the site by first removing all small (less than 1 foot diameter at breast height) trees and brush growing on the cutslope, roadbed, and embankment fillslope within the limits of the project area. Larger trees may also have to be removed while other trees growing in undisturbed soil that were partially buried by road embankment fill may be left standing. Large and/or old tree removal shall be conducted only under the explicit authority and observation of the PI. The organic material (i.e., mulch) accumulated during the brushing activities shall be stockpiled on the top of the cutslope or below the embankment fill. Mulch may be stockpiled in piles but shall be left accessible to the excavator when earthmoving tasks are complete (i.e., space the mulch piles evenly along the road so that the excavator does not have to walk too far to retrieve and spread the mulch). An excavator mounted vegetation masticator may be used to remove trees and brush. Tree boles shall be left a minimum of 24" high for later extraction with the excavator or dozer. If a masticator is used, a dozer may be employed to accumulate and pile ground mulch for use on finished surfaces.

   Alternatively, DPR's Senior Resource Ecologist may determine that the organic material accumulated during the brushing activities is contaminated with invasive plants like jubata grass and therefore unsuitable for mulch. Consequently, such material shall be disposed of offsite as per the directions of DPR's Senior Resource Ecologist.

b. After removing trees and brush, organic material such as leaves, twigs, and duff shall be removed from the inboard ditch, cutslope, and embankment. The material shall be stockpiled out of the way as mulch for later use. Organic materials are removed because once rotted they provide small conduits that runoff will follow and also form planes of weakness that can promote sliding of the overlying earth materials. If enough small conduits exist behind or under recontoured fills, they can lead to saturation and failure. Another benefit of saving organic material is that it is rich with seeds and nutrients. It can be used as mulch on the finished surface to promote rapid revegetation of work sites.

5.02 Ripping

a. After removing trees, brush, and organic material, a dozer equipped with rippers or an excavator shall decompact the inboard ditch and the cutbench portion of the road to a minimum depth of 12 inches. The cutslope shall be stripped of all organic accumulations using the dozer or the excavator or a combination of the two. Small, dispersed organic material shall be mixed and incorporated into the fill material and used to recontour the cutbench. Larger accumulations of organic debris shall be gathered by the excavator or dozer and stockpiled with trees and brush removed from the roadway.

b. Ripping the inboard ditch reduces ditch “memory” by decompacting the bottom of the ditch and mixing rocks along the bottom of the ditch with soil. Ripping breaks up the hard compacted surface that was caused by traffic on the old road surface allowing the recontoured fill to bond with subsurface furrows created by the rippers. Some sites that do not have significant compaction or are insloped may not need to be ripped. If the dozer does not have rippers the excavator can decompact the surface by breaking it up with the teeth of the bucket. It is usually sufficient to decompact to a depth of about one foot.

c. Where large inboard ditches or gullies have developed, operators shall cut cross-drains from the ditch to the outboard edge of the road. The cross-drains shall be cut to the depth equal or deeper than the ditch and shall drop toward the outboard at a downslope angle across the road. The cross drains shall only be placed where they can be drained into natural depressions. After the cross-drains are cut they are buried with recontoured fill to provide subsurface relief of ditch memory flow.

d. Ripping shall thoroughly decompact the road, landing surface or inboard ditch. When specified in the plan sheets, surfaces that are to receive fill shall be ripped as indicated prior to the placement of fill. Any method of decompacting is acceptable, as long as the required areas are thoroughly decompacted to a depth of 24 inches. If using ripper teeth, a sufficient number of passes shall be made to attain a maximum spacing of 18 inches between adjacent ripper shank paths.

e. Once a surface has been ripped it shall remain decompacted. If for any reason a ripped surface is re-compacted, such as by repeated heavy equipment or vehicle use, the surface shall be decompacted again before fill is placed, or equipment is removed from the area.

5.03 Rough Grading for Road Narrowing (a usable road will remain)

a. All fillslope excavations are to be accomplished from the roadbed using the excavator. In excavating fill material from around buried trees (that are to be saved), care shall be taken to prevent damage to the roots. Most excavated material shall be placed in dump trucks and hauled offsite for disposal. Some fill material may be used in constructing berms on the overgrown skid trail.

5.04 Roadway Outsloping

a. An Outslope treatment can either remove the entire road bench width or only the outboard portion of the bench, leaving an inboard bench. In both cases some or all of the excavated earth material cannot remain local and must be exported to a stable fillsite. Any fill that will remain locally on the bench must be shaped according to Fillsite instructions and specifications (Item 4.03). In the situation where a bench is to remain on the inboard side of the road, the bench shall be a free draining surface (minimum of 5% grade) and shall be cut to make it so, unless stated otherwise in the plan sheets.

5.05 Rough Grading for Full and Partial Recontouring

a. The dozer shall excavate the fillslope and push the excavated material into the cutslope in maximum 6-inch lifts. The dozer continues to push material against the cutslope compacting it in lifts until the material reaches the prescribed height, or no more fill is available locally. As the dozer cuts embankment fill it leaves a berm on the outside (downslope) edge to prevent material from being sidecast downslope.

b. The excavator follows the dozer removing the berm and what remains of the embankment fill further downslope. The excavated material is placed in lifts and compacted with the excavator bucket. The material at the bottom of the embankment fill is retrieved and placed last on the recontoured surface, as it contains the most organic material and provides nutrients and seeds to the newly recontoured surface. The excavator spreads the remaining fill evenly over the finished surface and blends the inboard edge of the fill against the cutslope being sure to eliminate any holes or depressions at the cutslope-fill interface.

c. Where slopes permit, the final surface is smoothed by back-dragging with the dozer blade, or by sliding the back of the excavator bucket back and fourth across the recontoured slope. Excavator buckets equipped with a blade attachment may also be used to smooth the recontoured slope. Trees and brush removed prior to excavation are raked across the surface with the excavator to remove the equipment tracks, then spread evenly over the surface as mulch. At some locations, mulch material may be saved and redistributed at stream crossings where more complete mulch coverage may be necessary to reduce surface erosion.

d. Cutslopes exposing seeps or springs, or those along the axes of topographic swales, shall not be recontoured. Instead, the embankment fill adjacent to the wet area shall be exported to nearby dry section of the road. An outsloped cutbench shall extend along all wet road sections.

e. As with full road recontouring, road through-cuts shall only be treated if the available fill can achieve a full match eliminating the possibility of runoff concentrating in the through-cut. In most cases a crown of soil approximately 5% of the total through-cut depth is left over the finished recontour to ensure runoff does not reoccupy the through-cut. As with road bench fill, through-cut fill shall be well compacted by the dozer depositing the material in maximum 6-inch lifts. Through-cuts that are steeply inclined on the slope shall be drained of subsurface flow using subsurface ditch relief drains. These drains are cut into the outboard berm and daylight on the adjacent slopes. The ditches are backfilled and provide a porous conduit for concentrated subsurface flow. In some cases where through-cuts are steeply inclined, recontouring may not be recommended due to a high probability of post-treatment failure.

f. Where gullies or other diversions have incised across crossing sites, reestablishment of the crossing grade shall be deeper than the intersecting diversion channel. This will eliminate the possibility of reoccupation of the treated feature by flow in the restored channel.

g. If a long section of road is not suitable for partial recontouring, the excavator removes the embankment fill and loads it into a dump truck to be end-hauled to more stable road reaches. The excavator and dozer recover the entire embankment fill and outslope the cutbench of the road. On steep linear grades broad swales are constructed along the road at appropriate locations to convey flow into natural drainage features below the road.

h. Usually dozer pushes in excess of 300 feet require exportation with dump trucks. Whenever possible and under the direction of the PI, exported fill shall be distributed widely across nearby, stable road reaches rather than surcharging one specific area. When space is limited along nearby stable road reaches, other roads in the project area may be identified by DPR to store fill. Roads with gentle and stable sideslopes or throughcuts with low gradients shall be used to deposit exported material. Sites with springs or other adverse hydrologic conditions shall not be used to store exported fill. Exported fill shall not be deposited in natural stream channels or wetland areas. As exported fill is deposited, the material shall be spread and compacted in 6-inch lifts by the dozer. Exported fill shall be deposited as close to the source area as possible to reduce the potential for spread of exotic plants and soil-borne plant pathogens. Mulch stockpiled adjacent to fill sites shall be spread evenly over the surface.

i. As with full road recontouring, cutslopes immediately adjacent to stream crossings are not typically fully recontoured. Instead, the fill is tapered toward the crossing and the cutslope is left exposed. This reduces the slope on each side of the crossing reducing the chance for direct sediment delivery if a post-treatment slope failure occurs.

5.06 Rough Grading for Watercourse Crossing Removal

a. The excavator shall prepare the site by first removing all trees and brush growing on the cutslope, roadbed, and embankment fillslope of the adjacent road sections. Trees and brush growing on the crossing fill are also removed. Mulch shall be stockpiled on the top of the adjacent road cutslopes or elsewhere in the crossing excavation area. Mulch may be stockpiled in piles but shall be left accessible to the excavator when earthmoving tasks are complete. Trees growing in undisturbed soil that were partially buried by fill may be left standing, however all fill shall be excavated away from around the base. Care should be taken not to damage roots. An excavator mounted vegetation masticator may be used to remove trees and brush. Tree boles shall be left a minimum of 24” high for later extraction with the excavator or dozer. If a masticator is used, a dozer may be employed to accumulate and pile ground mulch for use on finished surfaces.

b. If the stream is flowing, water shall be diverted away from the excavation area(s) to minimize turbidity. Where channel widths are sufficiently wide enough, a berm shall be constructed to divert water away from the work area. Where channels are narrow, a small diversion dam (or collection basin) shall be constructed upstream of the project work area. Water from the basin shall then be piped around the worksite in an appropriately sized pipe and discharged into the stream below the worksite. If streamflow is subsurface and cannot be captured and diverted, a filter fabric silt dam shall be constructed immediately downstream of the construction footprint.

c. At failed crossings, a small road bench is reconstructed along the upstream end of the crossing to allow access to both sides of the crossing. A minimal amount of fill is used and streamflow (if present) is piped around the site or a culvert is installed to convey streamflow under the temporary road.

d. Following clearing and access operations, a dozer equipped with rippers shall decompact the inboard ditch and the cutbench portion of the adjacent road sections to a minimum depth of 12 inches. The cutslope shall be stripped of all organic accumulations using the dozer or the excavator or a combination of the two. Small, dispersed organic material shall be mixed and incorporated into the fill material and used to recontour the cutbench. Larger accumulations of organic debris shall be gathered by the excavator and stockpiled with trees and brush removed from the crossing and adjacent roadway.

e. The dozer begins the crossing fill excavation at the center of the roadway. If stable disposal areas near (within 300 feet) the work site have been designated by DPR, the dozer can push the excavated materials to those areas and place the fill in maximum 6-inch lifts. The dozer shall push the excavated material to the most distant sections of disposal area first to avoid becoming overwhelmed by large accumulations of excavated fill at the crossing site. The dozer continues to push material out of the crossing compacting it in lifts until the recontoured material becomes 1) too steep on which to operate, 2) the dozer reaches the local Ordinary High Water elevation, or 3) no more fill is available in the crossing. During the excavation, a berm shall be constructed on the downstream perimeter to prevent excavated material from being sidecast downslope toward the stream.

f. As the dozer begins the crossing excavation, the excavator positions itself at the outboard edge of the crossing and begins excavating the fillslope placing the excavated material where the bulldozer can push it to the storage area. In those situations where there is no nearby disposal site, the excavator will be used to load the excavated material into dump trucks. In crossing excavations where stream flow is present, the excavator always works from downstream extent of excavation to the upstream extent to prevent pooling and uncontrolled release of water and sediment in the event of a failure of the bypass piping.

g. Dozer pushes in excess of 300 feet require exportation with dump trucks. In those cases, the excavated material shall be loaded directly into a dump truck and end-hauled off site to stable road segments (as approved by DPR and the PI) near the crossing excavation. Whenever possible exported fill shall be distributed along nearby stable road reaches under the direction of the PI. In no instance will surplus material be allowed to surcharge one specific area. When space is limited along nearby stable road reaches, other roads in the project area may be identified by the PI and approved by DPR to store the excavated material. Roads with gentle and stable sideslopes or through-cuts with low gradients are suitable as storage sites for the exported material. Sites with springs or other adverse hydrologic conditions shall not be used to store exported fill. Exported fill shall not be deposited in natural stream channels or wetland areas. As exported fill is deposited, the material shall be spread and compacted in 6-inch lifts by the dozer. Exported fill shall be deposited as close to the source area as possible to reduce the potential for spread of exotic plants and soil borne plant pathogens. Mulch stockpiled adjacent to fill sites shall be spread evenly over the surface.

h. The dozer and excavator continue to work in tandem until all crossing fill within the stream channel and on the adjacent slopes has been removed. Particular attention shall be paid to recognizing and exhuming the native slopes and stream channel under the direction of the PI. In addition to the crossing fill, any material deposited in an upstream colluvial/alluvial wedge is removed. The excavation should be designed to match the slopes and banks upstream and downstream from the crossing. In cases where the failed crossing includes a large steep-sided gully or has incised below pre-disturbance stream grade, it may be necessary to leave the channel configuration in its unnatural condition. Such determinations will be made on site by the PI.

i. The excavator makes final adjustments to the excavated stream crossing. The final surface is smoothed by back dragging with the dozer or the back of the excavator bucket. Excavator buckets equipped with a blade attachment may also be used to smooth the recontoured slope.

j. Trees and brush removed prior to excavation are then spread over the surface of the side slopes as mulch. Mulch shall be preferentially applied to stream crossing sites to reduce the delivery of sediment from surface erosion on crossing sideslopes. Within 100 feet of stream crossing excavations mulch shall be applied to sideslopes to provide 70% to 90% surface coverage. Between 100 feet and 250 feet mulch shall be applied to sideslopes to provide 50% to 70% surface coverage. Road approaches with less than a 50 foot natural buffer to stream channels shall be treated with mulch applied to provide 50% to 70% surface coverage. Where the quantity of mulch material is insufficient to meet these requirements, locally derived material will be imported to the crossing sites from nearby interfluvial road sections. Mulch applied at crossings should be pressed onto the ground surface wherever possible using either the excavator or the dozer.

k. Logs and rocks shall not be placed in the excavated channel because such structures promote lateral migration resulting in bank erosion and slope undercutting. Logs shall be placed along the channel margins or can span the channel. If instream structures are necessary for grade control or to stabilize the channel pattern, such structures will be designed by the PI prior to final grading and mulching.

l. Where stream crossing excavations extend upstream to disturbed portions of the natural channel and no apparent natural top of the crossing is obvious, the channel grade at the top of the excavation should be anchored to some grade control such as a rock outcrop, a large tree root, or large woody debris firmly embedded in the channel. In the absence of any hard-point, the upstream end of the crossing should be tapered to the unnatural channel grade as far upstream as is practical to minimize headcutting of the stream as it adjusts to the newly established local gradient.

m. Road sections immediately adjacent to stream crossings should not be fully recontoured. Instead, the fill is tapered toward the crossing and some cutslope is left exposed. This reduces the slope on each side of the crossing and reduces the chance for a post-treatment slope failure that will deliver sediment directly to the drainage network. In crossings with gentle sideslopes, cutslopes can be fully recontoured if post-treatment failure is not considered a significant hazard.

5.07 Finish Grading

a. The final earthmoving task is finish grading to eliminate berms or depressions on the fill that can collect runoff and cause gullying or failure. This is especially important where the recontoured fill meets the original slope above. As fill is placed against the cutslope, small berms and gaps often remain at the top of fill. These ridges or depressions collect slope runoff and concentrate runoff into the newly recontoured fills. Be sure that the interface between the natural slope and the recontoured fill is smooth and free of any ridges or depressions. This step is done with either the dozer back-blading the slopes or by the excavator using a straight log or wad of brush pinched in the bucket. Small windrows usually remain after this step but they are eliminated when the excavator spreads mulch on the finished surfaces. Finish grade must be approved by the DPTR before the mulch is placed. Removing mulch to change the shape of the recontoured fill is very time consuming and does not produce good results.

5.08 Mulching

a. Once the final shape has been achieved, the excavator shall place previously removed trees and brush on top of the recontoured fill. Woody material is spread evenly over the newly recontoured slope. Tamping woody material down onto the ground provides contact with the soil reducing sheet erosion. Large clumps of brush shall be pulled apart and spread whenever possible. In general, large tree trunks shall be laid perpendicular to the slope to break up surface runoff and catch fine sediment. Logs laying perpendicular to the slope shall be punched into the soil or keyed in behind something to keep them from rolling down the slope. In coastal climates, the use of straw mulch is not necessary and may actually slow down natural revegetation. In climates with a hot, dry season where natural revegetation is much slower and onsite organic material is limited, a weed free straw mulch will help retain soil moisture, promote seed germination and reduce surface erosion.

SECTION 6: REFERENCES

California Department of Transportation, 1999, Standard specifications: State of California Department of Transportation Publications Distribution Unit, Sacramento, California, 822 p.

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and B. Collins, 1998, California salmonid stream restoration manual, 3 ed., California Department of Fish and Game, Inland Fisheries Division, available at http://www.dfg.ca.gov/nafwb/manual.html., 497 pages.

Gray, D.H., and Sotir, R.B., 1996, Biotechnical and soil bioengineering slope stabilization; a practical guide for erosion control: John Wiley & Sons, Inc., New York, New York, 378 p.

Keller, G. and Sherar, J., 2003, Low-volume roads engineering, Best management practices field guide: US Agency for International Development, in cooperation with the USDA, Forest Service, International Programs & the Conservation Management Institute, Virginia Polytechnic Institute and State University, 158 p.

Merrill, B.R., and Casaday, E., 2001, Field techniques for forest and range road removal: unpublished agency report by California State Parks, 70 p.

Merrill, B.R., and Casaday, E., 2002, Best management practices for road rehabilitation, partial road recontouring: unpublished agency report by California State Parks, 19 p.

Merrill, B.R., and Casaday, E., 2002, Best management practices for road rehabilitation, road-stream crossing removal: unpublished agency report by California State Parks, 25 p.

Weaver, W.E., and Hagans, D.K., 1994, Handbook for forest and ranch roads; A guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads: U.S. Department of Agriculture, Mendocino County Resource Conservation District, 161 p.

APPENDIX A

Excerpted pages from the

California Salmonid Stream Habitat Restoration Manual (Flosi and others, 1998)

REFERENCE:
Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and B. Collins, 1998, California salmonid stream restoration manual, 3 ed., California Department of Fish and Game, Inland Fisheries Division, available at http://www.dfg.ca.gov/nafwb/manual.html., 497 pages.

Unanchored Large Woody Debris

Most instream habitat enhancement structures require some type of anchoring technique to ensure they will remain in place during high flow events and to prevent high flows from altering their configuration and intended function. However, in particular cases the addition of unanchored large woody material may be beneficially used to enhance some streams and stream reaches. In small streams, large woody debris (LWD) is often the structural agent in pool formation or a key element associated with the habitat quality of a pool. The effect LWD has on channel morphology is influenced by its size, orientation, spacing, and association with other structural elements as well as a number of other variables including stream-flow energy, sinuosity, substrate, bank composition, and channel width. First through third order streams are generally best suited for unanchored LWD placement projects. Where appropriate, the placement of unanchored LWD requires no maintenance and are free to adjust naturally to the stream's hydraulic regime.

In unanchored applications, logs selected for placement should have a minimum diameter of twelve inches and a minimum length 1.5 times the mean bankfull width of the stream channel type reach and the deployment site. A root wad should be selected with care and have a minimum root bole diameter of five feet and a minimum length of fifteen feet and at least half the channel type bankfull width. Regardless, a DFG Fish Habitat Specialist must be consulted prior to initiating these projects and obtaining necessary DFG permits.

INSTREAM HABITAT IMPROVEMENTS

There are three general categories of the most commonly used instream structures: 1) cover structures; 2) boulder structures; and 3) log structures. Often a single structure or combination of structures will provide for rearing, spawning, and cover. It is important that instream structures be monitored after high flows have occurred to determine if the desired habitat condition has been met (Part VIII, Project Monitoring and Evaluation). Often, maintenance or modification is needed to make the structure perform properly.

Cover Structures

Quality of a pool can be increased by adding cover structures. Amount of effective cover and the complexity of habitat is at least as important as the physical amount of pool created. Strategically placed cover can help keep pools scoured, while improperly placed cover will cause deposition of sediment.

A study on the effectiveness of placing tree bundles of fir, alder, maple, and myrtlewood was conducted on five different Oregon streams. Juvenile coho and steelhead populations were sampled in 16 pools before and after tree bundles were added. Before the tree bundles were added the pools sampled were holding 12 percent of their summer coho population during the winter. The following year, after tree bundles were added, these same pools contained 74 percent of their summer coho population during the winter sampling. The sampling showed an increase in steelhead populations between the summer and winter populations, the winter after tree bundles were added.

Riparian vegetation is a highly important source of cover. Overhanging vegetation or undercut banks, along with the associated roots, provide excellent, effective cover.

Logs, root wads, tree bundles, and boulders are the primary cover elements added to pools. Some guidelines concerning construction and installation of cover structures in a stream are:

- Cover should be incorporated with other stream enhancement structures such as log and boulder weirs, boulder clusters, and single and opposing wing-deflectors.

- Cover structures are often placed in pools, backwater areas, or along meanders to provide protection.

- Logs, tree bundles, or root wads can be cabled against the banks. Secure logs or root wads to a stump, a live tree, a bedrock outcropping, large boulders, or use a deadman. Cover can also be cabled to instream boulders using polyester resin adhesive.

- Cable all log and root wad cover structures tightly.

- Protect the upstream end of logs from direct flow of the stream.

Examples of cover structures are divide logs; digger logs; spider logs; and log, root wad and boulder combinations.

Divide Logs

Divide logs are installed mid-channel in spawning riffles to provide a visual barrier between adjacent spawning areas. This can increase spawner use of a riffle area and provide escape cover (Figure VII-17).

Divide logs require suitable substrate for anchoring. Such substrate consists of boulders or bedrock. Length and diameter of the log used will be dictated by length of the spawning channel and depth of flow. In general, divide logs should be 18 to 36 inches in diameter.

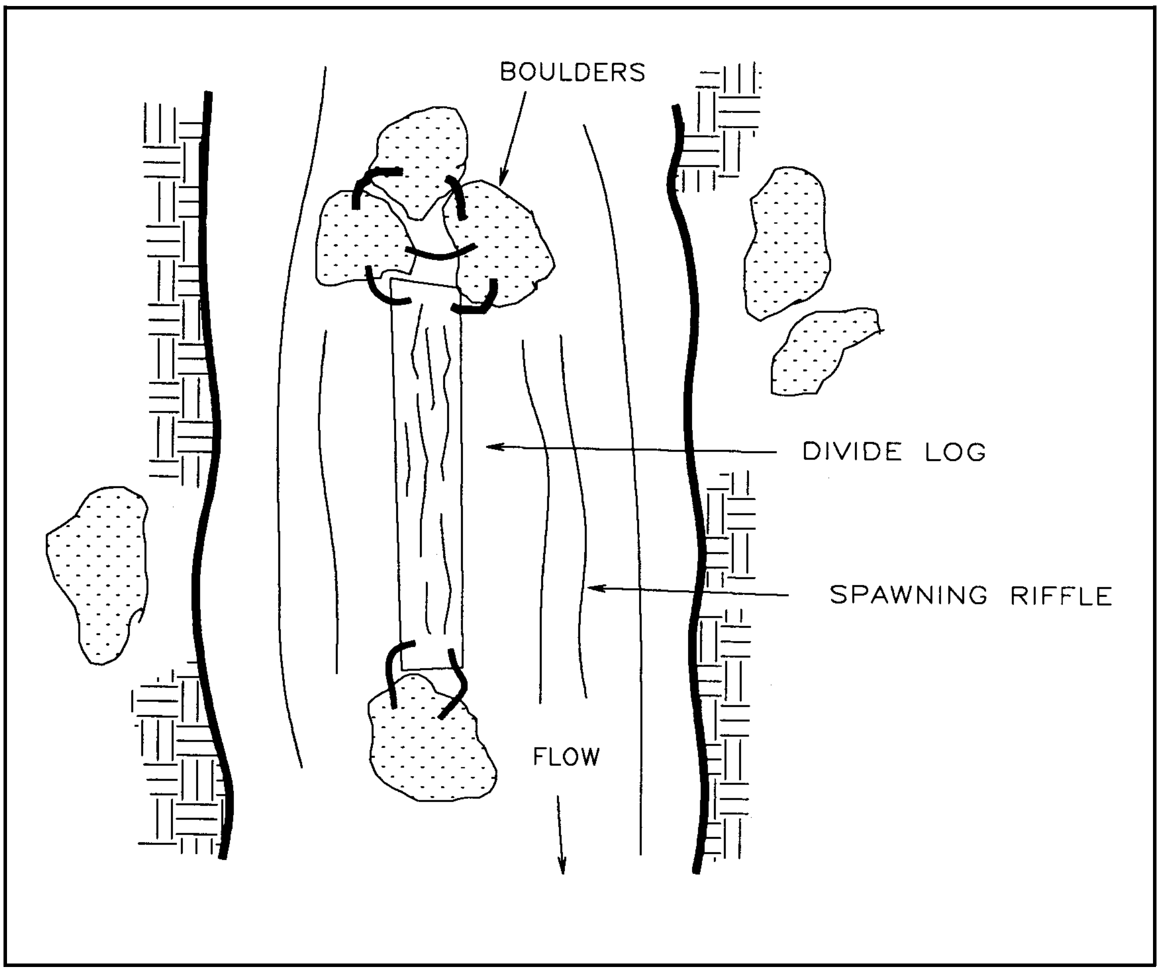

Figure VII-17. Divide log.

Digger Logs

Digger logs are placed with one end anchored securely on the bank and the other end plunging into the bottom of a pool. Primary use of digger logs is to enhance pool habitat by creating diverse cover for rearing juveniles as well as for migrating adults. They are also used to scour the channel, creating or expanding pool habitat. Logs with root wads intact should have the root wad end extending down into the pool to offer the most complexity for increasing rearing habitat and maximizing scour (Figure VII-18). Digger logs will be most secure when two-thirds of the log is on the bank and one-third of the log extends into the channel.

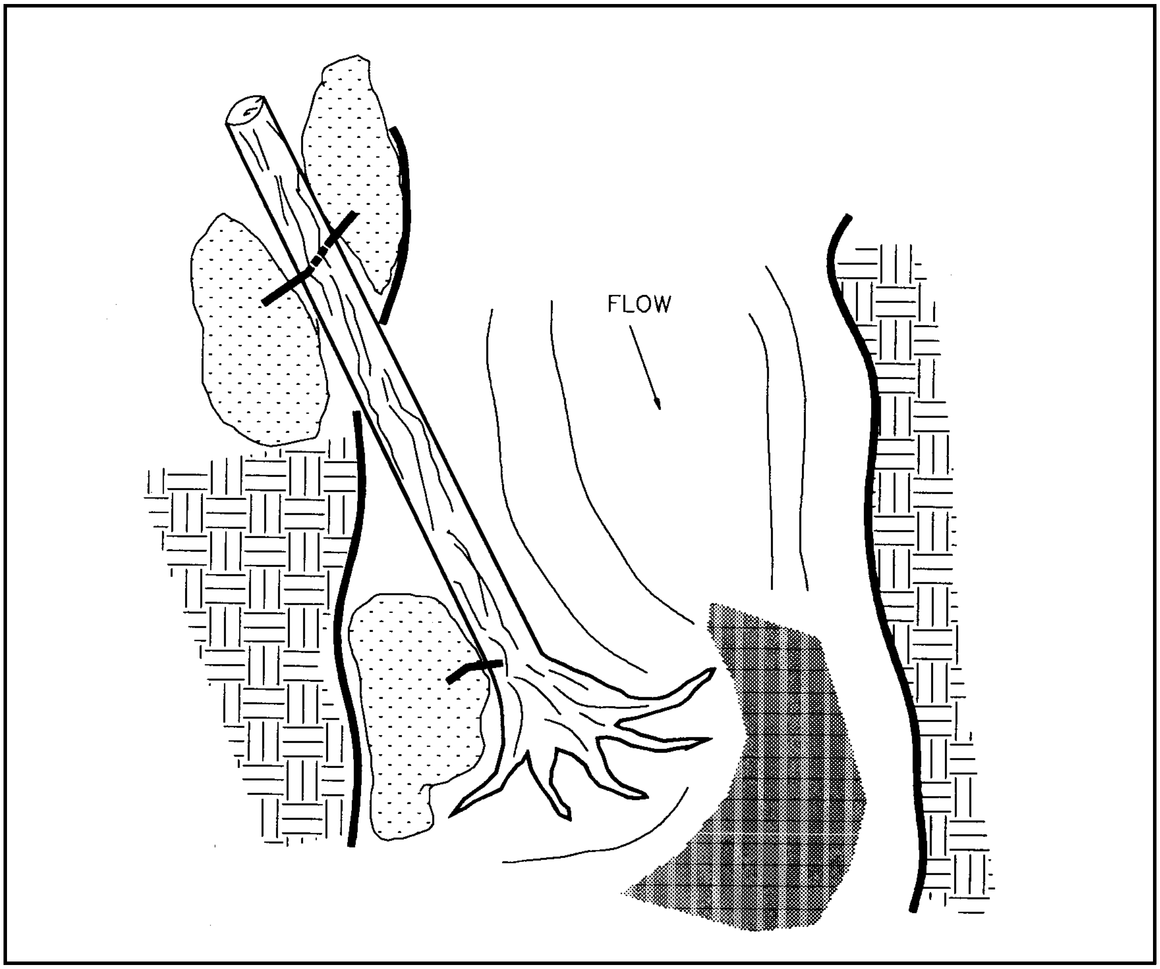

Figure VII-18. Digger log.

Digger logs are usually secured to bedrock and held in place using cable and polyester resin adhesive, or secured to live trees or downed wood with threaded rebar. The log must be anchored in at least two places, with anchors spaced as far apart on the log as possible to keep it secure during high flows. Digger logs can be set in a trench dug into the stream bank. At least one-third of the length of the log should be placed in the bank. This buried end of the log should be covered with boulders to anchor the structure. If the digger log is to successfully create scour, it is important that the end of the log in the water does not float during high flows.

Digger logs will usually be positioned to point downstream, although there may be some situations where pointing them upstream would be appropriate (where the intention of the log placement is to create scour). The vertical angle of the log should usually be 30 to 45 degrees to the bank.

Spider Logs

Spider logs, also called mini log jams, are several logs placed at angles to mimic a log or debris jam. They provide cover for juvenile rearing and adult spawning and collect woody debris to increase diversity. Their use is restricted to areas where there is no danger of causing bank failure or channel migration. Pools and backwater eddy areas on the stream channel margins are the best locations for these structures (Figure VII-19).

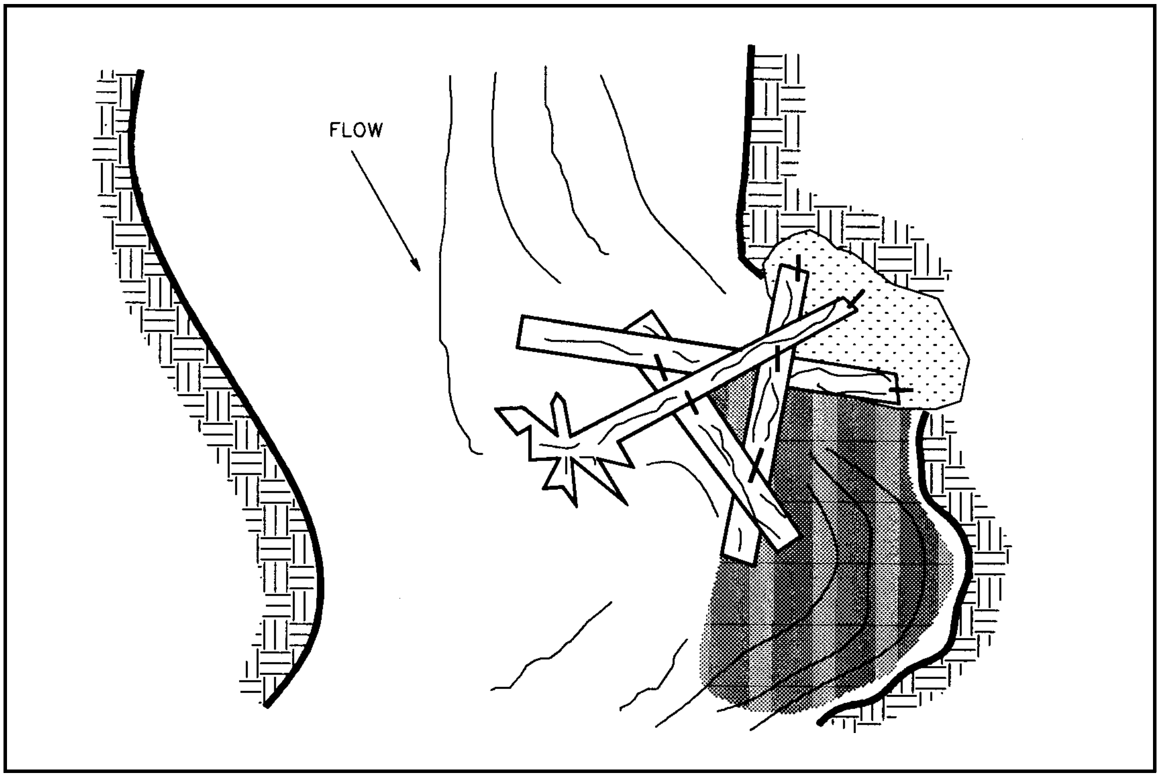

Figure VII-19. Spider logs.

The structures are composed of several logs placed across each other, in the shape of a triangle, to imitate a natural debris or log jam. Each of the logs must be secured to bedrock or large boulders in the channel with cable and polyester resin adhesive, or to live trees with threaded rebar. The logs are secured together with threaded rebar. Several other logs with branches and root wads attached are then fastened to these structure logs with cable or threaded rebar.

Caution must be used in locating these structures as the potential for an adverse effect is great. Before placing spider logs it is necessary to determine channel capacity and bankfull discharge that can be expected. Log structures should not reduce channel capacity below flood stage needs or a massive log jam and sediment trap could develop.

Log, Root Wad, and Boulder Combinations

Log, root wad, and boulder combinations combine the two main forms of structure added to a stream to enhance habitat. The longevity of boulders combined with the cover provided by logs can create habitat that is superior to that offered by either element individually.

Log, root wad, and boulder combinations are used to create cover for juvenile rearing. These structures also act as resting areas and escape cover for spawning salmonids. By creating velocity shear zones they create areas of deposition as well as scour, thereby enhancing spawning through gravel sorting (Figure VII-20).

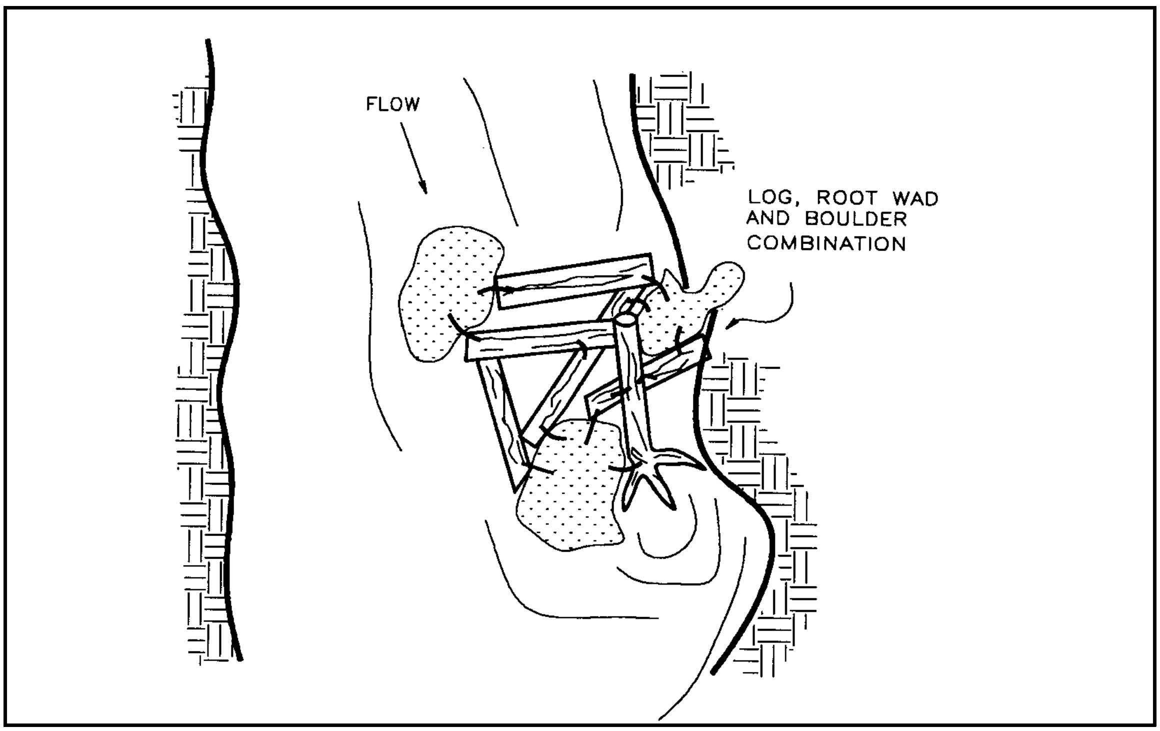

Figure VII-20. Log, root wad, and boulder combination.

Methods used to install log, root wads, boulder combination structures are the same as those used for installing log or boulder structures. The boulders used must be of sufficient size to counteract the buoyancy of the logs. Because of the potential for deflecting high flows into adjacent stream banks, it is important to make sure that banks are resistant to erosion or to take steps to increase their resistance by armoring them with boulders and/or logs.

Boulder Structures

Boulder structures are placed in the active channel and along stream banks for creating a desired habitat type. They are used to break up or diversify stream flow in a particular stream reach, to provide instream cover for juvenile salmonids and spawning adults, or to recruit spawning gravel. It is desirable to create a variety of stream flow velocities, because juvenile salmonids will select different velocities depending on whether they are feeding or resting. Different water velocities will also sort gravel and create diversity in the substrate.

Boulders are well suited for diversifying flows because they are resistant to being displaced by high flows. Because of this they can be placed mid-channel without constructing a full-channel spanning structure. The interstices in boulder clusters and between large boulders can provide escape cover for juvenile and adult salmonids. Boulders must be sized according to stream discharge and channel morphology. Whenever possible, it is best to individually select boulders for use in a project.

There are several disadvantages to using boulders. One is that boulders often must be hauled to the construction site from a quarry. If there is not a quarry nearby, the cost of buying and trucking boulders can be very high. A second problem with using boulders is that if they are placed in mobile substrate, perimeter scour may cause the boulder to bury itself. For this reason, it is necessary to use large boulders, or to secure boulders using polyester resin adhesive and cable to form a larger structure.

Design of boulder structures depends upon the primary function to be served. The range of flows to which a particular structure or series of structures may be subjected will dictate size of boulders to be used, and proper anchoring techniques to be employed.

Boulders can be used in a variety of situations and configurations to perform a desired function or fulfill a particular habitat need. Possible configurations of boulders include weirs, clusters, and single and opposing wing-deflectors.

Boulder Weirs

Boulder weirs are primarily used to collect and retain gravel for spawning habitat, or to create one or more jump pools to facilitate fish passage on marginally accessible or impassable stream reaches. Such fish barriers may be natural or human-induced.

When designing a boulder weir, the following factors must be considered. The boulders used should be larger than boulders occurring naturally in the stream. Large angular boulders are most desirable as they are least likely to roll out of place during high flows. Improper placement of downstream-V and diagonal weirs may direct flow in a manner creating undesirable erosion.

Weirs that span the full channel width can be configured in several shapes including: 1) perpendicular to the flow (if used for back-flooding); 2) diagonal; 3) downstream-oriented "V" (Figure VII-21); and 4) "U"-shaped (if used to improve spawning gravel). General construction principles are the same for all configurations; only one description of construction techniques is presented.

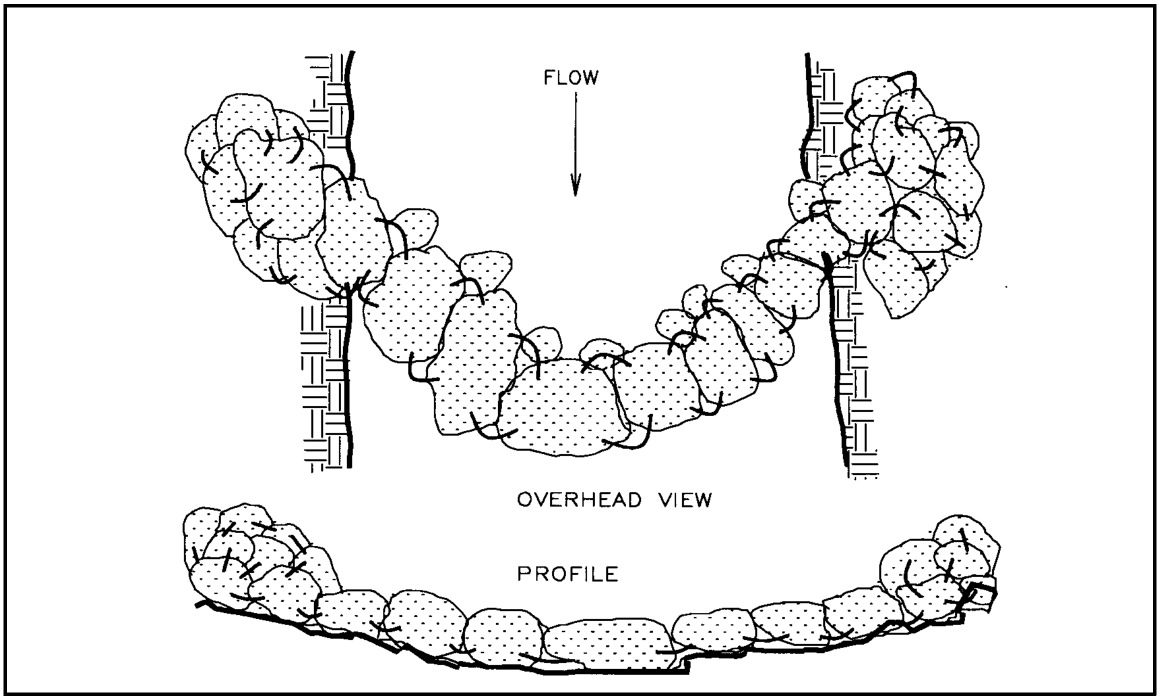

Figure VII-21. Downstream-V boulder weir.

Weirs should be keyed 4 to 6 feet horizontally into stream banks with a gradual downward slope of the weir height toward the thalweg. This slope can be adjusted to position the thalweg. The thalweg will tend to follow the low point in the weir. At the low point of the weir a "spillway" should be constructed by creating an opening one to two feet wide. This creates a notch through which flow is concentrated at low flows. The notch should be roughly triangular in shape with the apex of the triangle oriented down. Flat, broad spillways make fish passage difficult.

The weir should be sealed with smaller rock and cobble to prevent seepage flow and maintain flow over the spillway. This helps to prevent the weir from becoming a low flow barrier to juvenile salmonids.

To assure that the stream is not diverted around the end of the weir during high flows, ends of the weir should be extended to a point above normal high water level. Ends of the weir should be set in a trench dug to a depth of at least one boulder diameter. In bedrock substrate, the boulders on the ends of the weir should be cabled to bedrock. It is important that during high flows the stream does not flow around the end of the weir and cause bank erosion, or establish a new channel.

Quarry boulders will typically be more angular than stream boulders, and depending on the size of the boulders, will be fairly resistant to movement by stream flow. Therefore, they are usually considered to be superior to stream boulders for weir construction. Density of the boulder will also affect its stability in the stream, and how well it stands up to being drilled for cabling. Size of the boulder selected will depend on size available and the magnitude and velocity of stream flow. In general, the bigger the boulder the better. However, the boulder must suit the size of the channel (i.e., a 6-foot diameter boulder would not normally be placed in a 10-foot wide channel, or bank scour is likely).

Oversized boulders are seldom a problem. The opposite is more often the case. If boulders are relatively small and will be subjected to flows of such magnitude that they would not be stable in the stream should not be used. Even with suitably sized boulders it is often desirable to secure the boulders together using cable and polyester resin adhesive to create a stable structure. Cabling requires drilling holes into adjacent boulders and securing them with short lengths of cable. It is important that the cables are no longer than the distance between the boulders plus the depth of the holes. Drill the holes in the sides of the boulders (never the top). Any slack or flex in the cable will allow the boulders to move. By cabling adjacent boulders together, a series of boulders effectively creates a single unit which will remain stable during high flows.

Scour created on the downstream side of boulders may create a crater and cause boulders to roll into the scour hole. This is particularly true with stream boulders which tend to be rounded from abrasive action of years of high flows. Cabling boulders together will help reduce the tendency of the boulders to roll. Where possible, boulders should be imbedded into the substrate to a depth one third of their diameter to compensate for their tendency to roll downstream.

A boulder weir can be one or more rows wide. By setting the downstream row or rows of boulders at progressively lower elevations than the one above, a more gradual drop of stream elevation can be created so the energy in the plunge effect of the water flowing over the weir is dispersed over a wider area. Scour will occur slightly farther downstream and won't be as likely to undermine the boulders. Fish passage must be considered when designing weirs with wide crests.

If placed in a series, the appropriate distance between weirs depends on stream gradient and height of the weirs. In general, spacing should be such that water backed up by one weir will not affect the depth of the water in the plunge pool of the upstream weir. It is important to consider leaping abilities of the fish to be benefitted by the project. In general, no jump should be higher than 12 inches.

Vortex Boulder Weir

Vortex boulder weirs were designed by Wildland Hydrology for use in high bedload streams to maintain sediment transport capacity and low width/depth ratios (Figures VII-22, VII-23, and VII-24). These structures are most appropriate in 'F' and 'B' type channels. Vortex boulder weirs:

1) Provide instream cover and deepen feeding areas in riffle habitats;

2) Provide a wide range of velocities for salmonid holding water at high flow without creating backwater or sediment deposition;

3) Act as a grade control structure without upstream lateral migration, bank erosion or aggradation, characteristic of some log or boulder weir designs;

4) Maintain a low width/depth ratio to reduce sediment deposition and maintain the sediment transport capacity of the channel.

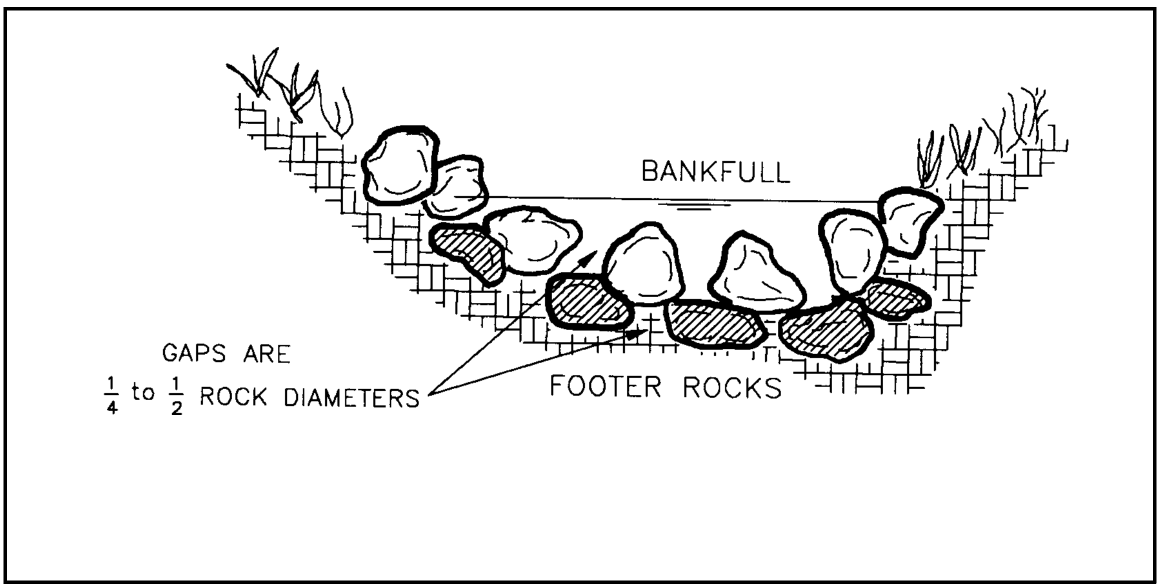

Figure VII-22. Vortex boulder weir, cross section view (Rosgen, 1993).

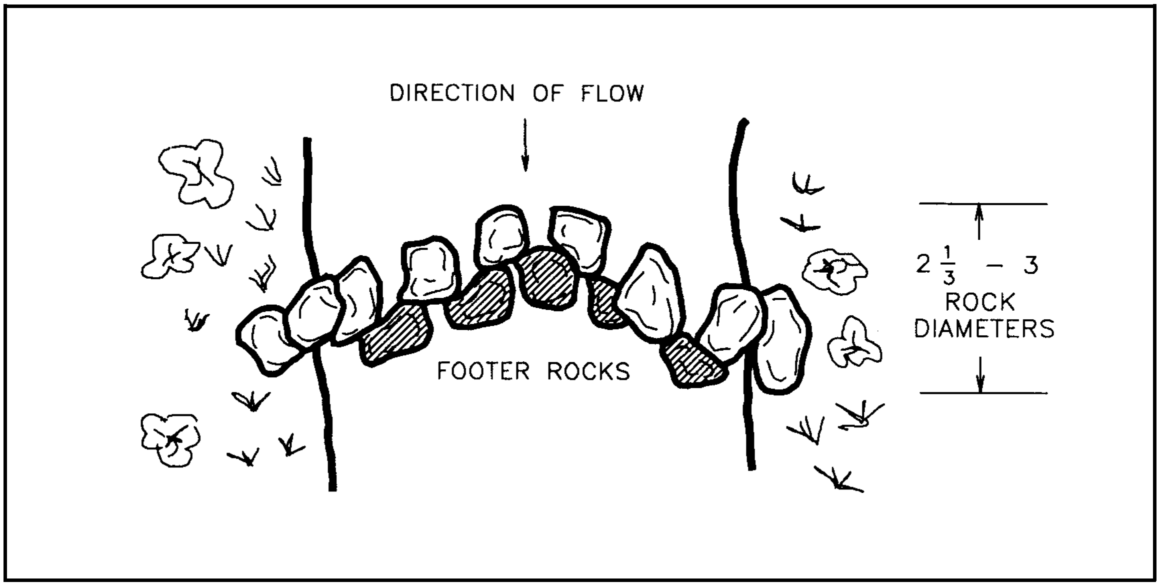

Figure VII-23. Vortex boulder weir, plan view (Rosgen, 1993).

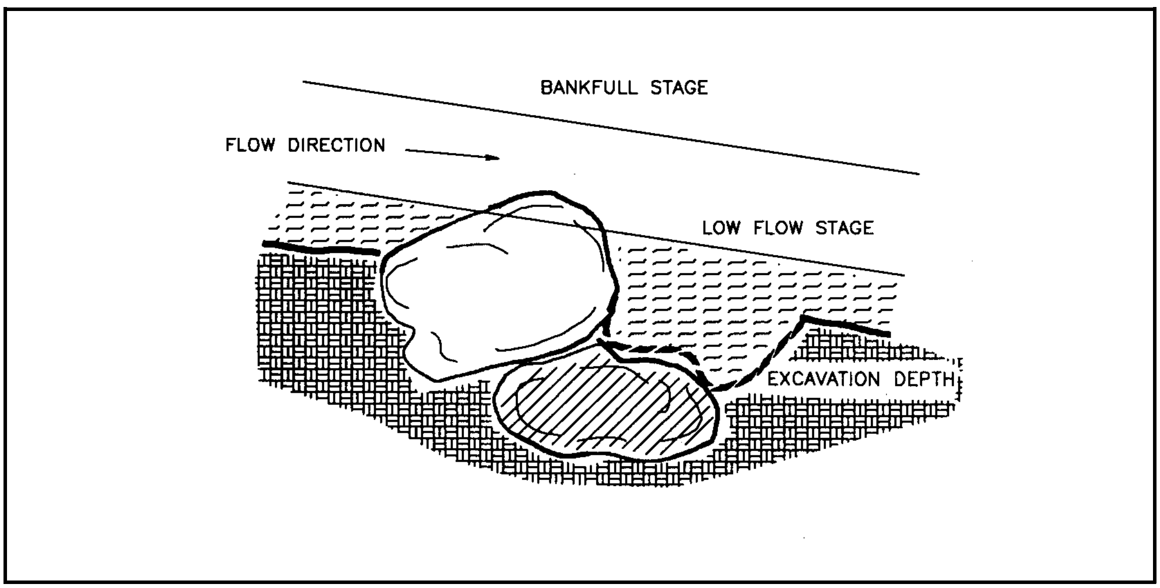

Figure VII-24. Vortex boulder weir, profile view (Rosgen, 1993).

Boulder Clusters

Boulder clusters are used to create scour pockets around boulders, to provide rearing habitat for juvenile salmonids, to build quiet water resting areas for upstream migrating spawners, and to sort spawning gravel (Figure VII-25).

Generally, clusters are located in straight, stable, moderately to well confined, low gradient riffles (0.5 to 1 percent slope) for spawning gravel enhancement; they are also placed in higher gradient riffles (1 to 4 percent slope) to improve rearing habitat and provide cover. At least 3 to 5 foot diameter boulders are recommended, except in very small streams.

To be effective in creating scour pockets and habitat niches around individual boulders, the correct distance between adjacent boulders and the configuration of the boulder clusters must be determined. In general, adjacent boulders should be 0.5 to 1 foot apart. The best configuration for boulders is usually a triangle of three boulders. Several of these clusters may be aggregated to increase scour area and create greater habitat complexity.

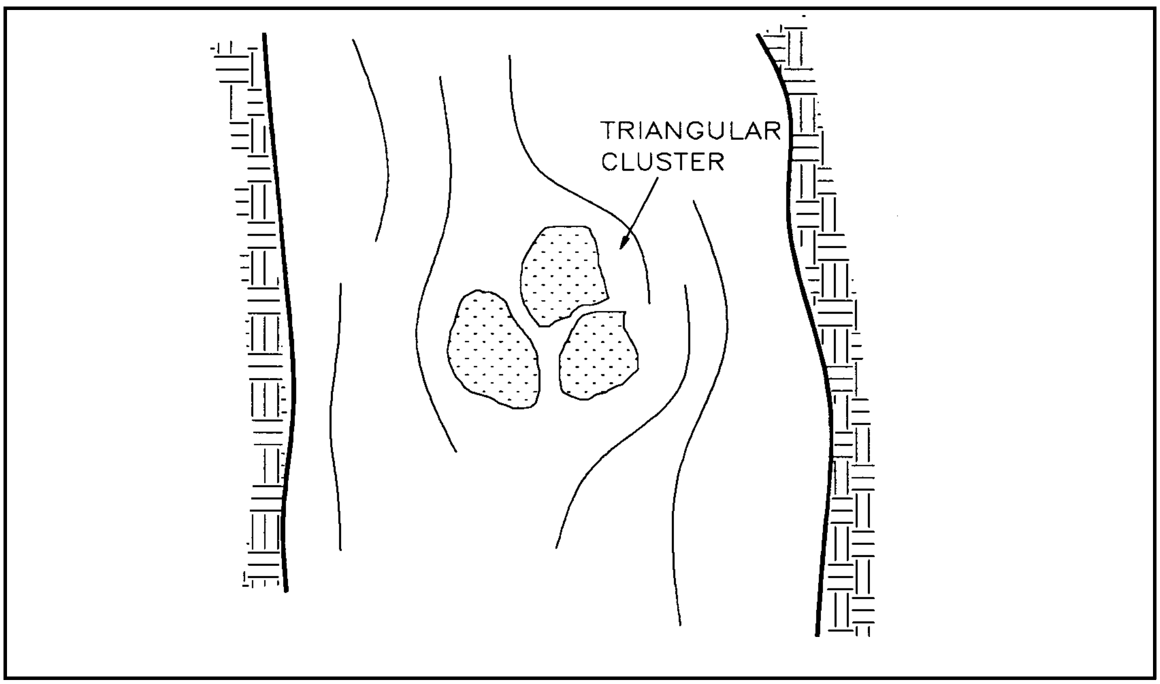

Figure VII-25. Boulder cluster.

If large angular quarry boulders are available, a single boulder can create good cover for juvenile and adult fish. Place the boulder within the middle two quarters of channel width, and not in a deposition zone. If the boulder is placed on a sand or silt bar, it may disappear into the bar. Do not use boulders that are so big that they divert the stream from its channel, or into soft stream banks.

Single and Opposing Boulder Wing-Deflectors

Single wing-deflectors are built to protect a portion of one bank, by deflecting the flow away from the bank. They are also used to create scour by constricting the channel thereby accelerating the flow (Figure VII-26). Wing-deflectors can also create quiet water resting areas for use by upstream migrating spawners.

Opposing wing-deflectors are built to constrict the flow to create a scour pool and sort spawning gravel. These structures are best installed in long, uniform glides or riffles. They create rearing habitat for juvenile salmonids as well as resting areas for upstream migrating spawners. The upstream side of the deflector will develop deposition that may become suitable spawning habitat.

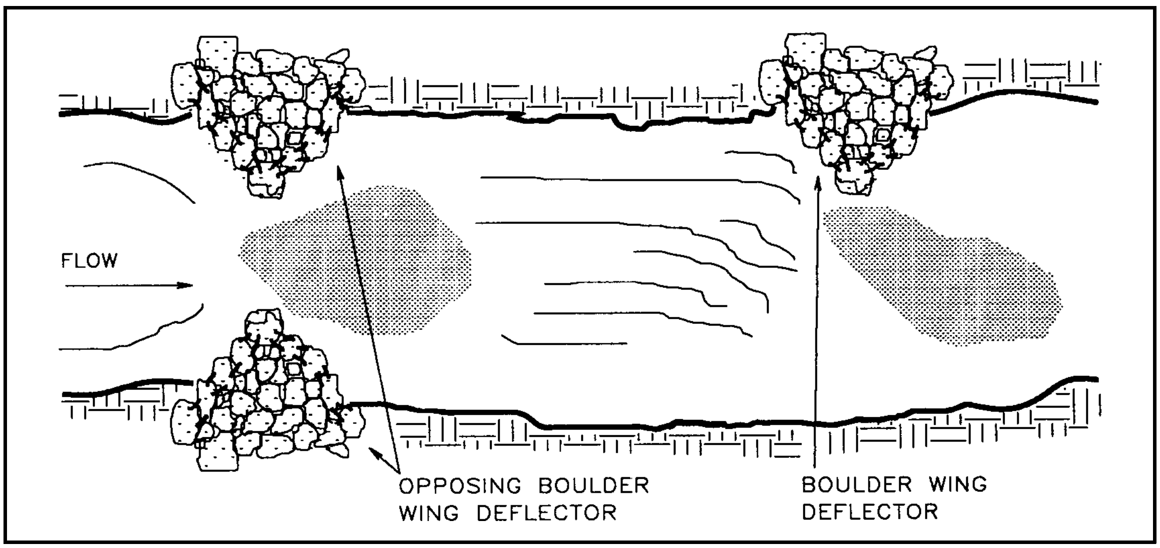

Figure VII-26. Single and opposing boulder wing-deflectors.

Wing-deflectors are similar to boulder weirs in that they are keyed into the stream banks, and slope to a low point near the center of the channel. Opposing wing-deflectors are created by constructing two single wing-deflectors opposite each other, reducing channel width by 40 to 80 percent. They should be constructed in low profile and their apexes should be equal in height.

Wing-deflectors are built in a triangular shape. This configuration will more effectively funnel flows between the apexes of opposing wing-deflectors, or to the apex of a single deflector.

Size of boulders will depend on the size of the channel, but oversized boulders are usually not a problem. To maintain the integrity of the structure it is desirable to secure the boulders with cable and polyester resin adhesive to create the perimeter of the structure. Smaller boulders or cobble can be used to fill the interior. The stream banks must either be naturally resistant to erosion or bank protection should be incorporated in construction of wing-deflectors.

Log Structures

Applications for log structures are similar to those for boulder structures. Logs may be used to provide instream cover for juvenile salmonids and spawning adults, to scour pools for rearing habitat, to recruit spawning gravel, and to stabilize eroding stream banks.

Log structures have a variety of shapes and uses. These include straight log weirs, downstream-V weirs, diagonal weirs, upstream-V weirs, upsurge weirs, wing-deflectors, divide logs, digger logs, and Hewitt ramps. The various structures have specific purposes which often dictate the specifications to which they are built. Many of these structures serve the dual purpose of trapping, sorting, and stabilizing gravel for spawning habitat as well as creating scour pools which act as rearing habitat for juvenile salmonids and escape cover or resting areas for spawning adults.

Log Weirs

As with boulder weirs, log weirs must be designed to specifications dictated by channel dimensions and range of flows that the stream may experience. It is important that log weirs are designed so that they do not become low-flow migration barriers. The maximum jump height that a log weir should create is 12 inches.

Log weirs are often placed in long, shallow riffles or runs. They may also be installed on straight reaches or meanders. The gradient should be between 1.5 and 4 percent in a moderately entrenched channel. Stream banks should be stable and composed of coarse, resistant material.

Log weirs have advantages and disadvantages compared to boulder weirs. The advantages are that logs are often available near the channel and are often obtainable at no cost other than the labor to bring them to the project site. A disadvantage of logs is that they will eventually rot, making the structure less durable than one of boulders. Redwood and cedar logs, however, can last for decades in a stream, are aesthetic, and are easy to work with.

Log weirs can be built in a variety of configurations. The type of log weir constructed is dependent on the desired habitat modification. Straight log weirs have been used extensively throughout the California coastal mountains. Constructed properly, they will trap gravel upstream and scour a pool downstream. Several problems have been associated with straight weir design. Straight log weirs can push too much water to sides, eroding fragile banks. Where there is not a proper downstream control, down-cutting immediately below the weir may create a jump in excess of 12 inches and a low-flow notch will be required (Figure VII-27). Generally, the only purpose for a straight log weir is to back-flood an area, such as a culvert. Downstream-V and diagonal weirs are more efficient at trapping gravel and upstream-V weirs are better for scouring pools.

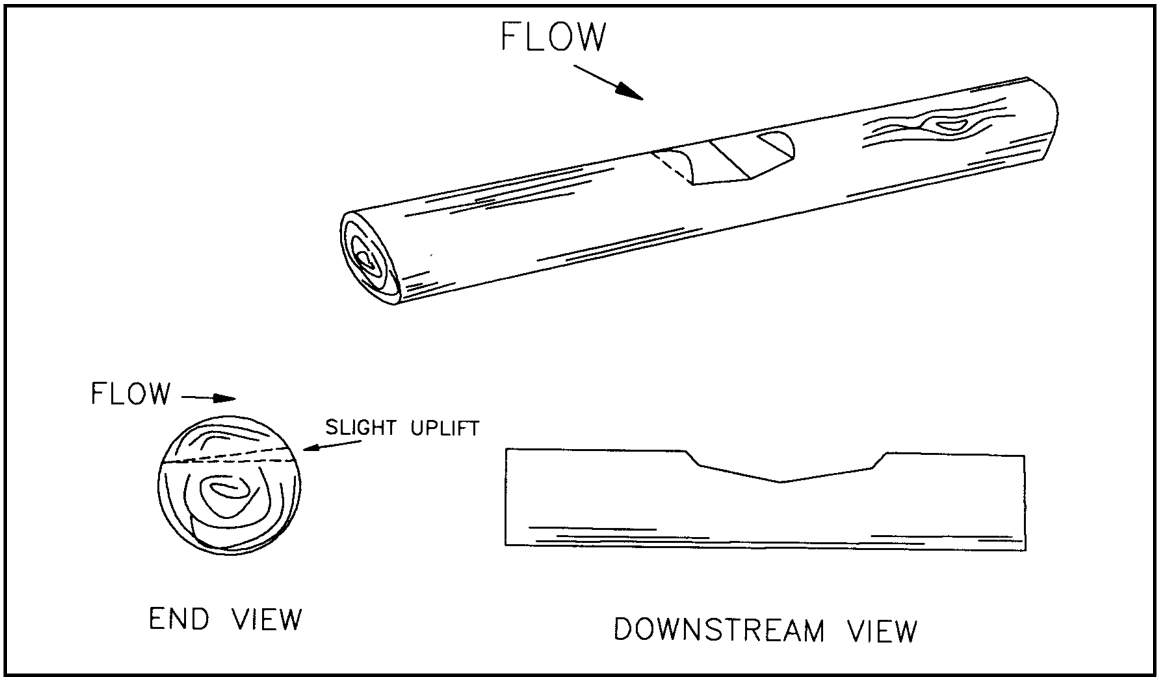

Figure VII-27. Straight log weir with low-flow notch.

Downstream-V weirs are effective in dissipating high flow energy and are used to collect spawning gravel. The downstream design forces water to the banks, therefore downstream-V weirs should only be constructed in areas of good bank stability (Figure VII-28).

Diagonal log weirs are placed diagonally to stream flow and span the full channel width. The upstream end of a diagonal log weir is set at a lower elevation than the downstream end. The drop in elevation should be approximately 6 inches in 10 feet. Diagonal log weirs cause stream flow to adjust direction so flow comes off the log at a right angle. Diagonal log weirs are good for creating lateral scour pools on river bends and for collecting spawning gravel, and they are also used to adjust direction of the stream. They can be very useful in directing flow away from unstable banks (Figure VII-29).

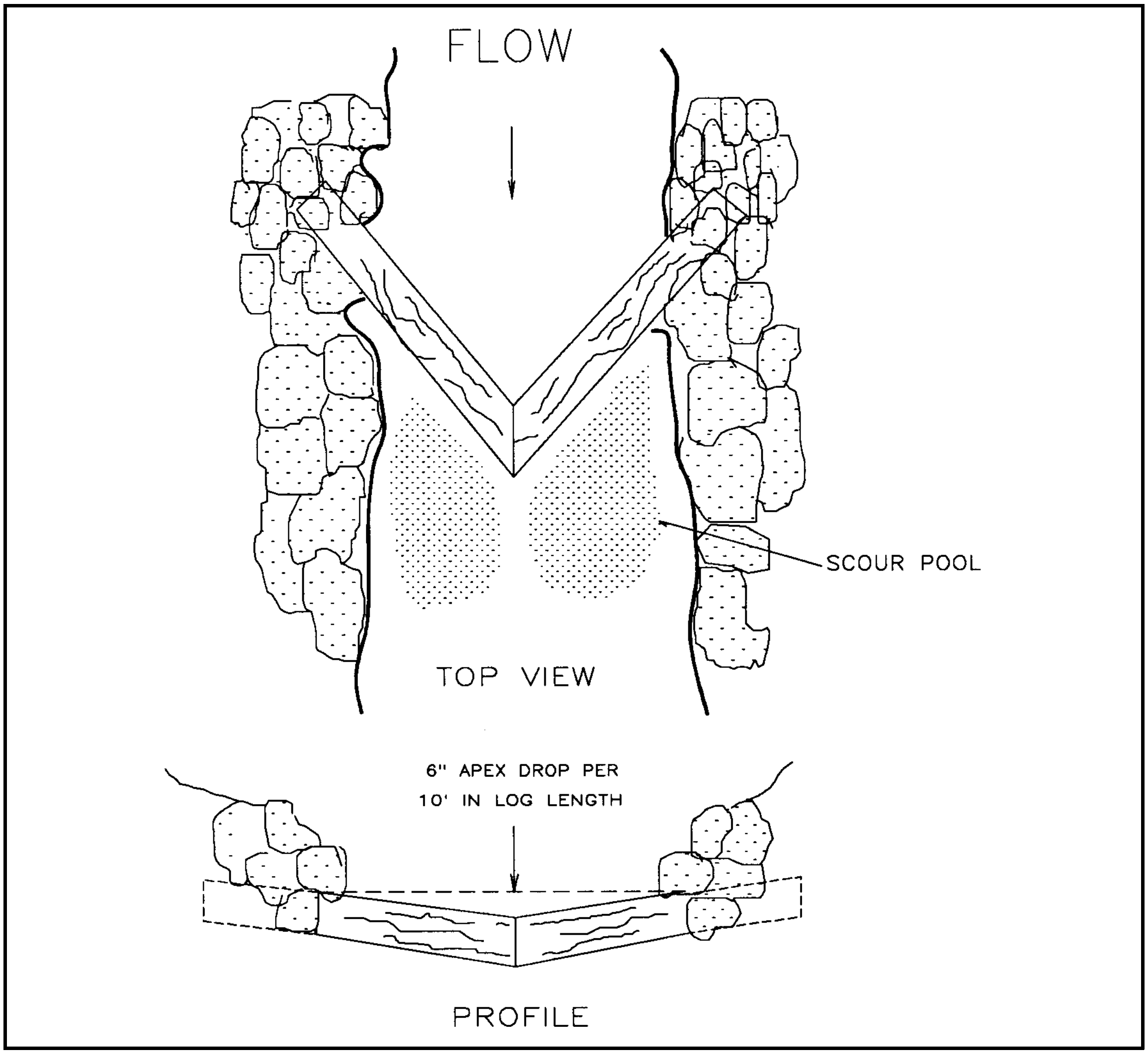

Figure VII-28. Downstream-V log weir.

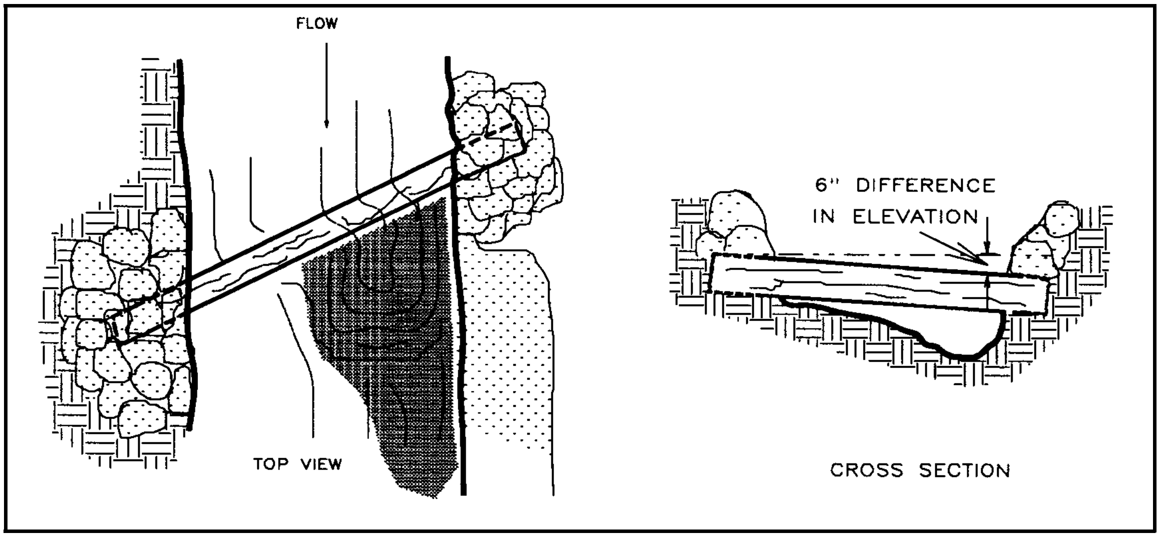

Figure VII-29. Diagonal log weir.

Upstream-V log weirs are used to scour deep pools. Principles of construction are the same for the various shapes of log weirs. Construction of an upstream-V weir will be described. These techniques of construction apply to other log weirs with some variations required to accommodate differences in configuration (Figure VII-30).

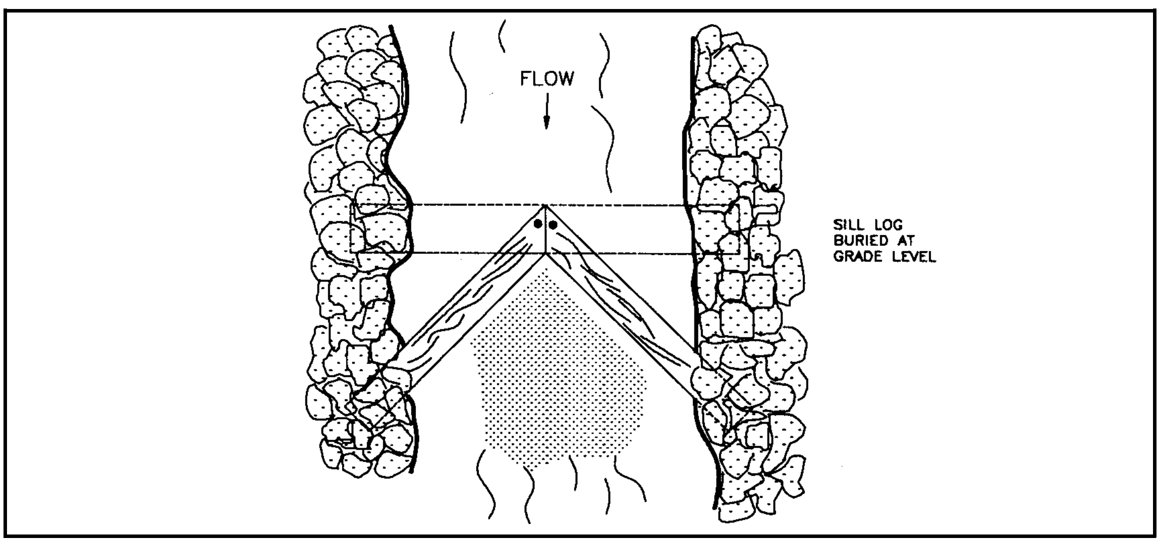

Figure VII-30. Upstream-V log weir.

Use redwood or cedar logs if available. Logs should be of appropriate size, determined by channel width, channel type, and bankfull discharge flows. Dig a trench perpendicular to the channel to bury the sill log at streambed grade. Key the ends of the sill log at least 6 feet into the bank. Place rock on keyed section of the log to prevent it from floating loose. Rock must be large enough and in sufficient quantity to protect banks.

Place the apex ends of the two logs forming the upstream "V" on top of the sill log. The two logs are placed so the apex is approximately 6 inches lower than the downstream keyed-in ends of the logs. The top of the logs at the apex should be no higher than 12 inches above the downstream water line. The apex of the logs must be shaped for a close fit. Drill through the apex ends of the two logs into the sill log, and hammer lengths of one-inch threaded rebar through both drill holes. Secure washers and nuts to the ends of the threaded rebar and tighten securely. Armor the bank ends of the logs with rock. Dig a 24-inch deep pool at the downstream apex so that fish can jump over the logs until high flows can create a scour pool.

If a series of weirs is to be installed, the downstream weir should be constructed first. Difference in elevation between lower and upper water surfaces should be 12 inches. Elevations can be determined with a hand or survey level and a stadia rod.

There are numerous variations of the upstream-V log weir. These include the upstream-V leaving a low-flow notch (Figure VII-31), the upstream-V using opposing log deflectors over a sill log (Figure VII-32), and log constrictors over a series of log planks (Figure VII-33).

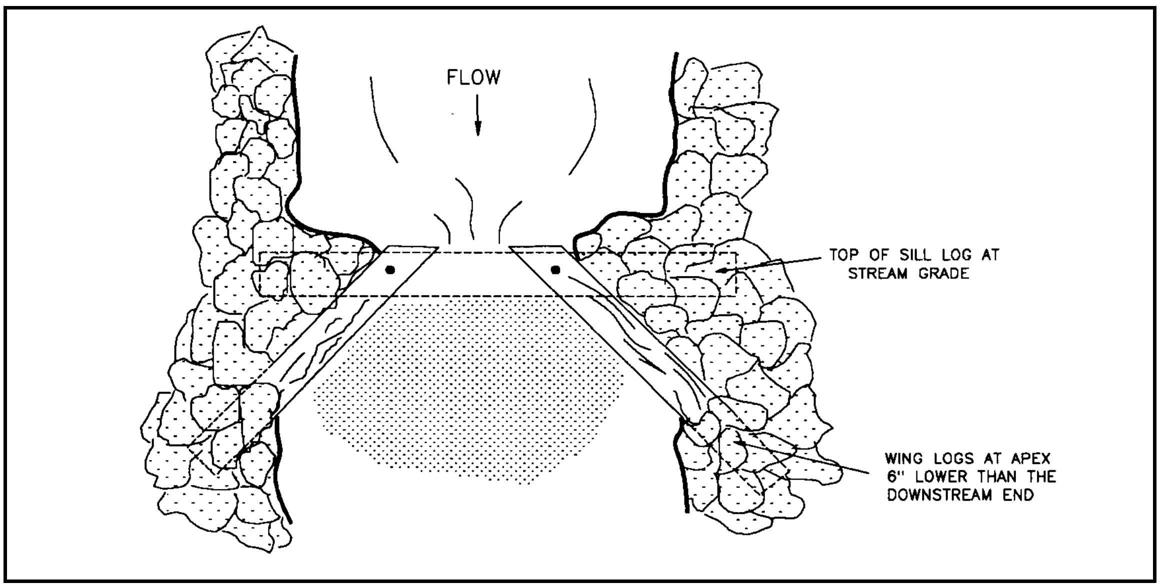

Figure VII-31. Upstream-V log weir with a low-flow notch.

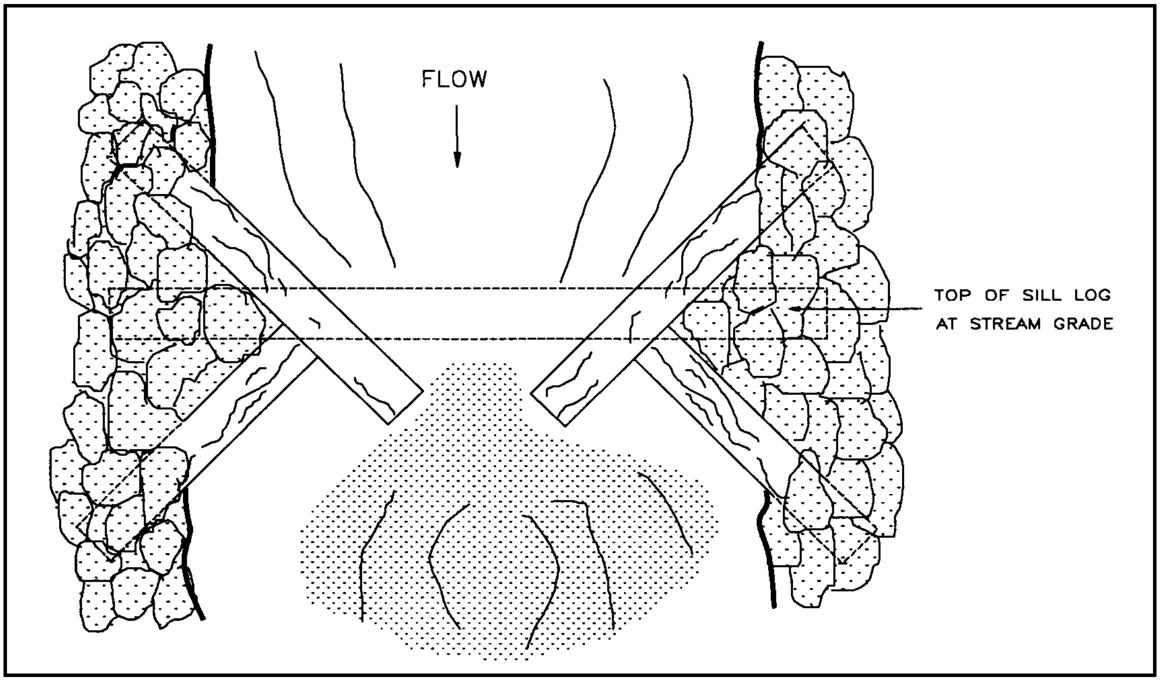

Figure VII-32. Opposing log deflectors over a sill log.

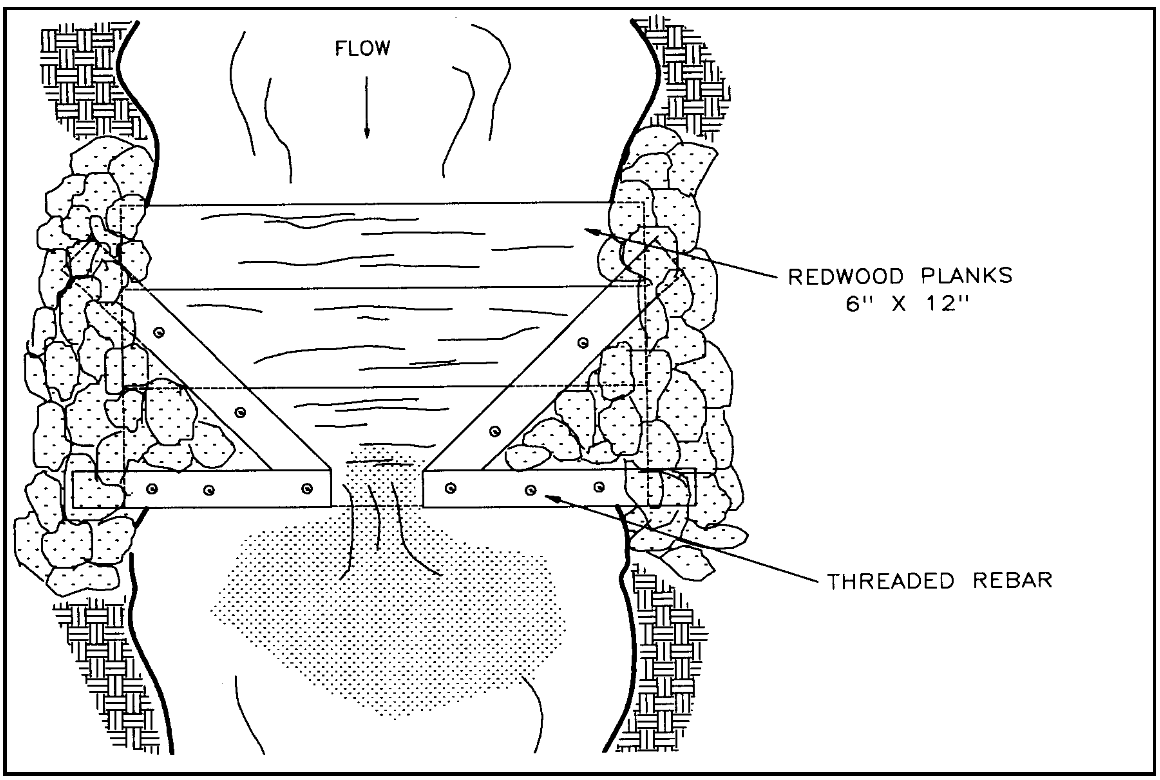

Figure VII-33. Log constrictors over planks.

Upsurge Weirs

Upsurge weirs are logs which span the full channel width. They are used to force stream flow under the log in order to scour the channel bottom to create or enhance pools for summer rearing habitat. Upsurge weirs are most effective when the bottom of the log is placed at the summer low-flow surface elevation (Figure VII-34).

Strong anchoring systems are required for upsurge weirs because of the strong hydraulic lifting force generated at scouring flows. Upsurge weirs should be anchored to stationary boulders on the banks or to bedrock. If this is not possible, both ends of the weir can be set into excavated trenches on opposite banks at the summer low-flow water level. Four to six feet of the log should be keyed into each bank. Enough weight must be placed on each log end to permanently secure it.

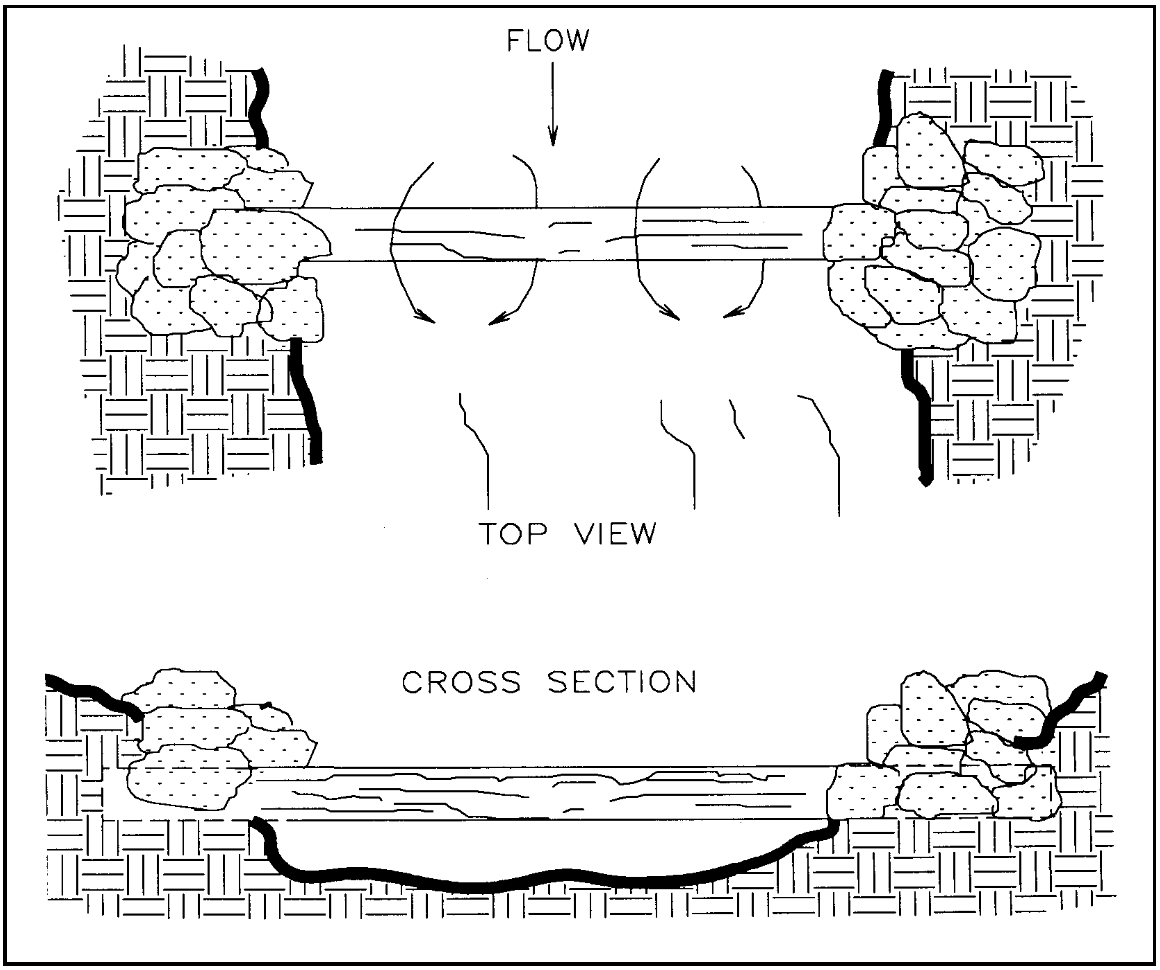

Figure VII-34. Upsurge weir.

Single and Opposing Log Wing-Deflectors

Wing-deflectors are used to concentrate the flow of water into a selected area of the channel to create scour. The scour creates a pool and the deflector(s) will act as cover and create a resting area for fish. They are primarily used in areas of long, uniform glides or riffles to diversify habitat and create velocity shear zones (Figure VII-35).

Wing-deflectors must not be placed or designed so that they create a severe channel constriction or deflect high flows into unstable or unprotected stream banks. The upstream log should extend into the summer low-flow channel so that it provides summer rearing habitat.

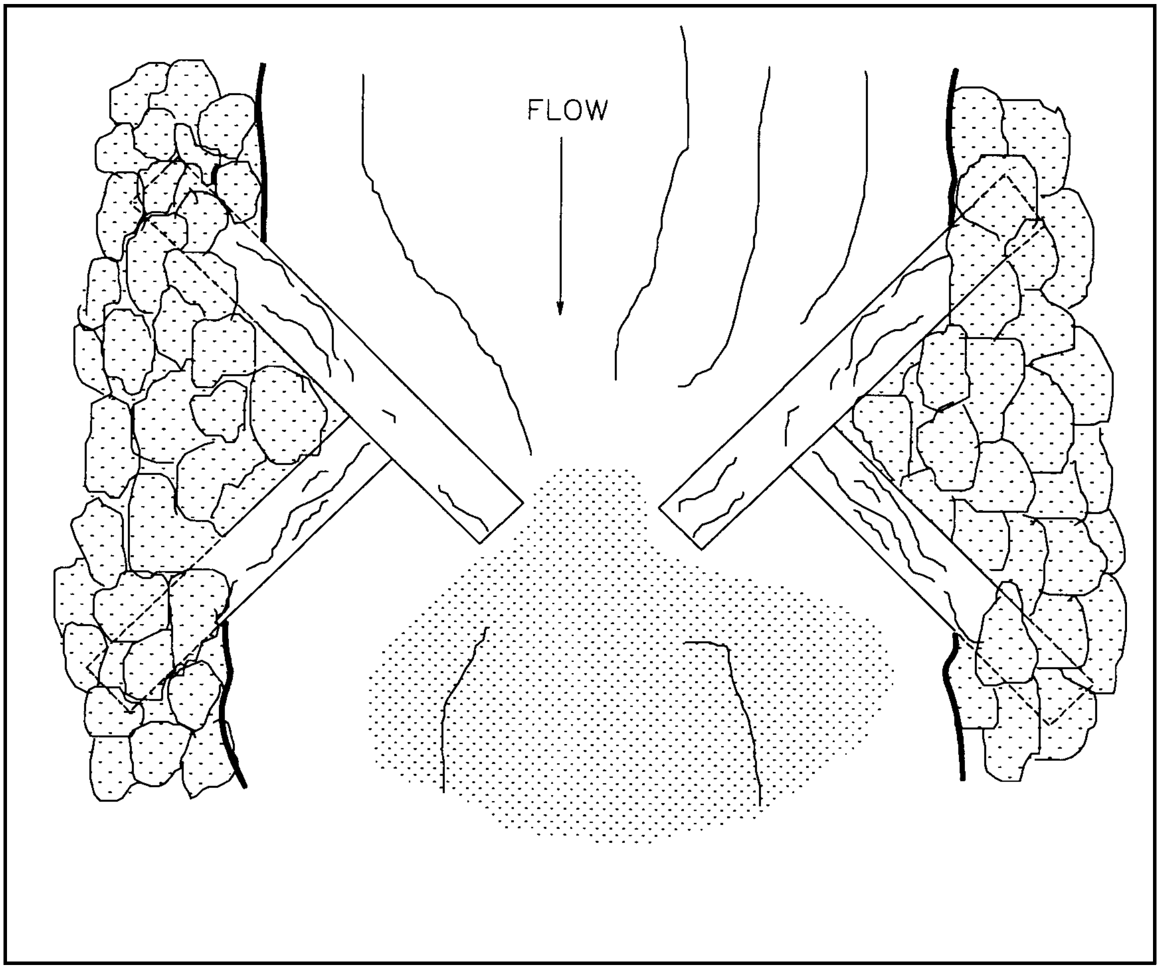

Figure VII-35. Opposing log wing-deflector.

The construction of the deflector involves making a "V" or a triangle whose base is parallel to the bank and whose two sides join to make the apex, which extends into the flow. A trench must be excavated into the bank to key-in the logs that make up the sides of the triangle. The trench must extend far enough into the bank to afford adequate anchoring for the deflector side logs. The angle of this trench will determine the angle at which the deflector sits. Orientation of the trenches will be determined by the desired apex angle. The apex angle will be 100 to 120 degrees. Location of the apex should be determined and the trenches should be laid out to conform to the desired angle of slope and the apex angle.

The ends of the side logs must be notched so that they fit together to create a joint that is the same diameter as the side logs (the top of the apex joint should form a smooth transition to either log). One log end (the one pointing downstream) can be extended past the apex to create scour and additional cover. The apex is held together with threaded rebar inserted through a hole drilled in the apex.

The base of the triangle parallels the bank. A smaller diameter log can be used to join the two sides of the apex. This will give the structure added strength, but if the bank ends of the logs are adequately anchored, the base log may not be needed.

Once logs are placed in their trenches and the ends have been joined to make the apex, the bank ends should secured to trees, stumps, boulders, or a deadman, then covered with boulders to weigh them down and act as anchors.

If opposing deflectors are installed, the distance between the apexes is important. This distance will determine velocity of water flowing between the deflectors and the amount of scour created. Opposing wing-deflectors typically should reduce channel width by 40 to 80 percent.

Hewitt Ramps

Hewitt ramps are constructed by installing base logs that support cedar or redwood planks. Planks are placed on the upstream side of the base log at an angle that will allow gravel to wash over the structure, creating a plunge pool on the downstream side of the structure. They are used to create pools in areas where there is a large volume of bedload movement. Construction costs for Hewitt ramps are high and the structures usually require periodic maintenance. Hewitt ramps must have a low profile or other design features to avoid creating a barrier to fish migration (Figure VII-36).

A Hewitt ramp is constructed with a base log placed in a trench excavated in the stream to one-third the log diameter. This log is secured by burying its ends in the stream banks. The log should be at least two feet in diameter. On the upstream side of the log, cedar or redwood planks (2 x 6 inch minimum) are laid to create a ramp at an angle of 30 to 45 degrees. Planks are set against each other and the ends are buried in the substrate to a depth of at least two feet. The area between the planks and the log should be filled with cobble to provide extra support for the planks. Tops of the planks are nailed to the log with 20d galvanized nails. The planks are cut off in a "V" configuration to concentrate stream flow into the thalweg during low flow conditions.

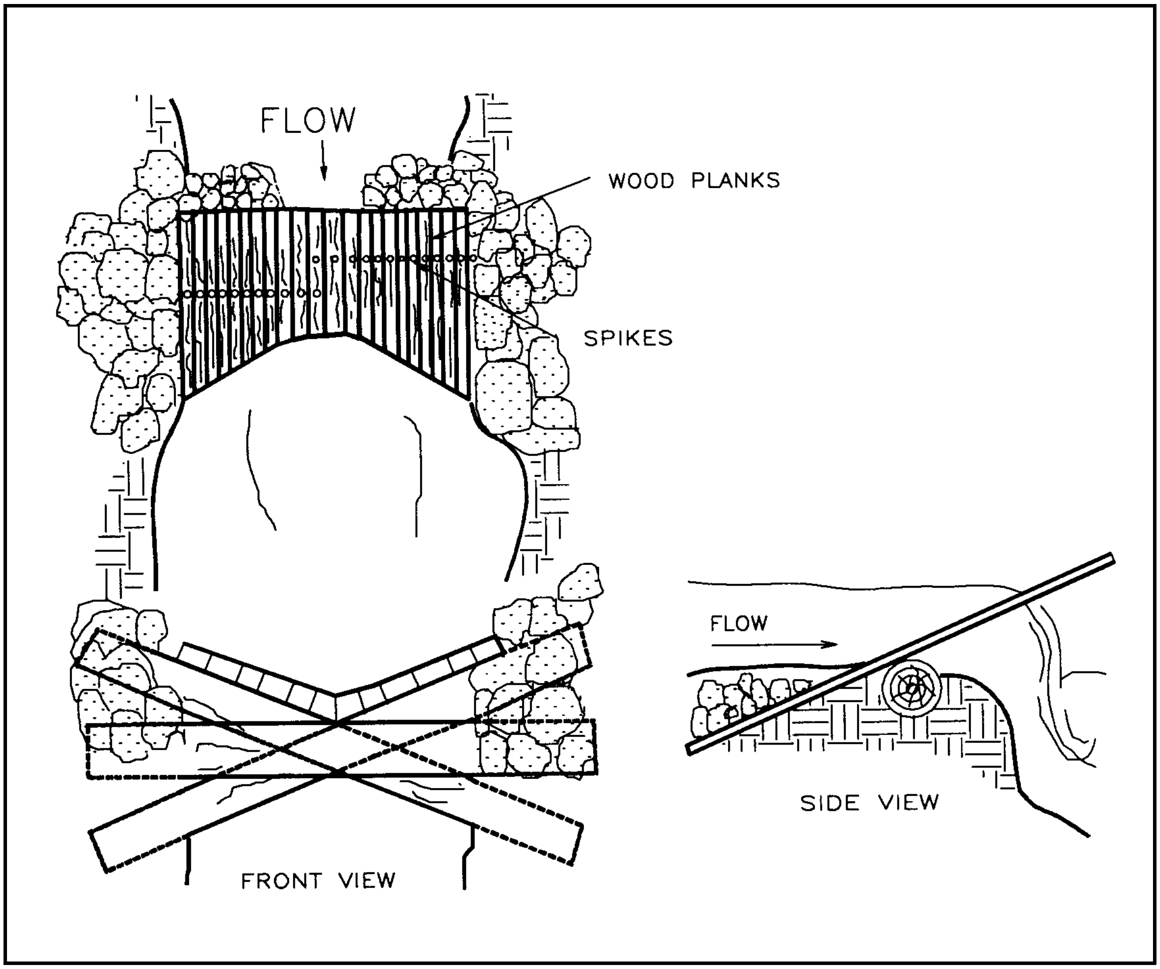

Figure VII-36. Hewitt ramp.